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A

Quality Assurance Project Plan

for

Ammunition Burning Grounds
Little Sulphur Creek and Jeep Trail
Resource Conservation and Recovery Act
Phase III RCRA Facility Investigation

Volume I of II
Text and Appendices A through H

Naval Surface Warfare Center Crane

Crane, Indiana

Southern Division
Naval Facilities Engineering Command

Contract Number N62467-94-D-0888

Contract Task Order 0126

April 2001

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QUALITY ASSURANCE PROJECT PLAN
FOR
AMMUNITION BURNING GROUNDS
LITTLE SULPHUR CREEK AND JEEP TRAIL
RESROUCE CONSERVATION AND RECOVERY ACT
PHASE III RCRA FACILITY INVESTIGATION

NAVAL SURFACE WARFARE CENTER, CRANE
CRANE, INDIANA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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ACRONYMS

ABG	Ammunition Burning Grounds
AMSL	Above Mean Sea Level
ANOVA	Analysis of Variance
AOC	Area of Concern
ATSDR	Agency for Toxic Substances and Disease Registry
AVS	Acid Volatile Sulfides
AWQC	Ambient Water Quality Criterion
BAF	Bioaccumulation factor
BAFs	Bioaccumulation factors
BCFs	Bioconcentration Factors
BERA	Baseline Ecological Risk Assessment
bgs	below ground surface
BRA	Baseline Risk Assessment
BSAF	Biota-Sediment Accumulation Factor
BTAG	Biological Technical Assistance Group
bw	Body weight
CAAA	Crane Army Ammunition Activity
CCME	Canadian Council of Ministers of the Environment
CCRA	Current Contamination Conditions Risk Assessment
CDDs	chlorinated dibenzo-p-dioxins
CDFs	dibenzofurans
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CMS	Corrective Measures Study
COPC	Chemical of Potential Concern
COPCs	Chemicals of Potential Concern
COPEC	Chemical of Potential Environmental 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
DAFs	Dilution and Attenuation Factors
DNB	Dinitrobenzene
DNT	Dinitrotoluene
DQO	Data Quality Objectives
DRMO	Defense Reutilization and Marketing Operations
EDQL	Ecological Data Quality Level
EDQLs	Ecological Data Quality Levels
EEQ	Ecological Effects Quotient
EMR	Environmental Monitoring Reports
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ER-L	Effects Range-Low
ER-M	Effects Range-Median
EU	Exposure Unit
FAQs	Frequently Asked Questions
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HI	Hazard Index
HIs	Hazard Indices
HMX	Octahydro-1,3,5,7-Tetranitro-1,3,5,7-Tetrazocine
HQ	Hazard Quotient
HQs	Hazard Quotients
IA	Installation Assessment
IAS	Initial Assessment Study
ICR	Incremental Cancer Risk
ICRs	Incremental Cancer Risks
IDEM	Indiana Department of Environmental Management
IEUBK Model	Integrated Exposure Uptake Biokinetic Model
IRIS	Integrated Risk Information System
LOAEL	Lowest Observed Adverse Effect Level
LOAELs	Lowest Observed Adverse Effect Levels
MCL	Maximum Contaminant Level
MCLs	Maximum Contaminant Levels
MDL	Method Detection Limit

MHSDE	Ministry of Housing, Spatial Planning, and Environmental
mg/kg	milligrams per kilogram
mg/kg/day	milligrams per kilogram per day
NAD	Naval Ammunition Depot
NCEA	National Center for Environmental Assessment
NEESA	Naval Energy and Environmental Support Activity
NFESC	Naval Facilities Engineering Service Center
NGVD	National Geodetic Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Level
NOAELs	No Observed Adverse Effect Levels
NSWC	Naval Surface Warfare Center
OMOE	Ontario Ministry of Environment and Energy
OPPTS	Office of Prevention, Pesticides, and Toxic Substances
ORNL	Oak Ridge National Laboratory
OSWER	Office of Solid Waste and Emergency Response
PAHs	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated biphenyls
PCBs	Polychlorinated Biphenyls
PCDD	Polychlorinated dibenzodioxins
PCDF	Polychlorinated dibenzofurans
PEP	Propellants, Explosives and Pyrotechnics
PRG	Preliminary Remediation Goal
PRGs	Preliminary Remediation Goals
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RAGS	Risk Assessment Guidance for Superfund
RBC	Risk-Based Concentration
RBSL	Risk-Based Screening Level
RBTL	Risk-Based Target Level
RCRA	Resource Conservation and Recovery Act
RCRA	Resource Conservation and Recovery Act
RCS	Release Characterization Study
RDX	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine
RfC	Reference Concentration
RfD	Reference Dose

RFI	RCRA Facility Investigation
RL	Reporting Limit
RME	Reasonable Maximum Exposure
SDWA	Safe Drinking Water Act
SEM	Simultaneously Extracted Metals
SERA	Screening-level Ecological Risk Assessment
SOUTHDIV	United States Navy Southern Division Naval Facilities Engineering Command
SQB	Sediment Quality Benchmarks
SQC	Sediment Quality Criteria
SSL	Sediment Screening Level; Soil Screening Level
SSLs	Soil Screening Levels
SSSL	Surface Soil Screening Level
SWMU	Solid Waste Management Unit
SWSL	Surface Water Screening Level
SWSLs	Surface Water Screening Levels
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TEFs	Toxicity Equivalence Factors
TEQ	Toxicity Equivalent Concentration
TIC	Tentatively Identified Compound
TNB	Trinitrobenzene
TNT	2,4,6-Trinitrotoluene
TOC	Total Organic Carbon
TRV	Toxicity Reference Value
TRVs	Terrestrial Reference Values
TRW	Technical Review Workgroup
TtNUS	Tetra Tech NUS, Inc.
µg/dL	micrograms per deciliter
µg/L	micrograms per liter
U.S. ACE	United States Army Corps of Engineers
U.S. EPA	United States Environmental Protection Agency
UCL	Upper Confidence Limit
UCLs	Upper Confidence Levels
USDA	U.S. Department of Agriculture
UST	Underground Storage Tank
VOC	Volatile Organic Compound
VOCs	Volatile Organic Chemicals

WQS	Water Quality Standard
WRS	Wilcoxon Rank-Sum

1.0 PROJECT DESCRIPTION

This Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Phase III investigation is being conducted in accordance with applicable RCRA Corrective Action requirements, including the need for RFIs to be conducted at the Naval Surface Warfare Center (NSWC) Crane, Crane, Indiana. Investigation requirements are specified in the NSWC Crane RCRA hazardous waste management permit originally issued on December, 29 1989 and renewed on September 14, 1995 (U.S. EPA, 1995), and approval letters issued by U.S. EPA Region 5 for two RFIs conducted at the Ammunition Burning Grounds (ABG), which is also known as solid waste management unit (SWMU) 03/10. The approval letters were issued by U.S. EPA Region 5 for the final report titled RFI Phase II Surface Water Release Assessment Report for SWMU 03/10 Ammunition Burning Ground (U.S. EPA, 1999) and the final report titled RCRA Facility Investigation Phase III Ground Water Release Characterization Report, dated May 1994 (U.S. EPA 1999a). This investigation will provide data on select organic and inorganic chemical concentrations in surface soils, subsurface soils, sediment, surface water and ground water at two Areas of Concern (AOC) located within the ABG: the Jeep Trail and Little Sulphur Creek. The Jeep Trail is inactive. While some samples will be taken within the ABG Treatment Unit boundaries, these samples will be used to assess the impact of surface soil washout into Little Sulphur Creek. This investigation is intended to address the potential risks associated with the ABG Jeep Trail and Little Sulphur Creek only.

Open burning treatment took place at two adjacent locations at the Jeep Trail. In one location, the Burn Area, bomb casings containing explosive residues were open burned using black powder to remove any explosive residues. In the second location (the Burn Pit), explosive-contaminated materials including small munitions items and components, solvent contaminated rags and packaging material were burned using wood dunnage in a pit. Ash was periodically removed from the pit and taken to the main ABG treatment area for disposal. The pit was closed by removal of ash and backfilling with dirt. No other removal action took place. Ground water monitoring and soil sampling have taken place at the Jeep Trail. The monitoring data show that chlorinated solvents, explosives, and metals were detected in the ground water and soils (Tetra Tech NUS, 1999).

Little Sulphur Creek receives runoff from the main ABG treatment area and the Jeep Trail. Until the early 1990s, the main ABG treatment area and surrounding areas were kept free of vegetation. During precipitation events, ABG surface soil eroded into Little Sulphur Creek. The Phase III Soils RFI conducted by the U.S. Army Corp of Engineers (U.S. ACE) (U.S.ACE, September 1998) showed that the soils contained explosives and metal contaminants. The Phase III Ground Water RFI (U.S. ACE, 1994) showed that explosives, solvents, and metals have contaminated the ground water underlying the main

ABG treatment area. This ground water is in a karst system that discharges to Spring A, which then drains into Little Sulphur Creek.

Additional details on historical site operations are provided in Section 1.3 of this Quality Assurance Project Plan (QAPP).

PROJECT PROBLEM STATEMENT

Because of known, operationally related chemical releases at the Jeep Trail and into Little Sulphur Creek (explained below), human and ecological receptors could be exposed to unacceptable health risks. The health risks are 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) are anticipated.

The degree of risk to a human or ecological receptor is determined based on the nature of contamination and the frequency, duration, and nature of exposure to contaminants. Consequently, it is important to understand where receptors could be exposed to the contaminants. This requires that the extent of contamination be established. In this context, extent will be established relative to numerical risk-based criteria. A risk evaluation must be conducted for human and ecological receptors in contaminated areas to determine whether risks posed by exposure of those receptors to site contaminants are unacceptable. Plausible land use scenarios must be considered when identifying the receptors that could be at risk.

1.1 INTRODUCTION

NSWC Crane is an U.S. Navy installation located within U.S. Environmental Protection Agency (EPA), Region 5. Tetra Tech NUS, Inc. (TtNUS) has prepared this QAPP on behalf of the U.S. Navy Southern Division Naval Facilities Engineering Command (SOUTHDIV) and NSWC Crane to comply with U.S. EPA Region 5 requirements. Those requirements and guidance, described in Section 1.1.3, govern all aspects of RCRA environmental investigations. In accordance with those requirements, project planning followed the U.S. EPA Data Quality Objectives (DQO) process (U.S. EPA, 1999b). That process requires explicit statements of the problem to be solved, the spatial and temporal boundaries related to the problem, the measurements to be made in solving the problem and, when applicable, quantitative specifications of the tolerances for making decision errors. It culminates in a specification of decision rules and in a sampling and analysis plan designed to solve the stated problem.

This QAPP presents the project organization, objectives, planned activities, and specific quality assurance/quality control (QA/QC) procedures associated with sample collection and analysis for the investigation. Specific protocols for sample collection, sample handling and storage, chain of custody, chemical analyses, and data evaluation and assessment are described. These protocols are specified to assure that the data generated during this investigation are of the expected quality necessary to support project objectives.

This QAPP was prepared under Contract Number N62467-94-D-0888, Contract Task Order (CTO) Number 0126.

1.1.1 Project Objectives and Decision Statement

Past sampling, although limited, identified the presence of select contaminants at concentrations greater than proposed risk-based target levels (RBTLs) at the Jeep Trail and Little Sulphur Creek. RBTLs are further discussed in Section 1.4.1.2. Previous sampling has not been adequate to delineate the extent of contamination. This investigation is designed to further delineate the nature and extent of contamination in surface water, ground water, soil, and sediment. It is also designed to provide information to implement a baseline human health risk assessment and a screening-level ecological risk assessment, including Navy Step 3A (see Section 1.4.3). Because of these two general objectives, two decision statements have been developed for this project, each of which applies to multiple environmental media and each of which applies to both the Jeep Trail and Little Sulphur Creek. The decision statements that will facilitate attainment of the project objectives are as follow:

From ground water, spring, surface water, soil, and sediment data, determine the nature and extent of chemical contaminant concentrations that exceed applicable screening levels in each environmental medium (surface soil, subsurface soil, sediment, ground water, surface water and spring water). If concentrations exceeding screening levels are found, proceed to risk assessments; otherwise take no further action.

Determine whether contamination associated with the Jeep Trail and Little Sulphur Creek poses an unacceptable risk to human or ecological receptors through the use of a baseline human health risk assessment and a screening-level ecological risk assessment. If human health risks are unacceptable, consider implementing a Corrective Measures Study (CMS) to evaluate options for reducing the risk to acceptable levels. If ecological risks are unacceptable consider conducting a baseline ecological risk assessment or a CMS to reduce risk to acceptable levels. If risks are acceptable, take no further action.

1.1.2 Project Status/Phase

At least one round of sampling is expected for this investigation, with additional sampling rounds possible to determine the extent of contamination. The need for additional sampling rounds will depend on whether the extent of contamination is established within prescribed bounds during the first and subsequent sampling rounds. The strategy for all sampling rounds is similar when establishing extent of contamination. Chemical concentrations will be compared to appropriate RBTLs and background (or upgradient/upstream) concentrations to identify chemicals of potential concern (COPCs). The spatial regions in soils and ground water over which the COPC concentrations are greater than acceptable human health risk levels will be bounded. Appropriate risk-based concentrations and background (upstream/upgradient) concentrations are described in Sections 1.1.3 and 1.4.1, 1.4.2, and 1.4.3. For surface water and sediment, establishing nature and extent of contamination will depend on the availability of surface water and sediment, because water is ephemeral (in certain sections of Little Sulphur Creek) and the drainage channels are well scoured.

The data analyses and approach to reconciling data with project objectives are described in Section 12.4 and throughout this document. Section 4 presents the sampling plan design and rationale for the number of soil, surface water, ground water, and sediment samples for this project.

1.1.3 QAPP Preparation Guidelines and Requirements

This QAPP has been prepared in accordance with the "U.S. EPA Region 5 QAPP Policy" (U.S. EPA, 1998a), which includes instructions for preparing RCRA Subtitle C corrective action investigations including RFIs. The "Example RCRA QAPP," included in the policy (U.S. EPA, 1998a), was followed. Also followed for establishing the QA/QC requirements specified in this QAPP was the Naval Facilities Engineering Service Center (NFESC) guidance document entitled "Navy Installation Restoration Laboratory Quality Assurance Guide" (NFESC, 1996). The NFESC guidance specifies criteria for acceptable laboratory performance and monitoring of that performance. U.S. EPA human health risk-based screening levels (RBSLs) and ecological data quality levels (EDQLs) were considered in developing this QAPP, especially when selecting sampling and analytical methods to measure target analyte concentrations in the media of interest. All QA/QC procedures are structured in accordance with applicable U.S. EPA Region 5 requirements, regulations, guidance, and technical standards.

Additional guidance regarding development of this QAPP was obtained through a formal "pre-QAPP" meeting held on 13 July 2000 via conference call. Representatives from U.S. EPA Region 5, SOUTHDIV, NSWC Crane, Indiana Department of Environmental Management (IDEM) and TtNUS participated in the

pre-QAPP conference call to introduce and discuss technical issues associated with QAPP preparation. The analyte lists were discussed, and the overall technical approach was agreed upon with minor changes. U.S. EPA Region 5 provided written comments via electronic mail on July 14, 2000. These comments have been addressed in this document.

Comparability of soils inorganic chemical data between this investigation and the "Base-wide Background Soil Investigation for NSWC Crane" (Tetra Tech NUS, 2000) is important to interpreting the data and making background comparisons. Therefore, Jeep Trail soil samples will be treated in a manner similar to those collected for the background investigation. Data comparability is discussed further in other sections of this QAPP.

1.1.4 Organization of the QAPP

This QAPP follows the U.S. EPA Region 5 model QAPP format with minor exceptions (U.S. EPA, 1998a). An effort has been made to ensure that the flow of information from one section to another is logical, while adhering to U.S. EPA Region 5 requirements. The Table of Contents provides an overview of the document organization. Tables and figures are placed at the end of each section in which they are first referenced.

1.2 SITE/FACILITY DESCRIPTION

This section is a presentation of background information, general site characteristics of the NSWC Crane facility, and physical site characteristics specific to the ABG and the AOCs, which are the focus of this investigation (Jeep Trail and Little Sulphur Creek). Information is also provided on the ABG Treatment Area. Part of this investigation will involve determining the potential impact of runoff of surface soils and sediments into Little Sulphur Creek. The ABG Treatment Area is not considered as a separate AOC in this investigation, but some samples will be taken from within its boundaries. A decision has already been made to remediate contaminated soils and ground water at the ABG (EPA 1999e). Remediation at the Jeep Trail or Little Sulphur Creek may also be required if unacceptable risk to receptors is associated with these AOCs. A corrective measures study (CMS) will be conducted to address remediation of unacceptable risk to receptors as necessary. The CMS will address corrective measures for all three AOCs. This section contains information on topics including site location, facility size and borders, natural and manmade features, climatology, topography, local hydrology and hydrogeology, surrounding land use, and ecological communities and habitats.

1.2.1 Location and Description

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. A location map of the NSWC Crane facility is provided as 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 ABG study area is located in the eastern portion of the installation and consists of two AOCs: Little Sulphur Creek and the Jeep Trail. These two AOCs all lie within the Sulphur Creek Complex Drainage Basin, which is one of five drainage basins that 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 (Figures 1-2 and 1-3).

Little Sulphur Creek is approximately 4.6 miles long from its northernmost headwaters to its intersection with Sulphur Creek south of the installation (Figure 1-3). The creek consists of a north and a south fork from the headwaters to approximately the center of the ABG Treatment Area (Figures 1-4 and 1-5). From the ABG, a single channel meanders south a distance of approximately 0.5 miles past the Jeep Trail (located approximately 100 feet east of the channel, see Figure 1-6), and continues another 0.6 miles until reaching the southern installation boundary. (Figure 1-6 shows the Jeep Trail as "Jeep Trail-25.") Several tributaries discharge into Little Sulphur Creek, including the Johnson Hollow tributary, which intersects with Little Sulphur Creek at the southern NSWC Crane boundary.

1.2.2 Land Use Classification

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, 2000). Because most of the region is covered by vegetation, the area is classified as rural (TtNUS, 2000).

There is no state or local planning within the vicinity of NSWC Crane. The only zoning and land use regulations are in the municipalities in the region. None of the municipalities are close enough to 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 (TtNUS, 2000).

1.2.3 Climatology 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 1-7 is a wind rose summarizing the wind direction and mean wind speed distribution for the Indianapolis International Airport over a 5-year period (1985-1989).

1.2.4 Physiography, Topography and Ground Cover

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 sinkholes and karst topographic features. 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 and on 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 is predominantly rolling with moderately incised stream valleys throughout, and occasional flat areas in the central and northern portions of NSWC Crane. 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 ABG Study Area is characterized by rugged relief, with ground surface elevations approaching 800 feet amsl in the headwaters of Little Sulphur Creek. Along the Jeep Trail, ground surface elevations are approximately 500 feet amsl; and ground surface elevations are approximately 480 feet amsl where Little Sulphur Creek exits the southern border of the installation.

The ABG treatment area is essentially devoid of vegetation, to minimize the potential for fires during open burning treatments. However, areas along Little Sulphur Creek have been seeded with grass to minimize erosion of soil into Little Sulphur Creek. The Jeep Trail is located in a gravel-covered area on the west side of the gravel access road (termed "Jeep Trail") where the road widens in excess of 50 feet. The Jeep Trail and remainder of the Little Sulphur Creek valley are surrounded by wooded areas along the hillsides to the east and west, with miscellaneous natural ground vegetation under the canopy and along the creek banks.

1.2.5 Geology and Stratigraphy

The unconsolidated overburden deposits at NWSC Crane generally range from 0 feet to 65 feet thick (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). 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), which is underlain by 42 to 48 inches of mottled tan, gray, and yellow clay with varying percentages of sand and silt. Occasionally, a clay hardpan occurs between 25 and 32 inches below ground surface (bgs).

Bedrock underlying the Crane facility consists of sedimentary rocks from the Lower Pennsylvanian-age Mansfield Formation (Raccoon Creek Group) and the Upper Mississippian-age Stephensport and West Baden Groups (Figure 1-8). The Mansfield Formation (uppermost bedrock) consists of alternating beds of shales (e.g., black shale and carbonaceous shale), sandstone, mudstone, siltstone, and thin discontinuous coal units and is typically about 110 feet thick or more (USACE, 1991). The Stephensport Group includes a number of sandstone and limestone formations, including the Big Clifty Sandstone and the Beech Creek Limestone. The Stephensport Group is generally 120 to 190 feet thick. The underlying West Baden Group also consists of limestone, shale, and sandstone units, and is generally 70 to 150 feet thick.

The Mansfield Formation of the Pennsylvanian Raccoon Creek Group occupies the higher elevations surrounding the ABG treatment area (Figure 1-9). Within the Little Sulphur Creek valley floor, which covers a portion of the ABG treatment area and the Jeep Trail, is up to approximately 15 ft of alluvial (stream-deposited) and colluvial (slope debris) soils overlying bedrock. The Big Clifty sandstone, and the lower Beech Creek limestone formation underly the alluvium / colluvium at the ABG treatment area and

along the valley slopes adjacent to the Jeep Trail Site, respectively. Immediately beneath the Jeep Trail site, the Beech creek limestone is eroded away and the alluvium / colluvium is in direct contact with the underlying Elwren Shale. Figure 1-10 is a geologic profile of the Jeep Trail Site

1.2.6 Hydrology and Hydrogeology

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, where they eventually drain into the East Fork of the White River and then to the Wabash River to the southwest. Figure 1-2 shows the basins and drainages of NSWC Crane. The ABG study area lies within the Sulphur Creek Drainage Basin, which discharges into the east fork of the White River, ultimately discharging into the Wabash River. The Sulphur Creek basin drains roughly 30 percent of NWSC Crane.

Ground water in the unglaciated southwestern portion of Indiana is generally contained in fractures and joint openings of limestone and sandstone aquifers. Aquifers are generally isolated from one another vertically by less permeable shale and siltstone units. Ground water enters the aquifers as infiltration through outcrops, and flows by gravity down the dip of the strata or locally in directions controlled by the potentiometric gradients.

Four geologic formations important to the hydrogeological investigation of the ABG study area comprise three aquifers, the Golconda-Haney limestone (the upper aquifer), the Big Clifty sandstone/Beech Creek limestone (the middle aquifer), and the Beaver Bend limestone (the lower aquifer). The Golconda-Haney and Big Clifty/Beech Creek aquifers are interconnected, forming the uppermost aquifer. The middle aquifer is the most significant aquifer of interest, as it immediately underlies the AOCs in this investigation.

Three shale formations beneath the ABG study area are important aquicludes (deterrents to vertical movement of ground water and contaminants). The Indiana Springs shale, the 20-feet-thick upper member of the Big Clifty Formation, underlies the Golconda-Haney limestone in the western half of the ABG study area, but has been removed by erosion in the eastern half. The Elwren shale is 20 feet thick and occurs at the base of the Beech Creek limestone. The Sample Formation is a 40- to 45-feet-thick black shale below the Elwren.

As previously discussed, a total of three aquifers are of interest in the ABG study area, consisting primarily of sandstone and limestone. These aquifers are separated by shale aquicludes. The upper

aquifer, which includes the Golconda/Haney limestone, is exposed in outcrops on the hillsides surrounding the ABG study area, at an elevation above any known treatment activities in the ABG study area. Therefore, the potential for contamination in this aquifer from the ABG study area is believed to be low. The Golconda/Haney limestone is underlain by the Indian Springs shale aquiclude. Ground water from the Golconda/Haney flows into the ABG by seepage eastward along the top of rock, prevented from vertical infiltration by the underlying Indian Springs shale. Hunt (1988) showed that ground water seeping from the Golconda/Haney within the ABG eventually infiltrates the Big Clifty/Beech Creek (middle) aquifer, which would be expected since the Indian Springs shale has been eroded in the eastern portion of the ABG study area. There was no evidence that possible contaminants entering the Golconda/Haney aquifer would exit the ABG other than through the middle aquifer system.

The Big Clifty sandstone is 40 feet thick and is hydraulically connected to the Beech Creek limestone, which are 18 to 22 feet thick at the ABG treatment Unit. The Beech Creek limestone contains joints and bedding planes, which have been widened by solution of the limestone by ground water moving through the formation. Some of the solution zones have been enlarged by collapse of Big Clifty sandstone and Beech Creek limestone into the solution voids. The Big Clifty sandstone and Beech Creek limestone are considered one aquifer (the middle aquifer). In addition, the Big Clifty sandstone and Beech Creek limestone are eroded away in some areas beneath the Jeep Trail where the alluvium/colluvium is in direct contact with the Elwren Shale.

The Beaver Bend limestone is 10 to 12 feet thick and comprises the lower aquifer. The Beaver Bend is considered to be isolated hydraulically from the higher aquifers in the ABG study Area. The Beaver Bend is reported to be artesian, and flows in a southerly direction.

Shallow ground water flow patterns are expected to mimic topography; highest ground water elevations are typically found along ridge crests, and ground water flow is toward the major stream or tributary valleys. Recharge to the shallow ground water system occurs over most of the uplands and sideslopes. Ground water moves downward and then laterally, where it discharges to the deeper stream valleys as springs, seeps, and baseflow.

The shallow ground water exists where the alluvium/colluvium is thick in the valley floors of the ABG study area, and is encountered at depths less than 10 feet beneath the ground surface. Ground water is not found in unconsolidated material where the alluvium/colluvium thins along the hills surrounding the ABG Study Area, but is found in the underlying bedrock formations. Although the shallow ground water flow direction is expected to mimic topography flowing from the hillsides toward the valley floor, it would be expected that ground water, once in the limestone and sandstone, would migrate down dip, and along

bedding planes, joints, and solution channels; until reaching a less permeable shale layer. The ground water would then flow laterally along the dip of the shale until reaching joints, allowing the ground water to migrate downward into the next bedrock unit. Regional ground water flow direction in the middle aquifer, which is the primary bedrock aquifer of interest in the study area, is reported to be in the direction of the Little Sulphur Creek Valley (see Figure 1-11). A potentiometric surface contour map has been developed for the Jeep Trail Site (Figure 1-12), which shows radial ground water flow away from the site in a east, south, and west direction.

The interaction between the surface waters of Little Sulphur Creek and the ground water also affect the hydrogeologic regime of the ABG study area. As evidenced during a site visit conducted in May 2000, Little Sulphur Creek surface water flows through the ABG treatment area, while continually seeping into the underlying leaking Big Clifty sandstone and Beech Creek limestone formations. Ultimately, surface water flow diminishes, leaving a dry creek bed further downstream of the ABG Treatment Unit and continues downstream, along and beyond the Jeep Trail. The surface water infiltrates into, and becomes ground water, which continues to flow along the preferential pathways previously identified. Surface water flow returns to Little Sulphur Creek further downstream of the Jeep Trail site in the form of springs caused by ground water discharge.

The Beach Creek (middle) aquifer is comprised of a karst system. Several studies, including a quantitative dye tracer test (Baedke, 1998) have been conducted to evaluate ground water flow in the karst system. The dye was injected into well 03-C02P2, located at the ABG treatment area, and springs throughout the Little Sulphur Creek valley were monitored for the presence of dye and for discharge in selected springs. The study concluded that the karst system discharged into one outlet, the spring A and A' complex, with little or no dye observed in the other springs. This study indicates that ground water flow from the ABG treatment area at the injection point is confined to this major conduit system that discharges to the Spring A - A' outlet. It would also be expected that a karst system beneath the Jeep Trail would also discharge to one of the spring outlets in the Little Sulphur Creek Valley.

The natural geochemical composition of the ground water in the three aquifers of interest at the ABG study area has been characterized. Information on the geochemical characterization of the ABG aquifers was obtained in studies conducted by the University of Indiana at the ABG (Baedke, 1998). The (upper) Golcany-Haney aquifer ground water chemical character is Ca^{2+} HCO_3^-. The prevalent "natural" chemical character of the (middle) Beech Creek aquifer ground water is Ca^{2+} + Mg^{2+} HCO_3^-, which is expected from a carbonate terrain. The determination of chemical character of the Beech Creek aquifer is complicated by a plume of Mg^{2+} and SO_4^{2-} from past practices and the presence of Na^+, K^+, and Cl^- in

wells near roads where salting occurs in the winter. The prevalent chemical character of ground water in the (lower) Beaver Bend aquifer is Na^+ HCO_3^-. The chemistry of ground water from the Beaver Bend aquifer is distinctly different from the other aquifers. This difference in chemistry demonstrates that the Beaver Bend aquifer is not interconnected with the Beech Creek aquifer system.

1.3 FACILITY HISTORY AND BACKGROUND

This section provides an overview of the site operations, and summarizes past environmental investigations at the ABG, including the two AOCs, which are the subject of this QAPP and the ABG treatment area. An evaluation of historical data gathered from past investigations is also provided.

1.3.1 Facility Operational History

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, Lake Greenwood 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—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 Crane tenant to accomplish this task for Naval ammunition. In 1992, based on changing missions and alignment, the facility name was changed to the Naval Surface Warfare Center (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 resides on base, Crane serves a modern and sophisticated Navy as a recognized leader in 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, including the Coast Guard and the Defense Reutilization and Marketing Operations (DRMO).

1.3.2 Ammunition Burning Grounds Operational History

The ABG has been used for treatment since the 1940s. The burning ground is used extensively for destroying unwanted materials contaminated with explosives, bulk explosives and propellant, rocket motors, pyrotechnic candles, flares, organic solvents, detonators, and fuse materials. Several separate burning areas are located within the site proper.

The largest quantities of materials were treated at the main treatment area from 1956 to 1960, when 15,000 pounds per day of smokeless powder was flashed. In the same period, about 46,000 pounds per day of high explosives were burned. The area is also used for flashing the residue from bombs and projectiles after they have been subjected to melt-out or drill-out operations for the removal of the bulk of the explosive (Murphy, 1992).

Prior to construction and use of steel pans (lined and unlined) for open burning operations, explosives and propellants and explosive/propellant contaminated materials were spread and ignited on pads or in pits at the main treatment area of the ABG. These burn pads and pits were reportedly in the area now occupied by the clay-lined steel burn pans shown as the Main Burn Pad Grid in Figure 1-13.

Three unlined surface impoundments were used to remove liquids from otherwise combustible sludges resulting from the blending and loading of munitions. In 1982, each impoundment was modified to include a liner and leachate collection system. Each of the impoundments was approximately 40 feet in diameter. The locations of the former impoundments are shown as open circles (Areas 6) on Figure 1-11. The two adjacent impoundments held TNT, RDX, and breakdown compounds in water from Rockeye and other locations within NSWC Crane. A third impoundment held phosphorus compounds. The three impoundments have been replaced by the dewatering units, shown as Areas 10 and 11 on Figure 1-13. The impoundments are now empty and scheduled for closure.

Two empty underground storage tanks (USTs) were used to store runoff and leachate from the three Area 6 impoundments. One tank was located immediately east of the phosphorus impoundment. The other tank (Area 6A) contained runoff from the two adjacent TNT and RDX impoundments. The tanks were removed in 1994 and are currently undergoing closure pursuant to a RCRA closure plan.

The area labeled "Ash Pile" on Figure 1-13 is the site of a former stockpile of burn residue. The pile was removed between July 1986 and February 1987 pursuant to a RCRA closure plan. The pile consisted of approximately 12,290 pounds of burn residue. The function served by the former Ash Pile has been replaced by the use of tarped ash roll-off boxes.

Prior to approximately 1985, pink water sludge was placed and burned in an unlined pit in the location of the Pink Water Tanks (see Area 13 on Figure 1-13). This flashing process was relocated to the burn pads in approximately 1985. The pink color of the water and sludge is caused by the presence of explosives and related chemicals.

The former primer burn box (see Area 11 on Figure 1-13) was used for thermal treatment of ammunition components (for example, small impact-sensitive primers) and pyrotechnic munitions. The burn box has been decommissioned, and these activities are now performed at the Primer Pit (Area 12 on Figure 1-13) and the Incendiary Cage (Area 13 on Figure 1-13).

Current operations at the ABG include:

- Solid bulk propellant and explosives are open burned in 18 clay-lined steel pans at the ABG.
- The primer pit operation involves treatment of small explosive components such as hand grenade fuses and cartridge primers.
- Solvents contaminated with propellants, explosives, and pyrotechnics (PEP) are burned in one unlined steel pan at the ABG.
- Waste scrap pyrotechnics which have been desensitized in No. 2 fuel oil are burned in a second unlined steel pan at the ABG.
- A third pan is used for the burning of scrap black powder desensitized with water.

- Two sets of four pans each are used at Area 6 (see Figure 1-13) for the treatment of a waste mixture containing red phosphorus and No. 2 fuel oil.

- The incendiary cage at the ABG is set up primarily to allow the open burning of pyrotechnic devices and components.

- The flashing and thermal treatment of suspect explosive-contaminated materials is carried out at three concrete-lined burn pads at the ABG.

- Explosive- and pyrotechnic-contaminated sludges from production operations are treated at thee sludge burning pans. RDX-contaminated sludge and phosphorus-contaminated sludge are currently burned at this unit.

1.3.3 Jeep Trail Operational History

From the mid-seventies through 1983, the Jeep Trail Area was used to burn-out bombs and flash powder. The treatment of materials was accomplished at two separate regions of the Jeep Trail Area, known as the Burn Area and the Burn Pit. At the Burn Area, bomb casings which had the bulk explosives removed were filled with initiating powder, tilted on-end towards a hillside to the east of the Jeep Trail in the direction of the adjacent hillside, and flashed to complete the demilitarization process. Some munitions are thought to have been lashed to a horizontally-positioned utility pole (which may have been creosote-treated) prior to flashing.

The Burn Pit was a trench approximately 100 feet long, 30 feet wide, and 10 to 12 feet in depth located just south of the Burn Area. Flashing of powder and burning of explosives-contaminated materials are reported to have taken place in this pit. The contaminated material may have included cardboard, paper, wood and metal packaging which may have come into contact with explosives, solvents-contaminated rags, or any other material that may have been explosives contaminated. Some of the wooden packaging material may have contained pentachlorophenol. Small munition items and components were also reportedly treated. The area has not been used for any operations since 1983. In 1983, the burn pit was filled with clean fill material.

1.3.4 Evaluation of Historical Data

As outlined previously, multiple environmental investigations and surveys have been conducted at the ABG treatment Area, Little Sulphur Creek, and the Jeep Trail. These past investigations are summarized in Table 1-1.

A multiphased Release Characterization Study (RCS) was conducted by the U.S. ACE in 1990 and 1993 to identify the nature, degree and extent of hazardous constituents in the soils, surface water, sediments, springs, and ground water at the ABG. In 1995-1997, in preparation for the CCRA, additional soil, surface water, sediment, springs and ground water samples were taken to supplement the 1990 and 1993 samples.

Much of the historical data (pre-1995) were collected through programs, which did not require independent data validation. Thus, most of these data had never undergone validation to the extent necessary for use in a risk assessment. USEPA reviewed select data packages from these historical databases in 1997 and concluded that much of the 1990 and 1993 data could not be used for risk assessment purposes due to a lack of QC package information. All of the 1995-1997 data were found to be acceptable for use in risk assessments, since they were independently validated.

The following sections describe the available historical data for each medium.

1.3.4.1 Soil

In 1990, 12 soil borings were made at the ABG (none at the Jeep Trail Area), with samples taken from the following depth intervals at each boring: 3-6 inches, 12-18 inches, 18-24 inches, 36-42 inches, and 6 inches above bedrock. According to the U.S. EPA technical memorandum (U.S. EPA, 1997), only the explosives data were deemed acceptable for use in risk assessments for this sampling event. Tables 1-2 and 1-3 presents a summary of the explosives data, showing that 2-AmDNT, 4-AmDNT, TNT, tetryl, DNB, TNB, RDX and HMX were found in the highest concentrations at the ABG. The data are presented in Appendix A.

In 1993, an additional 33 surface soil grab samples were taken, along with another 32 soil borings, as part of the Part II RCS. Samples were taken from depths of 1-30 inches, 30-60 inches, 60-90 inches, and/or at refusal. These samples were not analyzed for explosives. All other analytical data from these samples were found to be unacceptable for use in risk assessment by the U.S. EPA (U.S. EPA, 1997).

It was noted in the original review of the historical data in 1993 that none of the soil samples previously collected at ABG by U.S. ACE were analyzed for chlorinated dioxins and furans, and that no soil samples had been collected from the Jeep Trail. In 1995, three surface soil samples from around the burn pans and pads were collected and analyzed for PCDD/PCDF, and five surface soil samples were collected from the Jeep Trail and analyzed for explosives, inorganics, and semivolatile organics. All of these data were determined to be acceptable for use in risk assessments by the U.S. EPA (U.S. EPA, 1997). A summary of these data is found in Tables 1-2 and 1-3. The data are presented in Appendix A.

Based on the data validation findings on the historical data for this medium, another round of supplemental surface and subsurface soil samples was taken in 1997. Twenty-one (21) surface soil and five subsurface soil samples were collected at a subset of the previous sampling locations. All of these samples were analyzed for inorganics; seven were analyzed for semivolatile and volatile organics and pesticides. These data are summarized in Tables 1-2 and 1-3.

1.3.4.2 Surface Water/Sediment

Surface water and sediment sampling in Little Sulphur Creek was also conducted near the ABG as part of the RFI that was prepared by U.S. ACE (Murphy, 1992). Eleven locations were selected by U.S. ACE for two sampling events: three upstream (background) samples, three on-SWMU locations, and five locations situated progressively downstream of the ABG (and ultimately downstream of the Jeep Trail). Based on the U.S. EPA technical memorandum on data validation (U.S. EPA, 1997), only the explosives data collected for these samples was determined to be acceptable for risk assessments. Three explosives (2,4-DNT, HMX and RDX) were detected in the downstream surface water samples. The greatest frequency of surface water detections, as well as the greatest parameter concentrations, occurred in two samples directly downstream of the Jeep Trail Area. A summary of the data is presented in Table 1-4. The data are presented in Appendix A.

Based on the original review conducted in the historical data, several new sampling locations along Little Sulphur Creek were recommended for sampling, specifically to address potential impacts near the Jeep Trail Area. Two downstream samples near the Jeep Trail Area and three additional upstream samples were collected in 1995, and analyzed for inorganics, volatile and semivolatile organics, explosives and pesticides. The data are summarized in Table 1-4. The data are presented in Appendix A.

After the samples were collected in 1995 four additional samples were collected in 1997 to fill data gaps resulting as a consequence of the 1997 U.S. EPA Technical memorandum. All four samples were analyzed for inorganics, three for pesticides, and two for volatile and semivolatile organics. All sediment

samples were also analyzed for explosives. Table 1-4 also summarizes these data. The data are presented in Appendix A.

1.3.4.3 Springs

In 1990, as part of the U.S. ACE RFI, seven springs were sampled for water quality parameters (see Figure 1-4). One of these springs (Spring A) was sampled a seventh time. According to the U.S. EPA (U.S. EPA, 1997), only the explosives analyses from these samples were found to be acceptable for risk assessments.

Since the 1990 RFI, Springs A, B and C have been sampled four additional times: twice in 1993, once in 1994, and once in 1995. Only the 1994 data were found to be acceptable for risk assessments. Parameters analyzed for in this sampling event included inorganics, explosives, volatile and semivolatile organics, and pesticides. Table 1-5 presents a summary of the analytical data. The data are presented in Appendix A.

In 1995, additional sampling was conducted to fill data gaps for the CCRA. Spring A was selected for sampling for inorganics, volatile and semivolatile organics, and explosives. Springs B and C were selected for sampling for metals, cyanide, semivolatile organics and explosives. Two off-facility springs (Springs 8 and 10) were selected for sampling for inorganics, explosives, volatile and semivolatile organics, and pesticides/PCBs. A summary of these data is presented in Table 1-5. The data are presented in Appendix A.

No additional supplemental sampling of springs was necessary as a consequence of the 1997 USEPA Technical memorandum.

1.3.4.4 Ground Water

A total of 98 monitoring wells exist at the ABG. Sampling has been performed on a sporadic basis at 71 of these wells since 1987. The four main aquifers and/or geologic units at ABG are (from the deepest to the shallowest):

- Beaver Bend limestone
- Big Clifty sandstone/Beech Creek limestone
- Golconda limestone
- Alluvium

Following is a discussion of the sampling and analyses performed for each aquifer at the ABG.

1.3.4.4.1 Beaver Bend

The Beaver Bend aquifer is the deepest ground water unit that is currently monitored at the ABG. Five wells exist for this aquifer. Sampling of these wells has occurred over an 8 year period. Based on U.S. EPA's data review (U.S. EPA, 1997), the only valid historical sampling and analysis data for the Beaver Bend wells are those from 1993 at three wells (03C03, 03C08A, and 03C09). The 03C01 well was sampled again in 1997 as a result of these findings. Data for the acceptable analyses are presented in Tables 1-6 and 1-7.

Quarterly sampling has also been performed at one Beaver Bend well at the ABG as part of the ABG Ground Water Monitoring Program. This program began in the fall of 1998, and to date, four quarters of data have been collected for the ABG wells. The samples have been analyzed for inorganics, volatile organics, and explosives. A summary of these data is also provided in Tables 1-6 and 1-7. The data are presented in Appendix A.

1.3.4.4.2 Beech Creek/Big Clifty

The majority of the wells at the ABG are screened in the Beech Creek/Big Clifty Ground Water unit. Sixty-two (62) wells make up the monitoring network for the Beech Creek aquifer. While sampling and analysis of these wells has occurred frequently since 1987 as part of various investigations, only the data from one event in 1993 (23 wells) were found to be acceptable for risk assessment use prior to 1995.

Based on the original data review for the CCRA, sixteen wells were sampled to supplement the original data (including 15 wells in the vicinity of the Jeep Trail Area). Also, based on the data validation findings, five additional wells for the Beech Creek aquifer were resampled in 1997. Data from all acceptable analyses are summarized in Tables 1-6 and 1-7. The data are presented in Appendix A.

As part of the quarterly monitoring at selected ABG wells, fifteen Beech Creek monitoring wells have been monitored quarterly since Fall 1998. The samples have been analyzed for inorganics, volatile organics, and explosives. A summary of these data is also provided in Tables 1-6 and 1-7. The data are presented in Appendix A.

1.3.4.4.3 Golconda

The Golconda limestone occurs near the northern, southern and western edges of the ABG. This unit has been removed by erosional processes in the central portions of ABG, and in the valleys of Little Sulphur Creek and Johnson Hollow. Historical (pre-1995) data exist for all of the Golconda wells at ABG, and for the three off-SWMU wells screened in this formation, but none of the pre-1995 data were found to be acceptable for risk assessment use.

As a result of these data validation findings, three wells screened in the Golconda formation were resampled in 1997. A summary of the findings is presented in Tables 1-6 and 1-7. The data are presented in Appendix A.

No Golconda formation wells at the ABG are included in the ABG Ground Water Monitoring Program.

1.3.4.4.4 Alluvium

Since 1992, only a few alluvial wells have been sampled. The acceptable historical database for these wells (based on the U.S. EPA technical memorandum) includes the single well sample (03B02) obtained in 1993. In 1997, two additional alluvial wells were sampled as a consequence of the U.S. EPA memorandum. Tables 1-6 and 1-7 presents a summary of the data for these wells. The data are presented in Appendix A.

Two alluvial wells are included in the ABG Ground Water Monitoring program. The samples have been analyzed for inorganics, volatile organics, and explosives. A summary of these data is also provided in Tables 1-6 and 1-7. Organic positive detections in ground water for the Jeep Trail Site are shown on Figure 1-14 and will be used to support the ground water investigation rationale discussions in Section 4. The data are presented in Appendix A.

1.3.5 Current Little Sulphur Creek Site Status

Runoff from the ABG soils is a concern for Little Sulphur Creek. Prior operational practices no longer in use (i.e., thermal treatment of explosives directly on the ground) have resulted in contamination of the surface soils with metals and explosives. These contaminants may migrate to Little Sulphur Creek during large-scale rain events. Additionally, contaminated ground water may recharge the creek via the springs.

1.3.6 Current Jeep Trail Site Status

The Jeep Trail is no longer an operational area at the ABG. The Burn Pit has been backfilled with clean material. However, historical practices may have resulted in contamination of the soil and ground water in the Jeep Trail area with explosives and metals as indicated by historical data. Infiltration of rainfall into the ground water through contaminated soils may result in further contamination of the ground water (and subsequently Little Sulphur Creek by leaching contamination from the soil).

1.4 INTENDED DATA USES

This section provides a detailed description of the project target parameters and intended data uses.

1.4.1 Project Target Parameters and Rationale for Selection

Key target parameters for the Jeep Trail and Little Sulphur Creek for each media were selected based on historical activities, types of contaminants that may have been released as a result of the activity conducted, and available historical monitoring data.

Jeep Trail

Open burning treatment took place at two adjacent locations at the Jeep Trail. Ground water monitoring and soil sampling have taken place at the Jeep Trail. The monitoring data show that chlorinated solvents, explosives, and metals were detected in the ground water and soils (Tetra Tech NUS, 1999). Future ground water contamination could occur as the result of releases of contaminants from both the Jeep Trail Burn Area and Burn Pit soils.

Jeep Trail Burn Area – Soils

In one location, the Burn Area, bomb casings containing explosive residues were open burned using black powder to remove any explosive residues. The bomb casings may have been placed on creosote treated poles. Following are the parameters selected for analysis in soils at the Jeep Trail Burn Area and the rationales for selection of the parameters.

- SVOCs – Creosotes from the poles may have been released into the soils.
- Explosives – Untreated explosives may have been released. Explosives have been found in data from past ground water monitoring activities at the Jeep Trail.

- Nitrate/Nitrite – Residues of explosives treatment include nitrate and nitrite.

- Depositional environment and Grain Size – Provide information for potential use in corrective Measures Study and for comparison to background concentrations (for naturally-occurring inorganics).

Jeep Trail Burn Pit - Soils

In the second location (the Burn Pit), explosive-contaminated materials including small munitions items and components, solvent contaminated rags and packaging material were burned using wood dunnage in a pit. Ash was periodically removed from the pit and taken to the main ABG treatment area for disposal. The pit was closed by removal of ash and backfilling with dirt. Following are the parameters selected for analysis in soils at the Jeep Trail Burn Pit and the rationales for selection of the parameters.

- SVOCs – SVOCs may have been present in the materials treated or formed during open burning treatment.

- VOCs – Untreated solvents may have been released from solvent-contaminated rags before treatment. Data from past ground water monitoring activities at the Jeep Trail shows the presence of chlorinated solvents in ground water.

- Explosives – Explosives contained in small munitions items may have been released during open burning treatment. Data from past ground water monitoring activities at the Jeep Trail shows the presence of explosives in ground water.

- Dioxins/Furans – Burning of chlorinated solvents may have resulted in the formation of dioxins.

- Metals – Materials treated contained metals, which may have been released during the course of treatment. Data from past ground water monitoring activities at the Jeep Trail shows the presence of metals in ground water.

- Nitrate/Nitrite – Residues of explosives treatment include nitrate and nitrite.

- Depositional environment and grain size – Provide information for potential use in corrective Measures Study and for comparison to background concentrations (for naturally-occurring inorganics).

- Perchlorate – Small munitions items may have contained perchlorate.

Jeep Trail – Ground Water

Following are the parameters selected for analysis in ground water at the Jeep Trail and the rationales for selection of the parameters.

- SVOCs – SVOCs may be released into ground water from soils at the Burn Area and Burn Pit

- VOCs – Untreated solvents may be released into ground water from soils at the Burn Pit. Data from past ground water monitoring activities at the Jeep Trail shows the presence of chlorinated solvents in ground water.

- Explosives – Explosives may be released form soils at the Burn Pits. Data from past ground water monitoring activities at the Jeep Trail has shown the presence of explosives in ground water.

- Dioxins/Furans – Dioxins/Furans may be released into ground water from soils at the Burn Pit.

- Metals – Metals may be released into ground water from soils at the Burn Pit. Data from past ground water monitoring activities at the Jeep Trail has shown the the presence of metals in ground water.

- Nitrate/Nitrite – Nitrates/Nitrites may be released into the ground water from soils at the Burn Area and Burn Pit.

- Perchlorate – Perchlorate may be released into ground water from soils at the Burn Pit.

- General Water Quality Parameters (Dissolved Oxygen, Oxidation Reduction Potential (ORP), pH, Specific Conductance, Temperature, Turbidity, and Water Level) – Information on general water quality parameters is necessary to evaluate the overall quality of ground water at the Jeep Trail.

Jeep Trail – Little Sulphur Creek Surface Water and Sediment

Contaminants deposited onto surface soils at the Jeep Trail may migrate as the result of overland flow into Little Sulphur Creek, which is adjacent to the Jeep Trail. These contaminants may be present in surface water and sediments. Following are the parameters selected for analysis in surface waters and/or sediment in the portion of Little Sulphur Creek nearest the Jeep Trail.

- SVOCs (surface water and sediments) – SVOCs may be released into surface waters and accumulated in sediments.

- VOCs – (surface water and sediments) – VOCs may be released into surface waters and accumulated in sediments.

- Explosives – (surface water and sediments) – Explosives may be released into surface waters and accumulated in sediments.

- Dioxins/Furans – (surface water and sediments) – Dioxins may be released into surface waters and accumulated in sediments.

- Metals – (surface water [total and dissolved] and sediments [total]) – Metals may be released into surface waters and accumulated in sediments.

- Nitrate/Nitrite – (surface water and sediments) – Nitrates may be released into surface waters and accumulated in sediments.

- Perchlorate – (surface water and sediments) – Perchlorates may be released into surface waters and accumulated in sediments.

- General Surface Water Quality Parameters (Dissolved Oxygen, Oxidation Reduction Potential (ORP), pH, Specific Conductance, Temperature, Turbidity, and Flow Rate) – Information on general water quality parameters is necessary to evaluate the overall quality of Little Sulphur Creek surface water and provide information on contaminant masses (flow rate).

Little Sulphur Creek Surface Water and Sediment (main ABG Treatment Area)

Little Sulphur Creek receives runoff from the main ABG treatment. Until the early 1990s, the main ABG treatment area and surrounding areas were kept free of vegetation. During precipitation events, ABG surface soil eroded into Little Sulphur Creek. The Phase III Soils RFI conducted by the U.S. Army Corp of Engineers (U.S. ACE) (U.S.ACE, September 1998) showed that the soils contained explosives and metal contaminants. The Phase III Ground Water RFI (U.S. ACE, 1994) showed that explosives, solvents, and metals have contaminated the ground water underlying the main ABG treatment area. This ground water is in a karst system that discharges to Spring A, which then drains into Little Sulphur Creek.

Contaminants deposited onto surface soils may have migrated as the result of overland flow into Little Sulphur Creek from the main ABG treatment area . These contaminants may be present in surface water and sediments. Following are the parameters selected for analysis in surface waters and/or sediment in areas of Little Sulphur Creek adjacent to the main ABG treatment area and downstream of Spring A and the rationales for selection of the parameters.

- Herbicides (surface water and sediments) - Herbicides used to control vegetation at the main ABG treatment area may have been released into surface waters and accumulated in sediments.

- Pesticides/PCBs (surface water and sediments) - Pesticides/PCBs may have been released from the main ABG treatment area into surface waters and accumulated in sediments.

- SVOCs (surface water and sediments) – SVOCs may be released from contaminated soils into surface waters during storm events and accumulated in sediments.

- VOCs – (surface water and sediments) – VOCs may be released from contaminated soils into surface waters and accumulated in sediments. Data from past ground water monitoring activities at the main ABG treatment area shows the presence of VOCs in ground water.

- Explosives – (surface water and sediments) – Explosives may be released from contaminated soils into surface waters and accumulated in sediments. Data from past ground water monitoring activities at the Jeep Trail shows the presence of explosives in ground water.

- Dioxins/Furans – (surface water and sediments) – Dioxins resulting from the open burning treatment of chlorinated solvents may have released from contaminated soils into surface waters and accumulated in sediments.

- Metals – (surface water [total and dissolved] and sediments [total]) – Metals may be released into surface waters and accumulated in sediments. Data from past ground water monitoring activities at the main ABG treatment area shows the presence of metals in ground water.

- Nitrate/Nitrite – (surface water and sediments) – Nitrates may be released into surface waters and accumulated in sediments.

- Total Organic Carbon (TOC) – (surface water and sediments) – TOC content provides information for use in corroborating absence or presence of contamination and potential bioavailability.

- Depositional environment and Grain Size (sediment) – Provide information for potential use in corrective Measures Study and for comparison to background concentrations (for naturally-occurring inorganics).

- Grain Size and, Bulk Density, % of Coverage, and Average Depth (sediment) – Provide information for fate and transport.

- General Surface Water Quality Parameters (Dissolved Oxygen, Oxidation Reduction Potential (ORP), pH, Specific Conductance, Temperature, Turbidity, and Flow Rate) – Information on general water quality parameters is necessary to evaluate the overall quality of Little Sulphur Creek surface water and provide information on contaminant masses (flow rate).

Table 1-8 summarizes project target parameters for each medium (ground water, surface water, surface soil, subsurface soil, and sediment) and the associated intended data uses for the Jeep trail. Table 1-9 provides the same information for Little Sulphur Creek. The specified data uses are linked to the decision statements presented in Section 1.1.1. Data used to determine the nature and extent of contamination will also be used to evaluate human health and ecological risk.

All field and laboratory target parameter results greater than or equal to method detection limits (MDLs) will be reported. Target parameters not detected will be reported at the MDL. MDLs for field parameters are based on method or test kit capabilities and specifications. Analytical results for analytes that are less than applicable MDLs will be reported with a "U" flag. The "U" flag signifies that the parameter was analyzed for but was not detected at a concentration greater than or equal to the MDL. Analytical results that are between the MDL and the reporting limit (RL) will be reported with a "J" Flag. Laboratory MDLs

are based in part on best professional judgment and on statistical computations in accordance with 40 Code of Federal Regulations (CFR) Part 136, Appendix B. The CFR requires the MDL to be computed as the standard deviation of replicate analysis, results multiplied by the appropriate Student's t value. Refer to Laucks SOP LTL-1011 for a mathematical computation of IDL/MDL. Sample-specific laboratory MDLs will be computed for each sample to account for variations in the MDL that are caused by factors such as sample moisture content, the size of the sample aliquot used in the analysis, and dilutions.

1.4.1.1 Field Parameters

Several field measurements will be made for this investigation. As previously noted, Tables 1-8 and 1-9 summarize all project target parameters and the associated intended data uses. Table 1-10 indicates which measurements will be made in the field for aqueous samples and presents MDLs, as applicable, for the aqueous target parameters measured in the field.

1.4.1.2 Laboratory Parameters

Laboratory analyses will be used to estimate target analyte concentrations in ground water, surface water, surface soil, subsurface soil, and sediment. Use of target analyte data for decisionmaking is described in Sections 1.4.2, 1.4.3, 1.4.4, and 12.4.

Part of the data use includes comparing metal concentrations in soil at the Jeep Trail to soil background concentrations for naturally occurring metals. The background concentrations for soil types found at the jeep trail will be obtained from the "NSWC Crane Base-Wide Background Soil Investigation".

This report contains concentrations of naturally occurring metals in soil types found at the NSWC Crane SWMUs including the ABG.

The data use also includes comparing the analytical data to risk-based target levels (RBTLs), which are action levels derived from human health and ecological risk-based screening levels (RBSLs). The RBTL is the lowest (i.e., most conservative) RBSL. Following is a list of sources for the RBSLs applicable to this project:

<u>Ground Water and Surface Water RBSLs</u>

- Federal Maximum Contaminant Levels (MCLs)
- U.S. EPA Region 9 Preliminary Remediation Goals (PRGs) for Tap Water

- IDEM Tier I Default Residential and Commercial/Industrial Ground Water Closure Levels
- U.S. EPA Region 5 Ecological Data Quality Levels (EDQLs) for Surface Water
- Federal Ambient Water Quality Criteria (AWQC) for Freshwater

The same list of RBTLs will be applied to both ground water and surface water because ground water discharges to surface water in Little Sulphur Creek.

Soil and Sediment RBSLs

- U.S. EPA Generic Soil Screening Levels (SSLs) for Ingestion, Inhalation, and Migration to Ground Water
- U.S. EPA Region 9 PRGs for Residential and Industrial Land Use
- IDEM Tier I Default Residential and Commercial/Industrial Soil Closure Levels
- U.S. EPA Region 5 EDQLs for Soil (applicable to surface soil samples only)
- U.S. EPA Region 5 EDQLs for Sediment (applicable to sediment samples only)

Tabular presentations of the RBSLs are provided in Appendix B. Table 1-11 lists the laboratory parameters, analytical methods, laboratory detection and reporting limits, and RBTLs for water (applicable to both ground and surface water), soil, and sediment. MDLs are generally less than RLs. Measurement uncertainty is so great at concentrations less than the MDL that the presence of an analyte cannot be asserted with reasonable confidence in that concentration range. Thus, results less than the MDL represent analytes that are labeled as "non-detects." As concentration increases, the relative measurement uncertainty typically decreases up to the RL. Analyte concentrations greater than RLs are generally reported with a relatively high degree of accuracy (i.e., the reported value is within about 20 or 30 percent of the true value). .The uncertainty varies from analyte to analyte and is not typically quantified for individual analytes. The uncertainty associated with results between the MDL and RL is comparatively high, but also varies from analyte to analyte. This can cause problems when interpreting data, especially when comparing two values. However, the decision to report to concentrations as low as MDLs was made to provide the greatest chance for achieving the RBTLs in Table 1-11. Despite this relatively aggressive reporting convention, several RBTLs in both aqueous and solid media are still unattainable. TtNUS has worked closely with the subcontracted analytical laboratories to select and optimize analytical methods in an effort to attain, to the greatest extent possible, laboratory MDLs (or even RLs) that are less than or equal to the RBTLs. Analytes for which the MDL is greater than the RBTL for either aqueous or solid matrix are identified in Table 1-11 by shading.

1.4.2 Human Health Risk Assessment

A baseline human health risk assessment will be prepared to estimate risks to current or hypothetical future receptors at the Jeep Trail and Little Sulphur Creek. The assessment of potential contamination in Little Sulphur Creek will also consider the contribution of soil/sediment run-off from the ABG during a storm event. (A risk assessment of contaminant concentrations in environmental media at the ABG was presented in the CCRA [TtNUS, February 1999]).

This section presents an overview of the risk assessment methodology, including a conceptual site model (CSM) that will be used to evaluate chemical concentrations in environmental media obtained from the Phase III RFI at the Jeep Trail and Little Sulphur Creek. The detailed risk assessment methodology is presented in Appendix B. The methodology considers risk assessment protocols established by U.S. EPA Region 5 and the IDEM. The following components of a baseline risk assessment (BRA) are addressed:

- Data Evaluation Protocol (including data usability assessment; COPC selection)
- Exposure Assessment (including CSM)
- Toxicity Assessment
- Risk Characterization
- Uncertainty Analysis

Relevant human receptors, exposure units (EUs), and decision rules are discussed.

1.4.2.1 Data Evaluation Protocol

Data evaluation, the first component of a baseline human health risk assessment, is a two-step, medium-specific task involving the compilation and evaluation of analytical data. The first step involves the compilation of the analytical database and an evaluation of data usability for purposes of human health risk assessment. (A "data usability" evaluation is recommended in the U.S. EPA Risk Assessment Guidelines for Superfund [RAGS] Part D.) The second step of the data evaluation is the selection of a medium–specific list of COPCs, which will be used to quantitatively or qualitatively determine potential human health risks for site media. COPCs are selected based on a comparison of site contaminant concentrations to conservative toxicity screening values and background (or upstream/upgradient) concentrations. The following standards, criteria, and risk-based concentrations (RBCs) will be used as the basis of the toxicity screening values:

- Federal Safe Drinking Water Act (SDWA) MCLs for Public Drinking Water Supplies
- U. S. EPA Region 9 PRGs for Tap Water and Soil
- IDEM Tier I Default Closure Levels (soils/ground water) for Residential Land Use
- U. S. EPA SSLs for Soil Ingestion, Transfer from Soils to Air, and Migration from Soils to Ground water

These standards, criteria, and RBCs are referenced and defined in Appendix C.

1.4.2.2 Exposure Assessment Protocol

The exposure assessment component of a baseline human health risk assessment defines and provides a means to evaluate, quantitatively or qualitatively, the type and magnitude of human exposure to chemicals present at or migrating from a site. A foundation of the exposure assessment is the CSM, which identifies site characteristics including potential contaminant sources, contaminant release mechanisms, transport routes, receptors, and other appropriate information. The CSM must consider both current and future land use. (A detailed CSM discussion is presented in Appendix C). Estimated chemical intakes developed during the exposure assessment are evaluated in the risk characterization to produce quantitative estimates of cancer and non-cancer risk.

Sources of Environmental Contamination

Based on historical site data, the following parameters are among the site-related chemical contaminants known to be present or potentially present in environmental media within the study area:

- Explosives (e.g., TNT and HMX) and their degradation products (e.g., 2-amino-4,6-dinitrotoluene)
- Metals (e.g., lead)
- Chlorinated volatile organic chemicals (VOCs) including but not limited to 1,1,2,2-trichloroethane, 1,2-dichloroethene, trichloroethene, and vinyl chloride

Based on available historical information 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 at the ABG and the Jeep Trail. For example, TNT and 2,4-DNT concentrations in the surface soils of the ABG and the Jeep Trail exceed 1,500 milligrams per kilogram (mg/kg) and 35 mg/kg, respectively. TNT has also been detected in ground water underlying and downgradient of the ABG and the Jeep Trail. The existing historical ground water data for the ABG indicate the presence of several halogenated VOCs at concentrations exceeding 100 to 1,000 micrograms per liter (µg/L). VOC concentrations in monitoring wells at the Jeep Trail are typically less than 100 µg/L. Explosives such as

2,4-DNT have been detected in the surface waters and sediments of Little Sulphur Creek. HMX has been detected in the surface waters and sediments of Little Sulphur Creek at maximum concentrations of 45 µg/L and 10 mg/kg, respectively. These data indicate that VOCs, explosives, and other contaminants have been disposed of within source areas within the study area (i.e., the ABG, the Jeep Trail). In addition, dioxins have potentially been generated during burning of material containing chlorinated organic chemicals.

Potential Contaminant Migration Routes

Because the shallow water table aquifer may be in communication with the deeper Beech Creek aquifer, the contaminants identified above either have or may have migrated to Little Sulphur Creek via contaminant transport mechanisms such as infiltration, percolation and surface water run-off. Depth to ground water at the ABG and Jeep Trail is less than 10 feet bgs in the valley bottom and increases along the valley slopes. Consequently, the shallower water depths may facilitate transport of chemicals from soils to ground water. Because the shallow water table aquifer is in communication with deeper aquifers (e.g., Beech Creek aquifer) transport of contaminants has also occurred from one aquifer to another.

Given that surface and subsurface soil contamination has occurred as a result of waste disposal at the ABG and the Jeep Trail, and that contaminants have migrated to ground water and Little Sulphur Creek, plausible contaminant release and migration mechanisms include the following:

- Transport of surface soil contaminants to the subsurface soils and ground water (and from one aquifer to another) via infiltration, percolation, and migration within the ground water aquifer(s).

- Recharge of ground water via surface waters. The study area in the vicinity and immediately downgradient of the ABG is a ground water recharge area. Little Sulphur Creek is a "losing stream" just below the ABG.

- Discharge of ground water to surface water and sediments as noted at Spring C located downstream of the source areas. Little Sulphur Creek becomes a "gaining stream" downstream of the Jeep Trail in the vicinity of Spring C which feeds Little Sulphur Creek.

- Overland run-off of surface waters and sediments from the ABG and the Jeep Trail toward and into Little Sulphur Creek. (On-site surface soil contaminants at the Jeep Trail may also migrate to off-site soils as a result of overland flow of surface waters.)

- Migration of contaminants in ground water (i.e., lateral migration) to potential receptor locations downgradient of the ABG and Jeep Trail source areas and beyond the NSWC Crane boundary.

- Migration of fugitive dusts and VOCs from surface soils (and subsurface soils if construction/excavation activities occur).

Potential Current and Future Receptors of Concern and Exposure Pathways

NSWC Crane is an active naval base and will remain active for the foreseeable future. The ABG is an active and RCRA-permitted open burning ordinance treatment unit and there are no plans to close the unit. In contrast, the Jeep Trail is no longer used as a treatment area and is likely to be used for military (non-disposal) or recreational purposes in the future. However, for purposes of completeness, the baseline risk assessment will consider 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 within the study area:

- Trespassers – A plausible receptor under current or future land use. Although access to the base is controlled, once inside the base access to the study area is not limited by any physical constraints (this is particularly true for the Jeep Trail). In addition, hunting activities are permitted at the base. Because the study area is relatively remote and surrounded by forested areas, hunters (particularly adolescents) may trespass within the study area. This receptor may be exposed to potentially contaminated surface soil (0 to 2 feet bgs) (incidental ingestion, dermal contact), air (inhalation), surface water (incidental ingestion, dermal contact), and sediments (incidental ingestion, dermal contact) in the intermittent streams. However, because of the intermittent nature of surface water in some portions of Little Sulphur Creek, exposure to surface water is likely to be very limited for those portions (e.g., the section adjoining the Jeep Trail). Direct contact with ground water (except where ground water has discharged to Little Sulphur Creek) or subsurface soils is not anticipated for this receptor.

- Maintenance Workers – A plausible receptor under future land use. This includes adult military or civilian personnel assigned duties on an infrequent basis within the study area (e.g., groundskeeping activities, storm sewer/drainage maintenance). This receptor could be exposed to surface soils (incidental ingestion, dermal contact), surface water (dermal contact), sediments (incidental ingestion, dermal contact), and air (inhalation). Direct contact with ground water or subsurface soils is not anticipated for this receptor. There are currently no maintenance workers assigned to the Jeep Trail or to Little Sulphur Creek.

- Construction Workers – A plausible receptor under future land use. No construction activities are currently planned for the study area. Additionally, the shallow depth to ground water in some sections of the study area would likely preclude excavation and construction. However, excavation and construction is plausible in other sections of the study area. Consequently, this receptor could be exposed to surface and subsurface soils (to an estimated maximum depth of 10 feet bgs) (incidental ingestion, dermal contact), ground water (dermal contact), and air (inhalation). Routine exposure to surface water and sediments is not expected for the construction worker.

- Occupational Worker – A plausible receptor under future land use for the Jeep Trail. (It should be noted that Base workers are currently assigned to the ABG.) This includes adult military or civilian personnel assigned to routine daily work tasks. This receptor could be exposed to surface soil (incidental ingestion, dermal contact), and air (inhalation). It is anticipated that this receptor would not be exposed to subsurface soils, surface waters, or sediments. Conservatively, it will be assumed that the occupational worker may be exposed to ground water (ingestion, dermal contact). This receptor is expected to be exposed on a more frequent basis than the maintenance or construction worker is. (It should be noted that bottled water is currently provided as a drinking water supply for Base workers at the ABG.)

- Recreational Users – A plausible receptor under future land use. If NSWC Crane were to close, the most likely scenario is that the property would be converted to a 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 (incidental ingestion, dermal contact) and sediments (incidental ingestion, dermal contact) in Little Sulphur Creek. Conservatively, it will be assumed that the recreational user may be exposed to ground water (ingestion, dermal contact). It should be noted that surface water in the vicinity of the Jeep Trail is intermittent and exposure is expected to be very limited. Direct contact with subsurface soils is not anticipated for this receptor. NSWC Crane is not expected to close because principal Base operations, the demilitarization of munitions, are critical to the support of the U.S. Naval fleet.

- On-Base Residents – An unlikely receptor under future land use. 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 soils (incidental ingestion, dermal contract), ground water (ingestion, dermal

contact), surface water (ingestion, dermal contact), air (inhalation), and sediment (incidental ingestion, dermal contact).

- Off-Base Residents – Off-base residents do exist downgradient of the study area. It is assumed that an off-base resident may be exposed to ground water (ingestion, dermal contact), surface water (ingestion, dermal contact), air (inhalation), and sediment (incidental ingestion, dermal contact). These receptors have been previously defined in recent planning documents for NSWC Crane SWMUs 4, 5, 9, 10, and 01/12, and are similar to the following receptors evaluated in the CCRA [TtNUS, February 1999]):

- Base personnel and families (current land use)
- SWMU workers (current land use)
- Park employees (future land use)
- Park visitors (future land use)
- On-SWMU residents (future land use)
- Off-facility residents (current land use)

Details regarding the assumed receptor characteristics (e.g., intake rate, frequency, duration of exposure) are defined in Appendix C, which presents the methodologies for human health risk assessment.

Calculation of Exposure Point Concentrations

The exposure point concentration (EPC), which is calculated for COPCs only, is an estimate of the chemical concentrations within an EU likely to be contacted over time by a receptor and is used to estimate exposure intakes. The following paragraphs discuss the EUs to be evaluated and the guidelines for calculating the EPC.

The Jeep Trail EU will include the two treatment sub-units (the "burn pit" and the "burn area"; each treatment unit is approximately 100 feet by 30 feet separated by 30 feet) and the area immediately beyond (i.e., within 10 feet of) the presumed extent of contamination. The entire study area (approximately 1 acre) will be considered the EU for soils. Surface soils will extend to a depth of 2 feet; subsurface soil will be all soil from a depth of 2 feet to 10 feet or bedrock, whichever is shallower. A 1-acre EU area is considered a reasonable size based on the current and 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 EPC will be the upper 95 percent confidence limit on arithmetic average of soil sample concentrations in surface and subsurface soils. The inclusion (i.e., sampling) of the area immediately

beyond the presumed perimeter of the unit facilitates the assessment of the extent of contamination, but does not extend so far into expected uncontaminated regions that the average EU contaminant concentrations are artificially reduced. Additional EUs may be defined if, based on the first soil sampling event, significant soil contamination is noted beyond the presumed extent of the Jeep Trail study area. For example, contaminated surface soils may exist between (i.e., downslope of) the source areas and the creek as a result of surface water run-off. Additionally, the Jeep Trail EU may be subdivided to gain perspective on risk estimates if significant contaminant "hot spots" exist within the EU (e.g., contamination in the "burn area" or "burn pit" are distinctive).

As detailed below, the EPC for a receptor hypothetically using or otherwise exposed to ground water underlying the Jeep Trail study area will be the arithmetic average of wells in the most highly concentrated area of the plume potentially underlying the Jeep Trail study area. This approach is based on accepted industry practice that takes into account the fact that chemical concentrations in the ground water do fluctuate over time and the likelihood of installing a well in the most concentrated region of a contaminated plume. The approach is suggested in U.S. EPA Region 4 Supplemental Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment (November 1995). The Navy will discuss with EPA Region 5 the wells selected for computing ground water exposure point concentrations.

If it is determined that a ground water contaminant plume at the Jeep Trail is or may be moving beyond the study area boundaries, EPCs for ground water at receptor locations beyond the Jeep Trail study area may be determined via actual ground water monitoring data for wells at or near the facility boundary or by using modeling techniques. The locations will be selected, if necessary, based on the concentrations detected within the Jeep Trail study area (i.e., the observed or potential contaminant loading to or within the ground water aquifer), the aquifer characteristics (e.g., flow, direction), and the chemical and physical nature of contaminants detected in the ground water. The Navy will discuss with EPA Region 5 the best approach (modeling versus additional monitoring wells) to developing exposure point concentrations for specific receptor locations if it is apparent (based on the results of the proposed sampling) that significant contaminant migration is occurring.

Based on anticipated receptor activity, the entire proposed Little Sulphur Creek study area (i.e., upgradient of the ABG to the confluence with Johnson Hollow Creek) is the most plausible EU for surface water and sediment exposure. Subdivision of the creek may be warranted in light of contaminant profiles and receptor exposure scenarios but the degree of subdivision that is reasonable will not be known until the data have been collected. The EU for surface waters and sediments will include sediments in flood plains adjoining Little Sulphur Creek and Springs A, B, and C that feed Little Sulphur Creek. Additionally, the Jeep Trail EU may be subdivided to gain perspective on risk estimates at various exposure

points/sub-units along Little Sulphur Creek. Exposure points/sub-units evaluated may include the ABG, the Jeep Trail, and Springs A, B, and C. An evaluation of these exposure points/sub-units may be necessary to understand the relative contribution of risk from contaminant sources and because of the variable nature of surface water in Little Sulphur Creek. For example, the surface water flow in Little Sulphur Creek below the ABG, but above Spring C is intermittent and, consequently, can not be evaluated as a reliable domestic water supply resource. In contrast, there is year-round ground water-to-surface water flow at Springs A, B, and C. Additional EUs (below the confluence with Johnson Hollow) may be defined if, based on the first surface water and sediment sampling event, significant surface water and sediment contamination is suspected beyond the initially-defined Little Sulphur Creek study area.

The following guidelines will be used to calculate the EPCs:

- If a soil, surface water, or sediment data set for an EU contains fewer than 10 samples, the EPC for the reasonable maximum exposure (RME) and central tendency exposure (CTE) case will be defined as the maximum detected concentration.

- If a soil, surface water, or sediment data set for an EU contains 10 or more samples, the 95 percent upper confidence limit (UCL) on the arithmetic mean, which will be based on the distribution of the data set, will be selected as the EPC for the RME and CTE case. Conventional statistical methods (e.g., the Shapiro-Wilk W-Test, the *t*- and *H*-statistic based UCL calculation) will be used to determine the distribution and UCL. The "best fit" distribution (normal or lognormal) will be assumed if the data set distribution is undefined. However, the EPCs calculated assuming a lognormal distribution will be reviewed and re-calculated (if necessary) as recommended in a recent U.S. EPA reference to assure that the *H*-statistic based UCL is not an over-prediction of the EPC (U.S. EPA, 1997b). If the calculated 95 percent UCL exceeds the maximum detected concentration, the maximum concentration will be used as the EPC. If enough data are available and a qualified statistician judges bootstrapping to present a more realistic estimation of risk, the bootstrapping technique described in the U.S. EPA 1997 reference will be used.

- The EPC for a ground water receptor will be the arithmetic average of wells in the highly concentrated area of the plume.

Sample and duplicate analytical results will be averaged for statistical use. One-half the sample-specific detection limit (SDL), reported by the laboratory, will be used as a surrogate value for non-detect results when calculating the exposure point concentration. It should be noted that EPCs for ground water may

also be developed for specific receptor locations (e.g., the facility boundary), as necessary, using actual ground water modeling data or ground water modeling techniques.

Chemical and Intake Estimation

The methodologies and techniques used to estimate exposure intakes are presented in Appendix C of this QAPP. Intakes for the identified potential receptor groups will be calculated using current U.S. EPA risk assessment guidance and presented in the risk assessment spreadsheets. Risk assessment results will be presented using the U.S. EPA RAGS Part D tables format.

1.4.2.3 Toxicity Assessment Protocol

The objective of a toxicity assessment is to identify the potential for human 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 will be defined for the identified COPCs. Quantitative toxicity values (cancer slope factors [CSFs] and reference doses [RfDs]) determined during this component of the risk assessment will be integrated with outputs of the exposure assessment to characterize the potential for adverse health effects for each receptor group. The literature sources for the oral and inhalation toxicity criteria are identified in Appendix C. Methodology that will be used to calculate toxicity criteria for the dermal route of exposure is also presented in Appendix C.

1.4.2.4 Risk Characterization Protocol

Potential risks (noncarcinogenic and carcinogenic) for human receptors resulting from the potential exposures outlined in the exposure assessment are quantitatively determined during the risk characterization component of the baseline human health risk assessment. Both RME and CTE estimates will be generated. The quantitative estimates of risk are calculated in accordance with the risk assessment methods outlined in U.S. EPA guidance (U.S. EPA, 1989b). Lifetime cancer risks are expressed in the form of dimensionless probabilities, referred to as incremental cancer risks (ICRs), based on CSFs. For example, an ICR of 1×10^{-6} indicates that an exposed receptor has a one-in-one-million chance of developing cancer, in addition to the cancer risk from non-site-related contaminants. Noncarcinogenic risk estimates are presented in the form of a Hazard Quotient (HQ) that is determined by computing the ratio of an intake for a COPC with an appropriate published RfD for the COPC. (A Hazard Index [HI] is generated by summing individual HQs for all COPCs). Carcinogenic and noncarcinogenic risk estimates are calculated per the equations presented in Appendix C.

To interpret the quantitative risk estimates and to aid risk managers in determining the need for remediation, quantitative risk estimates will be compared to typical EPA risk benchmarks. The U.S. EPA has defined a "target cancer risk" range of $1x10^{-4}$ to $1x10^{-6}$ (i.e., a one-in-ten-thousand to one-in-one-million chance of developing cancer). HQs and HIs are typically evaluated and will be evaluated for this project using a value of 1.0. Generally, adverse noncarcinogenic health effects are not anticipated if an HQ or HI, developed on a target organ/effect-specific basis, does not exceed 1.0.

As a general guideline, a "no further action" recommendation will be forwarded to the Navy, the State of Indiana, and the EPA, if the cancer risk estimates and total HIs (developed on a target organ/target effect basis) for receptors of concern do not exceed $1x10^{-4}$ and 1.0, respectively. Otherwise, the need for remedial action (including institutional controls) will be evaluated in the Corrective Measures Study (CMS). However, as indicated in the U.S. EPA RAGS Part D, the upper boundary of the acceptable risk range is not a discrete line at $1x10^{-4}$. "Risks slightly greater than $1x10^{-4}$ may be considered to be acceptable (i.e., protective) if justified based on site-specific conditions, including any uncertainties about the nature and extent of contamination and associated risks." Consequently, a "no further action" recommendation may forwarded even when the $1x\ 10^{-4}$ risk benchmark is exceeded. The following factors will be considered in this determination:

- The magnitude of the media-specific risk estimates.

- Significant uncertainties in the baseline human health risk assessment that would tend to overestimate baseline risk assessment results. Uncertainties in the baseline human health risk assessment intake estimates (and their impact on the risk estimates) may be evaluated using "probabilistic risk assessment" techniques. Uncertainties associated with the toxicity criteria would be evaluated qualitatively.

- Significant uncertainties in the EPC estimates that would tend to overestimate baseline risk assessment results.

1.4.2.5 Human Health Risk Uncertainty Analysis

The baseline risk assessment will include an uncertainty analysis that qualitatively addresses major sources of uncertainty in the data evaluation, exposure assessment, toxicity assessment, and risk characterization. The major sources of uncertainty that will be discussed are presented in Appendix C. As noted above, probabilistic risk assessment techniques may be used to provide risk managers with a

more comprehensive understanding of the uncertainty attached to the quantitative risk assessment results.

1.4.3 Ecological Risk Assessment

An environmental risk assessment for contaminants at the ABG and the Jeep Trail was presented in the CCRA [TtNUS, February 1999]). The assessment included biota sampling (vegetation, mammals, aquatic vertebrates and invertebrates), an identification of threatened and endangered wildlife and plant species which exist or may exist within the study area, population studies, and an evaluation of the potential for adverse affects on ecological receptors. The conclusions of the assessment were as follows:

> "The majority of ecological risk posed by COPECs (chemicals of potential ecological concern) at the ABG/Jeep Trail, appear to be limited to the aquatic habitats at this SWMU. Elevated levels of barium, lead and zinc in the sediments at the site may have slight adverse effects to wildlife; however, population studies and tissue samples for fish and macroinvertebrates did not show any evidence of adverse effects. Elevated levels of various compounds in the surface water may have a potential adverse impact to wildlife at this site; however, impacts as a result of these COPECs would be very localized and unlikely to impact the viability of any one species at the site given the availability of similar habitat in close proximity to these locations. Populations studies at this SWMU support this conclusion as animal, fish, macroinvertebrate and vegetation species are diverse and abundant, and are similar to what would be expected to occur in a non-impacted area."

The objectives of this follow-up assessment are to:

- Update and augment the evaluation presented in the CCRA [TtNUS, February 1999]).
- Evaluate the potential effects of rainfall events (i.e., flooding) on surface water/sediment quality (and, consequently, ecological receptors) downstream of the ABG.

This section of the QAPP outlines the methodology that will be followed for completing a screening-level ecological risk assessment (SERA) for the Jeep Trail and Little Sulphur Creek. The goal of the SERA is to provide an initial screening of the analytical data (existing and new) to determine which contaminants may need to be further evaluated as part of a baseline ecological risk assessment (BERA), if any. A phased approach to the SERA will be used at the site. The approach relies first on environmental chemistry data and field observations for the preliminary assessments. Biological sampling or testing is not proposed for

this investigation. However, because some previous ecological sampling has been conducted at or near the site, the previous results will be used to supplement the data collected as part of this investigation. In addition, any recommendations for biological sampling or population studies will consider the biological sampling and environmental field work already conducted within the study area and Navy-sponsored biological sampling (i.e., insect tissue study) anticipated to occur Summer 2001.

This SERA will consist of the first two of eight steps required in the U.S. EPA guidance (U.S. EPA, 1997a and 1998b) and Step 3A of the Navy Policy for Conducting Ecological Risk Assessments. Figure 1-15 presents the Navy's Ecological Risk Assessment Tiered Approach (U.S. Navy, 1999). The first two steps are the screening-level assessment. Step 3A is the first step of the BERA and consists of refining the list of COPCs that were retained following the SERA, as discussed in Section 1.4.3.3. Steps 3B through 7 will be conducted if additional evaluations or investigations are necessary. Finally, Step 8, Risk Management, will be incorporated throughout the ecological risk assessment (ERA) process in cooperation with Region 5 Regulators.

The first phase in the ERA process is the screening-level risk assessment. In this phase, conservative exposure estimates are made for grouped or individual ecological receptors, and these exposures are compared to screening levels and threshold toxicity values. The SERA includes the following considerations, which are described in subsequent subsections of this QAPP:

- Screening-level problem formulation
- Screening-level ecological effects evaluation
- Screening-level exposure estimate
- Screening-level risk calculation

1.4.3.1 Screening-Level Problem Formulation

Screening-level problem formulation includes identification of potential receptor groups, COPCs, and the mechanisms for fate and transport, and toxicity. The complete exposure pathways that exist on a site are determined at this point to facilitate receptor selection. As part of receptor identification, site habitats and potential ecological receptors are described.

Environmental Setting

Section 1.2 of this QAPP presents the environmental setting at the site. Based on the habitat at the site, it is likely that a variety of mammals (small and large) and birds are present at the site, as well as fish and benthic macroinvertebrates.

Exposure Pathways

Based on the historical site operations, surface and shallow sub-surface soil at the ABG and the Jeep Trail are the primary source of contaminants. (As noted previously, the ABG has been thoroughly characterized in previous RFIs; the Jeep Trail and Little Sulphur Creek will be characterized in this RFI. The ABG and the Jeep Trail adjoin Little Sulphur Creek.) The contaminants at the ABG (and possibly the Jeep Trail) have migrated from soil to ground water. In addition, contaminants from the sites can enter surface water bodies via overland runoff and erosion, or through ground water discharge. A potential for overland runoff and soil erosion was noted at the ABG during the April 2000 site visit by TtNUS and Navy personnel. Finally, contaminants can enter the air via the emission of volatile chemicals or through wind erosion and dust re-suspension. The following paragraphs discuss each of these exposure pathways.

Ground Water

Currently, several discharge points for ground water potentially contaminated with site-related contaminants have been identified (e.g., Springs A, B, and C). As noted previously, Little Sulphur Creek is a "losing stream" in the vicinity of and just downgradient of the ABG. It reverts to a "gaining stream" in the vicinity of Spring C. Although ecological receptors are not directly exposed to ground water (prior to it discharging from a spring or as surface water), contaminants in ground water will be evaluated as surface water contaminants once the ground water discharges to Little Sulphur Creek.

Springs/Surface Water

Contaminants in the ground water do discharge to surface water. Contaminants in the soil may also enter the Little Sulphur Creek via overland flow. Based on the surrounding habitat, and the presence of mammals and birds, it is probable that these species use the springs and Little Sulphur Creek as a source of drinking water.

Portions of Little Sulphur Creek within the study area are intermittent and would not support fish or benthic macroinvertebrate community. However, other portions of Little Sulphur Creek (e.g., the portion below Spring C) can support healthy benthic macroinvertebrate and fish populations. These receptors

could be exposed to the water by direct contact with and incidental ingestion of water. Amphibians are likely to inhabit both the intermittent and perennial sections of Little Sulphur Creek; reptiles are likely to inhabit these aquatic environments, as well as surrounding terrestrial habitats. Amphibians and reptiles cold be exposed to contaminants in the surface water by direct contact or ingestion of water.

Surface Soil/Sediment

Several groups of terrestrial ecological receptors can be exposed to contaminants in the surface soil or sediments that are not submerged routinely. Invertebrates such as earthworms are exposed to the contaminants as they move through the soil, and ingest soil particles while searching for food. Plants are exposed to the contaminants via direct contact as contaminants are absorbed through the roots and then translocate to different parts of the plants (i.e., leaves, seeds).

Visual inspection of Little Sulphur Creek revealed a well-scoured creek bed with little accumulation of sediments. Mammals such as raccoons may be exposed to contaminants in the soil/sediments via several exposure routes. They may be exposed by direct contact as they search for food or burrow into the soil/sediment. 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 (note that this may not be true for amphibians). Therefore, the dermal pathway will not be evaluated in the SERA. Mammals may also be exposed to contaminants in the soil/sediments via incidental ingestion of soil and ingestion of plants or invertebrates that have accumulated contaminants from the soil/sediment. These pathways will be evaluated in the SERA. Because large sections of Little Sulphur Creek are typically dry except during rain events, some sediment samples collected in the creek may be evaluated as if they were surface soil samples.

Larger, predatory species such as the red fox and red-tailed hawk can be exposed to site contaminants in the soil/sediments by ingesting small mammals that have accumulated contaminants. Because of the relatively small size of the Jeep Trail site (approximately 1 acre) the Jeep Trail would represent only 1 or 2 percent of the predators' home range. Therefore, these species will not be evaluated as part of this SERA. However, risks to piscivorous wildlife will be evaluated in the SERA.

Because the Little Sulphur Creek is well-scoured, the sediment depths would not be expected to exceed approximately 12 inches. The fate of volatile contaminants is also different than that of nonvolatile contaminants in the top 0.5 feet of sediment, especially when exposed to air as expected in the Little Sulphur Creek. The volatile contaminants are more likely to be lost from the sediments through evaporation. Because the contaminant concentration profiles should vary the most within the 0-foot to

1-foot interval and the maximum depth is expected to be 1 foot or less, samples of Little Sulphur Creek sediments will be acquired over two depth intervals - 0.0 to 0.5 feet and 0.5 to 1.0 feet.

Air

The inhalation pathway will not be evaluated because air concentrations are expected to be minimal given the limited size of the Jeep Trail source area and the fact that VOCs associated with surface water/sediments would dissipate rapidly. Also, inhalation pathways typically are not evaluated in SERAs because of the uncertainty in exposures and effects concentrations.

Endpoints

Assessment endpoints are an explicit expression of the environmental value that is to be protected (U.S. EPA 1997a). The selection of these endpoints is based on the habitats present, the migration pathways of probable contaminants, and the routes that contaminants may take to enter receptors.

As discussed in Section 1.2.4, the habitat at and adjacent to the Jeep Trail and Little Sulphur Creek consists of forested areas and aquatic habitats. For this SERA, the assessment endpoints are protection of the following groups of receptors from adverse effects of contaminants on their growth, survival, and reproduction:

- Soil invertebrates
- Terrestrial vegetation
- Herbivorous mammals
- Herbivorous birds
- Soil invertebrate-eating birds
- Soil/sediment invertebrate-eating mammals (including bats)
- Omnivorous mammals
- Omnivorous birds
- Piscivorous mammals
- Piscivorous birds
- Benthic invertebrates
- Fish

Appendix D presents more information on each of these assessment endpoints, including identification of protected or endangered species such as the Indiana bat.

Measurement endpoints are used to evaluate assessment endpoints (i.e., mortality, growth, and reproduction). The following measures of effects will be used to evaluate the assessment endpoints in this SERA, where applicable.

- Soil screening values – Mortality, growth, and reproduction of plants and soil invertebrates will be evaluated by comparing the measured concentrations (maxima and averages) of chemicals in the surface soil to screening values designed to be protective of ecological receptors.

- No observed adverse effects levels (NOAELs) for surrogate wildlife species - Mortality, reproductive, or developmental effects of birds and mammals will be evaluated by comparing the estimated ingested dose (based on conservative and average assumptions) from contaminants in the surface water, sediment, surface soil, plants, fish, or invertebrates to these levels.

- Sediment screening values – Mortality of benthic macroinvertebrates will be evaluated by comparing the measured concentrations (maxima and averages) of chemicals in the sediment to screening values designed to be protective of ecological receptors.

- Surface water screening values – Mortality and other adverse effects (i.e., growth, feeding rates, behavioral changes) of aquatic organisms will be evaluated by comparing the measured concentrations (maxima and averages) of chemicals in the surface water to screening values designed to be protective of ecological receptors.

1.4.3.2 Ecological Effects Evaluation

The preliminary ecological effects evaluation examines the relationship between the magnitude of exposure to a chemical and the nature and magnitude of adverse effects resulting from exposure. In addition to being a toxicity study, it may also describe apparent effects seen during the May 2000 site visit. Toxicity thresholds are usually expressed in units of concentration when the medium of concern is in intimate contact with the receptor, such as surface water for pelagic organisms or soil for soil invertebrates. For other receptors, such as terrestrial vertebrates, toxicity data are typically available as doses, with units equal to mass of contaminant per unit of body mass per unit of time (usually milligrams per kilogram per day [mg/kg/day]). For the SERA (Steps 1 and 2), conservatively low toxicity thresholds are used to evaluate the potential for adverse ecological effects. However, less conservative thresholds used in Step 3A may be more appropriate for determining potential risks to the ecological receptors.

As the first step in the ecological effects evaluation, COPCs will be selected by comparing the contaminant concentrations in the surface water, sediment, and surface soil samples to U.S. EPA Region 5 EDQLs (U.S. EPA, Region 5, 1999b). The following items summarize the procedures that will be used in the specific SERAs for the Jeep Trail and Little Sulphur Creek to select COPCs. Calcium, magnesium, potassium, and sodium will not be retained as COPCs in any medium because of their relatively low toxicity to ecological receptors, and their high natural variability in concentrations. Contaminants without EDQLs will be retained as COPCs but they may only be evaluated qualitatively. If a chemical is non-detected at the MDL/IDL in all of the samples in a particular media, and the MDL/IDL exceeds the EDQL, the chemical will not be quantitatively carried through the risk assessment as a COPC. However, the chemical, its MDL/IDL and the EDQL will be summarized in a table and qualitatively discussed in the uncertainty analysis section. if a chemical is detected in at least one sample at levels greater than the MDL/IDL, one-half of the MDL/IDL will be substituted for the non-detects for calculating summary statistics (e.g., mean concentrations). The ecological COPC selection processes are described in Section 1.4.4.3.

Springs, Surface Water, and Sediment for Benthic Macroinvertebrates, Fish, and Terrestrial Wildlife

- Inorganic and organic contaminants with maximum concentrations that do not exceed EDQLs will not be retained as COPCs.

- Inorganic contaminants with maximum concentrations that do not exceed the maximum upstream or upgradient concentrations will not be retained as COPCs.

Surface water EDQLs were not established for the protection of wildlife ingesting water. However, based on the very low and conservative EDQLs for surface water, contaminants that do not exceed the EDQL are not expected to be toxic to terrestrial wildlife.

Surface Soil for Invertebrates, Plants, and Terrestrial Wildlife

- Inorganic and organic contaminants with maximum concentrations that do not exceed EDQLs will not be retained as COPCs.

- Inorganic contaminants with maximum concentrations that do not exceed the site-specific background concentrations will not be retained as COPCs.

The use of U.S. EPA Region 5 EDQLs incorporates the screening-level exposure estimate and screening-level risk calculation during the COPC selection process. Therefore, these are not presented as separate steps in this QAPP.

Contaminants that are retained as COPCs will be further evaluated as part of Step 3A of the eight-step ERA process (Navy, 1999). This will be done by using additional toxicity data in a lines-of-evidence approach to determine potential impacts to the ecological receptors. The following sections present the additional data sources that will be used to evaluate the COPCs.

1.4.3.3 Step 3A – Refinement of COPCs

Step 3A consists of a refining the list of COPCs from the SERA using less conservative screening values and more realistic exposure assumptions. In Step 3A, less conservative screening values will be used to more realistically estimate potential risks to ecological receptors (i.e., plants, invertebrates, vertebrates, and aquatic receptors). For example, for all the media, both maximum and average concentrations will be compared to the benchmark values because most receptors (other than immobile plants) will have an average exposure to contaminants as they move across the surface water, sediment, or soil. This evaluation may include (but is not necessarily limited to) a consideration of the following factors:

- Magnitude of criterion exceedence: Although risks may not relate directly to the magnitude of a criterion exceedence, the magnitude may be one item used in a lines-of-evidence approach to determine the need for further site evaluation.

- Frequency of chemical detection: A chemical that is detected at a low frequency typically will be of less concern than a chemical detected at higher frequency, provided that the toxicity and concentrations of the constituents are similar. All else being equal, chemicals detected frequently will be 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 will be considered when evaluating the exposures of receptors to site contaminants.

- Habitat: Although exceedences 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 will be used qualitatively when considering the site for additional evaluation.

Alternate Benchmarks and Evaluations

The following sections present some alternate benchmarks and evaluations that will be conducted as part of Step 3A.

Terrestrial Plants and Invertebrates

Risks to terrestrial plants and invertebrates resulting from exposure to the COPCs will be evaluated by comparing the contaminant concentrations in the surface soil to alternate soil benchmark values. These alternate benchmarks will be designated as Surface Soil Screening Levels (SSSLs). Currently, neither Indiana nor U.S. EPA has developed ecological SSSLs. The following list presents the SSSLs that have been developed by a few groups or agencies. Additional details explaining the origin and basis for the alternate benchmarks are provided in Appendix D.

- Dutch Intervention Values and Target Values – Soil Quality Standards (MHSPE, 2000)
- 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)

Springs/Surface Water

Water Quality Standards (WQSs) for surface water have been developed by Indiana (IDEM, 1998). These are the primary enforceable surface water standards. In addition, U.S. EPA has established AWQC for several contaminants. Other, non-regulatory surface water screening values will be used to evaluate the surface water data that do not have WQSs or AWQC. All values will be collectively referred to as surface water screening levels (SWSLs) in the SERA. The following presents the SWSLs that will be used in this evaluation. Additional details explaining the origin and basis for the alternate benchmarks are provided in Appendix D.

- Indiana Water Quality Standards (IDEM, 1998)

- Ambient Water Quality Criteria (U.S. EPA, 1999a)
- Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota, 1996 Revision (Suter and Tsao, 1996)
- "Eco Update-Ecotox Thresholds" (U.S. EPA, 1996a)

Sediment

Indiana has not established sediment screening levels (SSLs) for any contaminants, and U.S. EPA has established SSLs for only a few contaminants. Therefore, other, non-regulatory alternate benchmarks will be used to evaluate the sediment data. SSLs based on freshwater studies will be used where available. The following list presents the SSLs that will be used in this evaluation. Additional details on the SSLs are presented in Appendix D:

- "Eco Update-Ecotox Thresholds" (U.S. EPA, 1996)
- "Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario" (OMOE, 1993)
- "Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments" (Long et al., 1995)

Contaminants that exceed the SSLs also will be compared to background contaminant levels developed in the "Sediment Background Concentration Distributions of 172 Potential Pollutants in Indiana" (Wente, 1994). The term "background" was interpreted in that document as "the concentration that would be present in the absence of any particular pollutant source." Background values will be used as another piece of information in the weight-of-evidence approach for evaluating the sediments.

Terrestrial Wildlife

Most of the above-mentioned additional surface soil, surface water, and sediment standards and benchmarks are not designed to screen out risks to terrestrial wildlife via ingestion of soil, plants, fish, and invertebrates. Therefore, a terrestrial intake model (food chain) will used to estimate the exposure of terrestrial receptors to the COPCs.

Risks to terrestrial receptors posed by COPCs in the soil, surface water, and sediment will be determined 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 will be developed from NOAELs and Lowest-Observed-Adverse-Effect-Levels (LOAELs) obtained from wildlife studies, if available (see Appendix D). Most TRVs will come from the ORNL "Toxicological Benchmarks for Wildlife: 1996 Revision" (Sample et al., 1996). Toxicity data in the Agency for Toxic Substances and Disease Registry toxicity profiles and Integrated Risk Information System printouts will be used, when necessary.

Appropriate scaling factors to convert a NOAEL from one species to a NOAEL for another species will be used as detailed in Appendix D. If a subchronic study is used to develop the TRV, the final value will be multiplied by a factor of 0.1 to account for uncertainty between subchronic and chronic effects. Also, if a LOAEL study is used to develop the NOAEL TRV, then the LOAEL will be multiplied by a factor of 0.1 to obtain the NOAEL. Finally, the estimated doses will incorporate literature-based soil–to-plant and soil-to-earthworm bioaccumulation factors.

The lower bound of the threshold effects is based on consistently conservative assumptions and NOAEL toxicity values (U.S. EPA, 1997). This bound will present the greatest potential risks. The upper bound is based on observed impacts or predictions that ecological effects could occur and is developed using consistent assumptions, site-specific data, LOAEL toxicity values, or an impact evaluation (U.S. EPA, 1997). This bound will present the average potential risk. Both the upper and lower bounds will be evaluated in the SERA to provide a range of potential risks as presented in the following table:

Conservative Scenario	Alternate Scenario
95% UCL, surface water, or sediment concentration	Average soil, surface water, or sediment concentration
Highest receptor body weight for NOAEL calculation	Average receptor body weight for NOAEL calculation
Lowest receptor body weight for CDI calculation	Average receptor body weight for CDI calculation
Highest receptor ingestion rate	Average receptor ingestion rate
Use of NOAELS	Use of LOAELs
Receptors that spend 100% of their time at the site	Receptor's home range taken into account

The exposure assumptions (i.e., ingestion rate, body weight) will be obtained from the Wildlife Exposure Factors Handbook (U.S. EPA, 1993a) or other literature sources, if necessary.

1.4.3.4 Ecological Risk Characterization

The risk characterization is the final phase of a risk assessment and compares the exposure to the ecological effects. This phase evaluates the likelihood that adverse effects will occur as a result of exposure to a stressor.

An HQ approach will be used to characterize the risk to terrestrial receptors. This approach characterizes the potential effects by comparing exposure concentrations to the effects data. An HQ of greater than 1.0 is considered to indicate a potential risk. However, the HQ is not an expression of probability, and the meaning of values greater than 1.0 must be interpreted in light of attendant uncertainties in risk assessment.

1.4.3.5 Ecological Risk Uncertainty Analysis

Uncertainties are associated with most steps of an ERA, from selecting endpoints, collecting data, and evaluating toxicity. The following topics summarize some of the uncertainties associated with an ERA. The uncertainties are discussed in more detail in Appendix D.

Assessment and Measurement Endpoints: Measurement endpoints are used to evaluate the assessment endpoints based on measurements pertaining to representative species or other indicators. There is uncertainty in this prediction because the species or indicators may not accurately represent the assessment endpoints. Species for measurement endpoints are deliberately selected to be sensitive rather than insensitive to contaminants.

Exposure Characterization: The contaminant dose to terrestrial wildlife is calculated using an equation that incorporates ingestion rates, body weights, bioaccumulation factors, and other exposure factors. Because these exposure factors are obtained from literature studies or predicted using various equations, there is uncertainty when they are applied to other sites. There is also uncertainty in the chemical concentration data used for exposure estimates.

Ecological Effects Data: There is uncertainty in some of the ecological effects data because they are typically developed in a laboratory for species that may or may not be present at the site. In addition, for some media (i.e., sediment, soil) often only a few studies are available, or the guideline value is based on highly variable data.

Risk Characterization: Risks are projected if an HQ is greater than or equal to unity regardless of the magnitude of the HQ. Also, there is uncertainty in how the predicted risks to a species at the site translate into risk to the population in the area as a whole.

1.4.4 Decision Rules

Based on site-specific factors described above, and the DQO process outputs, this section describes how the data will ultimately be used for making decisions concerning the nature and extent of chemicals at the site, and the risks to human health and ecological receptors. Decision rules are designed to be technically defensible and practical to implement. The decision rules below apply to all target analytes except field and geotechnical parameters, which have no bearing on COPC selection or evaluations of risk.

To select COPCs, site chemical concentrations will be compared to RBTLs and background/upgradient concentrations. For determinations of nature and extent, risk contours will be plotted. The contours will be based on cumulative risk estimates calculated for COPC concentrations at the sampled locations. At a minimum, plots representing the 1E-4 cancer risk level and a hazard index (HI) of 1 will be presented. Contours less than or greater than these risk levels may also be plotted for perspective to aid in interpreting the data.

Human health and ecological risks will be computed within an EU boundary and compared to unacceptable risk limits to determine whether an unacceptable risk exists within the EU. For the Jeep Trail, the EU consists of a 1-acre area, which represents an area likely to be traversed by a human receptor. The area will include the adjacent portion of the Little Sulphur Creek, if that portion of the Little Sulphur Creek contains COPCs. If contamination extends beyond the EU boundary, the EU may be either reshaped or relocated to coincide with the contaminated area, or additional EUs may be established to encompass contamination extending beyond the 1-acre area. Any reshaping or relocation of the EU will not change the size of the EU materially, as the EU size is based on receptor behavior. For ground water and soils, site conditions are not expected to change during the time frame of this investigation, so no particular temporal considerations are necessary. For the Little Sulphur Creek, the EU concept will be more flexible. Its shape and size will depend on the spatial contaminant distributions and expected receptor behaviors. Both the Jeep Trail and Little Sulphur Creek EUs will be consistent with the risk model.

For surface water and sediment, the ability to collect samples will be affected by rain events. Sampling will be timed to coincide with rain events when collecting high flow surface water samples. Base flow sampling will not be timed to coincide with any precipitation events.

All of these facets of decision making are presented in detail below, with flow charts, where appropriate.

1.4.4.1 Definition

The decision rule is a statement that integrates DQO planning process outputs into a concise summary of how data will be interpreted when making decisions about the site being investigated. In this case, several decision rules have been developed to address the multiple project objectives. The decision rules form a basis for establishing a sampling plan design that enables data of the correct type, quantity, and quality to be collected for attaining project objectives. Where kriging is incorporated into the decision rule, it is understood that the krlged surface indicates the perimeter bounding a three-dimensional volume that represents concentrations in excess of the indicated action level. RBTLs are analyte- and medium-specific, so the applicable analyte- and medium-specific RBTL and EDQL will be used for a given environmental medium when making decisions.

1.4.4.2 Decision Rules for Establishing Background Concentrations

Selecting COPCs requires the comparison of site data to background concentrations. Therefore, it is necessary to establish background concentrations before proceeding to the COPC evaluation step.

Background concentrations are concentrations that would exist in the absence of influence from site operations. For mobile media such as ground water, surface water and sediment the background concentration is represented by concentrations upstream or upgradient of the site being investigated. When upgradient concentrations cannot be obtained because of flow patterns, side gradient (cross gradient) concentrations are the next best choice. For soils, background concentrations are the concentrations found in soils that are not influenced by site operations. These will be represented by soil data from the NSWC Crane Basewide Background Soil Investigation. The background data set corresponding to soil having physical characteristics (i.e., grain size, depositional environment and depth) that most closely represents the SWMU samples will be used. For COPC selection, organic chemicals will be assumed to have zero concentration in the natural environment.

Background locations for sediment, ground water, and surface water have been selected to represent locations not influenced by operations at a particular SWMU. Background sediment and surface water

samples will be collected upstream of the Jeep Trail and downstream of the ABG treatment area to allow evaluation of the Jeep Trail impacts on surface water and sediments. Background sediment and surface water samples from tributaries to Little Sulphur Creek upstream of the ABG will be used to evaluate Little Sulphur Creek as a whole. Background ground water samples for the Jeep Trail will be collected from existing monitoring well 03-16 to represent water entering the Jeep Trail SWMU. Water level measurements made immediately prior to collection of samples will be used to verify the monitoring well 03-16 is upgradient of the Jeep Trail. If data from the selected locations indicate that any of those media do not represent background concentrations, the Navy may consult with the U.S. EPA Region 5 to agree on the most appropriate course of action.

1.4.4.3 Decision Rules for Selecting COPCs

Non-detected Chemicals

As explained in section 1.4.1.2, all reasonable efforts were made to obtain detection limits low enough for concentrations less than background concentrations RBTLs and EDQLs to be measured for each analyte. Therefore, non-detected chemicals will not be classified as COPCs. However, if a chemical is non-detected at the MDL/IDL in all of the samples in a particular media, and the MDL/IDL exceeds the risk-based level, the chemical will be qualitatively discussed in the uncertainty analysis section.

Flowcharts (Figures 1-15 through 1-20) are provided to show the step-wise logic used when identifying COPCs.

Surface Water and Sediment (0-6 inches and 6 inches - 12 inches depths) COPC Selection (for Human Health and Ecological Risk)

- Organic Target Analytes:
  - An organic target analyte is classified as a COPC if the maximum detected target analyte concentration in any site surface water (sediment) sample exceeds its RBTL (human health risk) or its EDQL (ecological risk).

- Inorganic Target Analytes:
  - An inorganic target analyte is classified as a COPC if:

    1. The Wilcoxon Rank-Sum (WRS) test at a 5% significance level indicates that the site surface water (sediment) population has a concentration exceeding the corresponding

upstream surface water (sediment) population concentration. The upstream data set used for these comparisons will be surface water (sediment) samples collected upstream of the ABG.

AND

2. The maximum detected target analyte concentration in any site surface water (sediment) sample exceeds its RBTL (human health risk) **or** its EDQL (ecological risk)

Surface (0' to 2' depth) Soil COPC Selection (for Human Health and Ecological Risk)

- Organic Target Analytes:
  - An organic target analyte is classified as a COPC if the maximum detected target analyte concentration in any site surface soil sample exceeds its RBTL (human health risk) or its EDQL (ecological risk).

- Inorganic Target Analytes:
  - An inorganic target analyte is classified as a COPC if:

    1. The WRS test at a 5% significance level indicates that the site surface soil population has a concentration exceeding the corresponding background surface soil population concentration. **Note:** The background data set used for these comparisons will be that soil type from the NSWC Crane Basewide Background Soil Investigation which most closely matches the site soil samples in terms of depositional environment, depth and grain size. If multiple soil types exist at a site, the appropriate corresponding soil type from the background data set will be used in the comparison with each site soil type.

    AND

    2. The maximum detected target analyte concentration in any site surface soil sample exceeds its RBTL (human health risk) **or** its EDQL (ecological risk)

Subsurface (>2' depth) Soil COPC Selection (for Human Health Risk Only)

- Organic Target Analytes:

- An organic target analyte is classified as a COPC if the maximum detected target analyte concentration in any site subsurface soil sample exceeds its RBTL.

- Inorganic Target Analytes:
  - An inorganic target analyte is classified as a COPC if:

    1. The WRS test at a 5% significance level indicates that the site subsurface soil population has a concentration exceeding the corresponding background subsurface soil population concentration. **Note:** The background data set used for these comparisons will be that soil type from the NSWC Crane Basewide Background Soil Investigation which most closely matches the site soil samples in terms of depositional environment, depth and grain size. If multiple soil types exist at a site, the appropriate corresponding soil type from the background data set will be used in the comparison with each site soil type

       AND

    2. The maximum detected target analyte concentration in any site subsurface soil sample exceeds its RBTL (human health risk).

- All Target Analytes:
  - No COPCs will be selected for ecological risk considerations in subsurface soil.

<u>Ground Water COPC Selection (for Human Health Risk Only)</u>

- Organic Target Analytes:
  - An organic target analyte is classified as a COPC if the maximum detected target analyte concentration in any site monitoring well sample exceeds its RBTL.

- Inorganic Target Analytes:
  - An inorganic target analyte is classified as a COPC if:

    1. The WRS test at a 5% significance level indicates that the site ground water population has a concentration exceeding the upgradient population concentration. **Note:** Data from all site wells of a given depth (shallow or deep) will be compared to the upgradient well concentrations associated with the corresponding depth

AND

2. The maximum detected target analyte concentration in any site monitoring well sample exceeds its RBTL.

- All Target Analytes:
  - No COPCs will be selected for ecological risk considerations in ground water.

1.4.4.4 Decision Rules for Establishing the Nature and Extent of COPCs

The concept of nature and extent conveys the notion that a concentration gradient decreases radially from a contamination source. If multiple contamination sources exist, multiple independent or overlapping regions of contamination will exist. This is likely for heterogeneous media such as soil. The nature and extent concept implies that a region exists within which COPC concentrations may be declared to present a potentially unacceptable risk to receptors and outside of which unacceptable risk is not expected to exist.

A receptor's behavior translates into the receptor roaming a geographical area (or volume) called the EU. The receptor risk reflects the combined effect of exposure to both contaminated and uncontaminated regions within the EU. The relative proportions of the EU that are covered by contaminated and uncontaminated regions, and the contaminant concentrations within those areas, influence the magnitude of risk incurred. Even if multiple localized regions of elevated contaminant concentrations exist within the EU, the risk to the receptor may be acceptable. Consequently, relatively non-conservative reference values may be used to establish the extent of contamination. The computation of risk levels to receptors considers both the nature and extent of contamination and each receptor's EU. EUs may differ for individual receptors, so a representative EU is used for each receptor based on receptor behavior. The extent of contamination is based on human health risk comparisons.

If appropriate, geostatistical kriging will be used to estimate contaminant concentration boundaries in ground water and soil because it takes advantage of an entire data set and the spatial relationships among individual concentration values, rather than relying on individual data points. The appropriateness of kriging will depend on the concentration distributions, density of data values, spatial correlations and similar characteristics, which can only be determined after collecting the data. If geostatistical kriging is not appropriate, contouring will be based solely on professional judgment and the observed COPC concentrations.

Ground Water and Soil Nature and Extent

The decision rules for ground water and soils are presented on Figure 1-21.

Solid samples will not be collected from bedrock or from beyond the Jeep Trail or Little Sulphur Creek study areas without discussions between the Navy and U.S. EPA.

Surface Water and Sediment Nature and Extent

The extent of contamination will not be determined for any drainage channel surface water in which water is not present during the sampling event. However, sediments will be sampled, if available, regardless of the availability of water in the drainage channels.

The decision rules for surface water and sediment are presented on Figure 1-22.

Failure to Establish Nature and Extent Within Three Sampling Rounds

If the COPC extent boundary is not identified within three rounds of sampling, the Navy will seek consultation with the U.S. EPA to discuss the need for additional sampling. The following will 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

1.4.4.5 Decision Rules for Evaluations of Risk

The human health and ecological risk assessment methodologies are summarized in Sections 1.4.2 and 1.4.3, respectively. The decision rules for those methodologies are presented graphically on Figures 1-23 and 1-24. EPCs in the figures refer to those established in Section 1.4.2.2.

1.5 STATISTICAL METHODOLOGY

1.5.1 Limit of Detection / Field Duplicates

In the chemical analysis of environmental samples, some analytes may be present at concentrations that are below the method detection limit (MDL) of the analytical procedure. The results are generally reported as not detected (rather than zero), and the appropriate limit of detection is given. The amount of data that are below the detection limit plays an important role in selecting the method of addressing the limit-of-detection problem. The MDL will be replaced with the MDL divided by two prior to statistical analysis. If all the observations are nondetect results, no statistical analysis is warranted. The "original" result of a duplicate pair will be used to represent the chemical concentration at a particular sampling point.

1.5.2 Parametric versus Nonparametric Analysis of Variance (ANOVA)

Analysis of Variance (ANOVA) is widely used in the examination of environmental data sets. A one-way classification ANOVA is used to determine whether or not the difference between mean concentrations of a parameter detected at a site is higher than background concentrations at a pre-determined level of statistical significance.

Two types of ANOVA may be used. A parametric ANOVA is based on the mean and standard deviation of the analytical results. A nonparametric ANOVA is conducted using the ranks of the analytical results rather than the analytical results themselves.

Parametric ANOVA methods make two key assumptions (1) that the background and site data sets are both drawn from an underlying normal (or lognormal) distribution and (2) that the data sets have homogeneous variances. A parametric ANOVA is not robust to outliers because sample means and standard deviations are sensitive to outliers. The parametric ANOVA is also not recommended for data sets with >15% non-detects.

A nonparametric ANOVA (like the WRS test) is a 'distribution-free' test. It is not influenced by the distributional characteristics that constrain the parametric ANOVA (underlying distribution and homogeneity of variances). The WRS test is more robust to outliers, because the analysis is conducted in terms of rankings of observations. This limits the influence of outliers because rather than relying on the values themselves, it relies on the relative positions (ranks) of the values after they have been sorted from greatest to least. The WRS test is also recommended for data sets with up to 90% non-detects.

Verifying the assumptions made for the parametric ANOVA requires performing the Shapiro-Wilk "W-test" of Normality and Levene's test of Homogeneity of Variances for each parameter for both site and background data sets. An outlier test (e.g., Rosner's test, Walsh's test, etc.) should also be performed on all the data sets. In many cases, because either the distributional characteristics or the percentage of non-detects recommendations are not satisfied for both populations, a nonparametric ANOVA is required anyway. Since parametric tests are less powerful than nonparametric statistical tests when the distributional assumptions are violated and are only slightly more powerful than nonparametric statistical tests even when all the distributional assumptions are met, the WRS test will be used for all statistical analyses.

1.5.3 Nonparametric ANOVA: The Wilcoxon Rank-Sum Test (a.k.a the Mann-Whitney U test)

The following equations present a step-by-step procedure for conducting the Wilcoxon Rank-Sum test.

- Step 1. Combine the upgradient and downgradient data and rank the ordered values from 1 to *N*. Assume there are *n* downgradient samples and m upgradient samples so that $N = m + n$.

- Step 2. Compute the Wilcoxon statistic *W*:

$$W = \sum_{i=1}^{n} E_i - \frac{1}{2}n(n+1)$$

where E_i is the ranks of the downgradient sample (Large values of the statistic *W* give evidence of contamination in downgradient wells).

- Step 3. Compute an approximate *Z-score*. To find the critical value of *W*, a normal approximation to its distribution is used. The expected value and standard deviation of *W* under the null hypothesis (i.e., no contamination exists) are given by the formulas

$$E(W) = \frac{1}{2}mn; \qquad SD(W) = \sqrt{\frac{1}{12}mn(N+1)}$$

An approximate *Z-score* for the Wilcoxon Rank-Sum test may be calculated by the following equations:

$$Z = \frac{W - E(W) - \frac{1}{2}}{SD(W)}$$

The factor of 1/2 in the numerator serves as a continuity correction since the discrete distribution of the statistic W is being approximated by the continuous normal distribution. If $n,m > 10$ and ties (more than an occurrence of a given rank) are present, an adjustment to the approximate *Z-score* must be made:

$$Z_{rs} = \frac{W - E(W) - \frac{1}{2}}{S'D(W)}$$

where: $SD'(W) = \left(\frac{mn}{12} \left[N + 1 - \frac{\sum_{j=1}^{g} t_j(t_j^2 - 1)}{N(N-1)} \right] \right)^{\frac{1}{2}}$

g = the number of tied groups and t_j is the number of tied data in the jth group.

- Step 4. For a one-tailed 0.05 significance level test for H_0 versus the H_A (i.e. the measurements from population 1 tend to exceed those from population 2), reject H_0 and accept H_A if $Z_{rs} > Z_{0.95} = 1.645$. For a one-tailed significance level test for H_0 versus the H_A that the measurements from population 2 tend to exceed those from population 1, reject H_0 and accept H_A if $-Z_{rs} < -Z_{0.95} = -1.645$.

An example of the use of the Wilcoxon Rank-Sum test is included as Appendix E.

TABLE 1-1

**SUMMARY OF PREVIOUS INVESTIGATIONS
ABG AND JEEP TRAIL AREA
NSWC CRANE
CRANE, INDIANA
PAGE 1 OF 2**

Investigation	Summary/Conclusions
1997 Current Contamination Conditions Risk Assessment	• Hazard indices for Base Personnel and their families and SWMU worker are < 1.0. • Potential health hazard exists for off-facility residents (if Little Sulphur Creek is primary drinking water source), future park visitors/employees (ground water), on-SWMU resident (future residential scenario; soil and ground water). • No cancer risk for Base Personnel and their families or SWMU worker. • Off-facility residents have cancer risk only if they use ABG Alluvium ground water or Little Sulphur Creek as their primary drinking water source. • Future park employees and visitors could be at potential significant cancer risk if groundwater beneath the ABG is ever used as drinking water. • Soil and ground water present potential cancer risks to the on-site SWMU Resident receptor (future scenario). • Expected impact of soils, sediments and surface water on ecological receptors is minimal. • Implementation of a surface water erosion control program would further reduce any potential aquatic risk.
1993 Part 2 RCRA Facility Investigation Phase III Soils Study (ABG Treatment Area)	• Treatment activities have contributed residues of explosives compounds and metals contaminants to the soils at the ABG. • Explosives contamination was seen at all sample depths (greatest depth = ft), but were more frequent and at higher concentrations in samples less than 30 inches bgs. • Metals contamination was also found to be a near-surface (less than 30 inches bgs) phenomenon. • Action levels (to determine the necessity of Corrective Measures) should be set.
1992 RCRA Facility Investigation Phase II Surface Water Study	• Flow in Little Sulphur Creek is variable and seasonal. Portions of the lower stream do not contain surface water in extended dry periods. • Certain contaminants have been released to the surface water and bottom sediments of Little Sulphur Creek. The distribution and extent of contaminants in the surface water differ from those in the sediments. Contaminants detected in one of the two sampling rounds were not necessarily detected in the other round. • Contaminants detected include certain metals (aluminum, barium, manganese, chromium, copper, lead and zinc) as well as certain explosives compounds (RDX, HMX and 2,4-dinitrotoluene). • Metals, nitrates and explosives occurred somewhat more frequently or at higher levels in the surface water samples taken in the summer than in the spring. • Surface water and sediment sampling should be performed for additional sites along Little Sulphur Creek, including additional background samples

TABLE 1-1

**SUMMARY OF PREVIOUS INVESTIGATIONS
ABG AND JEEP TRAIL AREA
NSWC CRANE
CRANE, INDIANA
PAGE 2 OF 2**

Investigation	Summary/Conclusions
	upstream of the ABG Treatment Area.
1987-1994 Phase III Groundwater Study	• 72 wells were monitored quarterly for RCRA 40 CFR 265 Groups I, II, and III parameters, selected volatile organics, and selected explosives. • Noted contaminants probably originating from operations within the ABG and detected in a number of wells in more than one sampling period include RDX, trichloroethene, and Barium. • RDX contamination was confined to wells in the ABG Treatment Area and wells south of Spring A. • Wells in the deep aquifer (Beaver Bend) had detected amounts of RDX, organics and metals, but generally at lower concentrations than in the middle aquifer.
1998-1999 Ground Water Monitoring Program at the ABG	• Four quarters of ground water samples were collected at 18 monitoring wells at the ABG. • One surface water sample and two springs samples were also taken in each quarter. • Contaminants detected at one or more locations included chlorinated solvents (e.g., trichloroethene), explosives (e.g., HMX and RDX), and total and dissolved metals. • Exceedences of risk-based target levels were noted for trichloroethene, chloroform, carbon tetrachloride, 1,2-dichloroethane, cis-1,2-dichloroethene, RDX, barium, copper, lead, manganese, lead, and zinc.

TABLE 1-2

DETECTION STATISTICS FOR SOIL
JEEP TRAIL STUDY AREA SAMPLES
NWS CRANE, INDIANA

Parameter	Frequency	Minimum	Maximum	Average	Sample Maximum
Semivolatile Organics (ug/kg)					
2,4-DINITROTOLUENE	3/10	99	76000	7,770.40	CR95-03SS-A01-01-MAX
2,6-DINITROTOLUENE	2/10	39	4000	528.90	CR95-03SS-A01-01-MAX
DIETHYL PHTHALATE	5/5	24	56000	11,440.80	CR95-03SS-A01-01-MAX
DI-N-BUTYL PHTHALATE	1/5	23	23	1,082.60	CR95-03SS-A03-01
N-NITROSODIPHENYLAMINE	2/5	48	8100	1,749.60	CR95-03SS-A01-01-MAX
Energetics (ug/kg)					
HMX	3/5	449	2310	1,185.20	CR95-03SS-A01-01-MAX
RDX	1/5	2070	2070	814.00	CR95-03SS-A01-01-MAX
Inorganics (mg/kg)					
ALUMINUM	5/5	3810	9050	6,446.00	CR95-03SS-A05-01
ANTIMONY	2/5	0.93	1.3	0.67	CR95-03SS-A03-01
ARSENIC	5/5	6	14.3	8.82	CR95-03SS-A05-01
BARIUM	5/5	121	2720	702.40	CR95-03SS-A05-01
BERYLLIUM	5/5	0.55	0.9	0.70	CR95-03SS-A05-01
CADMIUM	4/5	0.78	1.8	0.94	CR95-03SS-A01-01-MAX
CALCIUM	5/5	2930	9350	6,160.00	CR95-03SS-A02-01
CHROMIUM	5/5	7.3	14	11.18	CR95-03SS-A05-01
COBALT	5/5	9.9	20	12.72	CR95-03SS-A05-01
COPPER	5/5	19.2	91.6	46.44	CR95-03SS-A04-01
CYANIDE	5/5	0.2	0.47	0.37	CR95-03SS-A01-01-MAX
IRON	5/5	11100	30900	17,340.00	CR95-03SS-A05-01
LEAD	1/5	32.1	32.1	52.04	CR95-03SS-A05-01
MAGNESIUM	5/5	753	1610	1,122.00	CR95-03SS-A05-01
MANGANESE	5/5	839	1070	997.80	CR95-03SS-A01-01-MAX
NICKEL	5/5	11.5	28.2	15.86	CR95-03SS-A05-01
POTASSIUM	1/5	2140	2140	757.40	CR95-03SS-A05-01
SELENIUM	2/5	0.62	0.68	0.41	CR95-03SS-A05-01
SILVER	1/5	0.55	0.55	0.21	CR95-03SS-A04-01
VANADIUM	5/5	10.4	19.2	14.66	CR95-03SS-A05-01
ZINC	5/5	71.6	301	160.52	CR95-03SS-A04-01

Includes samples:
CR95-03SS-A01-01-MAX
CR95-03SS-A02-01
CR95-03SS-A03-01
CR95-03SS-A04-01
CR95-03SS-A05-01

TABLE 1-3

DETECTION STATISTICS FOR SOIL
ABG PROPER STUDY AREA
NWS CRANE, INDIANA

Parameter	Frequency	Minimum	Maximum	Average	Sample Maximum
Dioxins (ng/kg)					
1,2,3,4,6,7,8-HPCDD	3/3	30	42.3	37.00	CR95-03SS-A06-01-MAX
1,2,3,4,6,7,8-HPCDF	3/3	7.09	11.4	9.15	CR95-03SS-A07-01
1,2,3,4,7,8-HXCDD	1/3	0.84	0.84	0.34	CR95-03SS-A06-01-MAX
1,2,3,4,7,8-HXCDF	1/3	2.45	2.45	2.82	CR95-03SS-A07-01
1,2,3,6,7,8-HXCDD	2/3	1.11	2.39	1.34	CR95-03SS-A08-01
1,2,3,7,8,9-HXCDD	3/3	1.9	3.69	2.66	CR95-03SS-A08-01
2,3,7,8-TCDF	2/3	1.81	2.23	1.37	CR95-03SS-A08-01
OCDD	3/3	256	1510	863.33	CR95-03SS-A06-01-MAX
OCDF	3/3	13.4	31.1	23.30	CR95-03SS-A07-01
Semivolatile Organics (ug/kg)					
2,4-DINITROTOLUENE	26/91	15	11600	468.30	03/10-12-93-1
2,6-DINITROTOLUENE	15/91	100	575	294.56	03/10-49-93-1
Energetics (ug/kg)					
1,3,5-TRINITROBENZENE	26/91	65	37500	696.04	03/10-35-93-2
1,3-DINITROBENZENE	8/91	250	250	271.98	03/10-40-93-1
2,4,6-TRINITROTOLUENE	46/91	20	2030000	25,441.59	03/10-35-93-2
2-AMINO-4,6-DINITROTOLUENE	32/91	10	5650	421.00	03/10-61-93-1
4-AMINO-2,6-DINITROTOLUENE	39/91	20	8200	465.51	03/10-61-93-1
HMX	48/91	35	232000	11,194.82	03/10-35-93-2
RDX	37/91	35	1820000	27,853.19	03/10-61-93-1
TETRYL	8/91	650	650	1,060.71	03/10-41-93-1

Includes samples:

03/10-01-93-1-MAX	03/10-17-93-2	03/10-34-93-1	03/10-56-93-1
03/10-02-93-1	03/10-17-93-3	03/10-34-93-2	03/10-57-93-1
03/10-03-93-2	03/10-19-93-1	03/10-35-93-1	03/10-58-93-1
03/10-05-93-1	03/10-19-93-2	03/10-35-93-2	03/10-59-93-1
03/10-05-93-2	03/10-19-93-3	03/10-36-93-1	03/10-60-93-1
03/10-06-93-1	03/10-21-93-1	03/10-37-93-1-MAX	03/10-61-93-1
03/10-06-93-2	03/10-21-93-2	03/10-38-93-1	03/10-62-93-1
03/10-07-93-1	03/10-21-93-3	03/10-38-93-2	03/10-63-93-1
03/10-07-93-2	03/10-22-93-1	03/10-39-93-1	03/10-64-93-1
03/10-08-93-1-MAX	03/10-22-93-2	03/10-40-93-1	03/10-65-93-1
03/10-09-93-1	03/10-22-93-3	03/10-41-93-1	03/10-66-93-1
03/10-10-93-1	03/10-23-93-1	03/10-42-93-1	03/10-67-93-1
03/10-10-93-2	03/10-23-93-2	03/10-43-93-1	03/10-68-93-1
03/10-11-93-1	03/10-23-93-3	03/10-44-93-1	03/10-69-93-1
03/10-11-93-2	03/10-24-93-1	03/10-45-93-1	03/10-70-93-1
03/10-12-93-1	03/10-25-93-1	03/10-46-93-1	03/10-71-93-1
03/10-12-93-2	03/10-25-93-2	03/10-47-93-1	CR95-03SS-A06-01-MAX
03/10-12-93-3	03/10-28-93-1	03/10-48-93-1-MAX	CR95-03SS-A07-01
03/10-13-93-1	03/10-28-93-2	03/10-49-93-1	CR95-03SS-A08-01
03/10-13-93-2	03/10-28-93-3	03/10-50-93-1-MAX	
03/10-14-93-1	03/10-29-93-1	03/10-51-93-1	
03/10-14-93-2	03/10-29-93-2	03/10-52-93-1	
03/10-15-93-1	03/10-31-93-1	03/10-53-93-1	
03/10-16-93-1-MAX	03/10-32-93-1	03/10-54-93-1-MAX	
03/10-17-93-1	03/10-33-93-1-MAX	03/10-55-93-1	

TABLE 1-4

DETECTION STATISTICS FOR SEDIMENT
ABG STUDY AREA
NWS CRANE, INDIANA
PAGE 1 OF 2

Parameter	Frequency	Minimum	Maximum	Average	Sample Maximum
Volatile Organics (ug/kg)					
2-BUTANONE	3/5	1	8	4.90	CR95-03SD-ABG-13-01
ACETONE	5/5	7	24	12.20	CR95-03SD-ABG-13-01
XYLENES, TOTAL	1/5	2	2	4.90	CR95-03SD-ABG-14-01
Semivolatile Organics (ug/kg)					
2,4-DINITROTOLUENE	2/32	105	550	147.50	ABGS03 (92b)
BUTYLBENZYL PHTHALATE	1/5	22	22	151.40	CR95-03SD-ABG-14-01
DI-N-BUTYL PHTHALATE	5/5	23	87	40.60	CR95-03SD-ABG-1-01
Energetics (ug/kg)					
1,3,5-TRINITROBENZENE	5/26	50	200	119.81	ABGS03 (92b)
2,4,6-TRINITROTOLUENE	16/27	70	1,130	286.07	ABGS08 (92a)
HMX	12/27	145	10,200	1,403.15	ABGS04 (92a)
RDX	2/27	405	1,780	543.89	ABGS06 (92b)
Inorganics (mg/kg)					
ALUMINUM	5/5	6370	11,200	7,902.00	CR95-03SD-ABG-12-01-MAX
ANTIMONY	5/5	1.4	4.3	2.92	CR95-03SD-ABG-13-01
ARSENIC	5/5	19.8	62	38.68	CR95-03SD-ABG-13-01
BARIUM	5/5	55.4	373	167.28	CR95-03SD-ABG-12-01-MAX
BERYLLIUM	5/5	0.94	2.4	1.67	CR95-03SD-ABG-14-01
CADMIUM	1/5	0.24	0.24	0.14*	CR95-03SD-ABG-13-01
CALCIUM	5/5	579	14,600	3,991.40	CR95-03SD-ABG-13-01
CHROMIUM	5/5	35.7	61.9	50.62	CR95-03SD-ABG-13-01
COBALT	5/5	17.7	47.3	31.16	CR95-03SD-ABG-15-01
COPPER	5/5	15.5	46.5	25.30	CR95-03SD-ABG-13-01
CYANIDE	2/4	0.39	0.4	0.24*	CR95-03SD-ABG-12-01-MAX
IRON	5/5	44,100	108,000	85,420.00	CR95-03SD-ABG-1-01
LEAD	5/5	29.4	284	85.02	CR95-03SD-ABG-13-01
MAGNESIUM	5/5	439	2,210	957.40	CR95-03SD-ABG-13-01
MANGANESE	5/5	1010	2,930	1,968.00	CR95-03SD-ABG-12-01-MAX
MERCURY	1/5	0.13	0.13	0.07*	CR95-03SD-ABG-1-01
NICKEL	5/5	26	68.1	41.62	CR95-03SD-ABG-15-01
POTASSIUM	3/5	919	1,460	881.00	CR95-03SD-ABG-13-01
SELENIUM	4/5	0.92	2.8	1.45	CR95-03SD-ABG-1-01
SILVER	1/5	0.3	0.3	0.17*	CR95-03SD-ABG-15-01
SODIUM	1/5	39.7	39.7	31.02	CR95-03SD-ABG-14-01
THALLIUM	4/5	1.9	7.5	4.59	CR95-03SD-ABG-1-01
VANADIUM	5/5	29.1	58.3	47.16	CR95-03SD-ABG-13-01
ZINC	5/5	74.4	861	247.32	CR95-03SD-ABG-13-01
Miscellaneous Parameters (mg/kg)					
NITRATE/NITRITE, AS N	4/5	1.12	1.88	1.26	CR95-03SD-ABG-1-01

TABLE 1-4

DETECTION STATISTICS FOR SEDIMENT
ABG STUDY AREA
NWS CRANE, INDIANA
PAGE 2 OF 2

Includes samples:

ABGS01 (92a)	ABGS05 (92b)	ABGS10 (92a)
ABGS01 (92b)	ABGS06 (92a)	ABGS10 (92b)
ABGS02 (92a)	ABGS06 (92b)	ABGS11 (92a)
ABGS02 (92b)	ABGS07 (92a)	ABGS11 (92b)
ABGS03 (92a)	ABGS07 (92b)	CR95-03SD-ABG-1-01
ABGS03 (92b)	ABGS08 (92a)	CR95-03SD-ABG-12-01-MAX
ABGS04 (92a)	ABGS08 (92b)	CR95-03SD-ABG-13-01
ABGS04 (92b)	ABGS09 (92a)	CR95-03SD-ABG-14-01
ABGS05 (92a)	ABGS09 (92b)	CR95-03SD-ABG-15-01

* - Average < Minimum

TABLE 1-5

DETECTION STATISTICS FOR SURFACE WATER
ABG STUDY AREA
NWS CRANE, INDIANA
PAGE 1 OF 2

Parameter	Frequency	Minimum	Maximum	Average	Sample Maximum
Volatile Organics (ug/L)					
TRICHLOROETHENE	1/15	0.6	0.6	0.27*	ASPA1A99
Dissolved Gases (ug/L)					
ETHANE	5/15	0.006	0.1695	0.04	ACRB1A99-AVG
ETHENE	4/15	0.026	0.036	0.01*	ACRB1A99-AVG
METHANE	12/15	0.048	9.4	1.74	ABGCRELSDSW01
Energetics (ug/L)					
2,4,6-TRINITROTOLUENE	3/15	0.49	1.8	0.51	ASPA3A99
2-AMINO-4,6-DINITROTOLUENE	2/15	1.8	2.1	0.56*	ASPA3A99
3,5-DINITROANILINE	1/15	0.94	0.94	0.86*	ASPA3A99
4-AMINO-2,6-DINITROTOLUENE	4/15	0.785	4.9	0.93	ASPA3A99
HMX	13/15	0.525	31	6.81	ASPA3A99
MNX	1/15	2.4	2.4	0.48*	ASPA3A99
RDX	15/15	0.745	120	17.17*	ASPA3A99
Total Metals (ug/L)					
BARIUM	15/15	27.6	158	82.46	ABGCRELSDSW01, ACRB3A99
COPPER	1/15	3.7	3.7	1.27*	ABGSPRASW01
IRON	11/15	86.75	517	189.42	ACRB3A99
LEAD	1/12	3.8	3.8	0.82*	ABGSPRASW01
MANGANESE	2/15	102	362	38.17	ACRB3A99
MERCURY	1/15	0.15	0.15	0.10*	ASPA2A99-AVG
SELENIUM	3/15	0.875	1.6	0.69*	ASPA3A99
ZINC	2/15	11.9	11.9	6.40*	ABGSPRASW01, ACRB3A99
Dissolved Metals (ug/L)					
BARIUM, FILTERED	15/15	30.2	158	82.58	ACRB3A99-F
CALCIUM, FILTERED	15/15	10,900	71,800	37,120.00	ASPA3A99-F
COBALT, FILTERED	2/15	3.4	4	1.92*	ACRA1A99-F
MAGNESIUM, FILTERED	15/15	2,470	15,800	7,900.00	ASPA3A99-F
MANGANESE, FILTERED	2/15	110	356	38.30*	ACRB3A99-F
POTASSIUM, FILTERED	13/15	1,110	5870	1,819.67	ABGSPRASW01-F
SELENIUM, FILTERED	3/15	0.875	1.1	0.65*	ABGSPRASW01-F, ASPA3A99-F
SODIUM, FILTERED	15/15	1530	11,400	5,076.67	ASPA3A99-F
ZINC, FILTERED	3/15	8.825	32.8	7.98*	ASPA3A99-F
Miscellaneous Parameters (ug/L)					
ALKALINITY (MG/L)	11/11	20.4	167	76.89	ACRB3A99
ALKALINITY AS CACO3	4/4	130	150	137.50	ABGSPRCSW01
BICARBONATE ALKALINITY	4/4	130	150	137.50	ABGSPRCSW01
BICARBONATE ALKALINITY-FIELD	11/11	20.4	167	76.89	ACRB3A99
CARBON DIOXIDE (MG/L)	11/11	17.4	56	32.68	ACRB2A99
CHLORIDE	11/15	1	14	4.93	ABGSPRASW01
CYANIDE	2/15	0.02	0.06	0.001*	ABGSPRASW01
DISSOLVED OXYGEN-HACH (MG/L)	11/11	6	12	9.56	ASPA3A99
DISSOLVED OXYGEN-METER (MG/L)	15/15	4.55	13.15	9.75	ASPC1A99
FERROUS IRON (MG/L)	7/11	0.005	0.01	0.01	ACRA1A99, ACRB2A99,ACRB3A99, ASPA3A99
NITRATE (MG/L)	11/11	0.054	2.43	0.67	ASPA3A99
NITRATE, AS NITROGEN	4/4	0.2	2.9	1.13	ABGSPRASW01
NITRITE (MG/L)	7/11	0.001	0.006	0.00*	ACRA2A99, ACRB2A99
NITRITE, AS NITROGEN	2/4	0.2	0.3	0.15*	ABGSPRASW01
OXIDATION REDUCTION POTENTIAL (MV)	15/15	19	1,412	203.34	ABGSPRASW01
PH ()	15/15	3.675	8.36	6.81	ABGSPRASW01
SPECIFIC CONDUCTIVITY (MS/CM)	15/15	0.0475	0.531	0.26	ABGSPRASW01
SULFATE	15/15	16	59	33.93	ASPA3A99
SULFIDE (MG/L)	6/11	0.01	0.06	0.02	ACRA1A99, ACRB1A99-AVG, ASPA3A99
TEMPERATURE (C)	15/15	3.95	19.3	9.96	ACRB3A99
TOTAL ORGANIC CARBON	14/15	1.4	7.5	3.09	ASPA3A99

TABLE 1-5

DETECTION STATISTICS FOR SURFACE WATER
ABG STUDY AREA
NWS CRANE, INDIANA
PAGE 2 OF 2

Parameter	Frequency	Minimum	Maximum	Average	Sample Maximum
TOTAL ORGANIC HALOGENS	1/15	0.02	0.02	0.01*	ACRB1A99-AVG
TURBIDITY (NTU)	15/15	0.5	15.9	6.63	ASPA1A99

Includes samples:

ABGCRELSDSW01	ACRA2A99	ASPA2A99-AVG
ABGCRELSDSW01-F	ACRA2A99-F	ASPA2A99-F-AVG
ABGCRELSUSW01	ACRB1A99-AVG	ASPA3A99
ABGCRELSUSW01-F	ACRB1A99-F-AVG	ASPA3A99-F
ABGSPRASW01	ACRB2A99	ASPC1A99
ABGSPRASW01-F	ACRB2A99-F	ASPC1A99-F
ABGSPRCSW01	ACRB3A99	ASPC2A99
ABGSPRCSW01-F	ACRB3A99-F	ASPC2A99-F
ACRA1A99	ASPA1A99	ASPC3A99-AVG
ACRA1A99-F	ASPA1A99-F	ASPC3A99-F-AVG

* - Average < Minimum

TABLE 1-6

DETECTION STATISTICS FOR GROUNDWATER
JEEP TRAIL STUDY AREA
NWS CRANE, INDIANA

Parameter	Frequency	Minimum	Maximum	Average	Sample Maximum
Volatile Organics (ug/L)					
1,1,1-TRICHLOROETHANE	1/16	1.00	1.00	10.06	03-15-GW-94
1,1,2,2-TETRACHLOROETHANE	4/16	3.60	2,100	134.14	03-07-GW-94
CIS-1,2-DICHLOROETHENE	2/16	9.30	1,000	65.27	03-07-GW-94
TRANS-1,2-DICHLOROETHENE	1/16	1.20	1.20	10.08	03-24-GW-94
TRICHLOROETHENE	6/16	0.76	4,000	253.63	03-07-GW-94
Energetics (ug/L)					
HMX	6/16	13.0	134	31.50	03-21-GW-94
RDX	8/16	13.0	365	44.38	03-21-GW-94
Total Metals (ug/L)					
ALUMINUM	2/16	435	646	78.50	03-17-GW-94
ANTIMONY	7/16	3.40	7.40	3.14	03-16-GW-94
BARIUM	15/16	36	162	61.22	03-22-GW-94
CADMIUM	6/16	0.30	2.87	0.46	03-20-GW-94
CALCIUM	16/16	27,100	258,000	93,393.75	03-07-GW-94
IRON	3/16	121	1,010	137.34	03-17-GW-94
LEAD	3/16	1.60	5.20	1.10	03-17-GW-94
MAGNESIUM	16/16	979	419,000	36,610.56	03-07-GW-94
MANGANESE	5/16	16.0	8,610	570.28	03-07-GW-94
MERCURY	2/16	0.02	0.03	0.01	03-10-GW-94
NICKEL	1/16	16.0	16.0	3.34	03-07-GW-94
POTASSIUM	16/16	877	68,000	6,969.81	03-07-GW-94
VANADIUM	13/16	8.00	35.0	15.47	03-20-GW-94
ZINC	3/16	10.0	24.0	7.00	03-24-GW-94
Miscellaneous Parameters (mg/L)					
NITRATE/NITRITE	16/16	0.026	2.99	0.83	03-16-GW-94
SODIUM	16/16	1.28	10.6	4.09	03-07-GW-94

Includes samples:
03-07-GW-94
03-10-GW-94
03-11-GW-94
03-12-GW-94
03-13-GW-94
03-14-GW-94
03-15-GW-94
03-16-GW-94
03-17-GW-94
03-18-GW-94
03-20-GW-94
03-21-GW-94
03-22-GW-94
03-23-GW-94
03-24-GW-94
03-25-GW-94

TABLE 1-7

DETECTION STATISTICS FOR GROUNDWATER
ABG PROPER STUDYAREA
NWS CRANE, INDIANA
PAGE 1 OF 2

Parameter	Frequency	Minimum	Maximum	Average	Sample Maximum
Volatile Organics (ug/L)					
1,2-DICHLOROETHANE	3/24	23	29	3.43	AC101A99
CARBON TETRACHLORIDE	3/24	1.2	1.6	0.34	AC101A99
CHLOROFORM	6/24	1.4	2.2	0.62	AC101A99
CIS-1,2-DICHLOROETHENE	15/72	0.7	120	6.91	AC112A99
TRANS-1,2-DICHLOROETHENE	4/72	7.2	8.8	0.66	ABG03C20GW01
TRICHLOROETHENE	41/72	0.6	3700	302.84	AC201A99
VINYL CHLORIDE	1/72	8	8	0.36	AC112A99
Dissolved Gases (ug/L)					
ETHANE	22/32	0.011	1.494	0.16	AB041A99
ETHENE	14/32	0.009	0.232	0.02	AB041A99
METHANE	29/32	0.051	5320	269.69	AC112A99
Energetics (ug/L)					
1,3,5-TRINITROBENZENE	4/72	6.1	6.7	0.73	AC203A99
2,4,6-TRINITROTOLUENE	1/72	0.54	0.54	0.40	ABG03C20GW01
2,6-DINITROTOLUENE	5/72	0.58	0.94	0.42	ABG03C09P2GW01-AVG, AC09P23A99
2-AMINO-4,6-DINITROTOLUENE	8/72	2.1	12	1.13	ABG03C20GW01, AC201A99, AC203A99
4-AMINO-2,6-DINITROTOLUENE	10/72	0.4	19	1.53	AC203A99
HMX	32/72	2.8	38	7.28	AC123A99
MNX	5/33	0.32	3.1	0.71	AC101A99
NITROCELLULOSE	7/72	850	1400	585.07	AC252A99
RDX	34/72	0.7	190	34.01	ABG03C20GW01
TNX	2/33	0.57	0.66	0.42	AC102A99
Total Metals (ug/L)					
ARSENIC	18/72	1.1	10.3	1.38	AB023A99
BARIUM	71/72	11	105	44.58	AC02P23A99-AVG
CHROMIUM	1/72	82.9	82.9	3.91	AC112A99
COPPER	4/72	2.8	30.1	1.79	AC073A99
IRON	31/43	107	13500	1,873.78	AB021A99
LEAD	3/63	2.275	8.3	0.74	AC073A99
MANGANESE	37/72	19.1	1760	198.50	AB043A99
NICKEL	1/72	137	137	7.38	AB041A99
SELENIUM	45/72	1.1	8.7	1.60	AC112A99
ZINC	12/72	13.175	99.275	10.47	AC02P23A99-AVG
Dissolved Metals (ug/L)					
ARSENIC, FILTERED	15/71	1.2	10.9	1.31	AB023A99-F
BARIUM, FILTERED	71/71	10	107	47.05	AB043A99-F
CADMIUM, FILTERED	1/71	2.6	2.6	0.58	AC042A99-F
CALCIUM, FILTERED	70/71	1140	237000	94,017.54	AC113A99-F
CHROMIUM, FILTERED	3/71	7.3	99	4.29	AC112A99-F
COPPER, FILTERED	4/71	2.6	11.2	1.37	AC301A99-F
MAGNESIUM, FILTERED	67/71	2830	205000	46,269.51	ABG03C17GW01-F
MANGANESE, FILTERED	31/71	17.8	1730	192.32	AB043A99-F
NICKEL, FILTERED	8/71	11.1	33.4	7.13	AC113A99-F
POTASSIUM, FILTERED	59/71	1120	165000	5,398.24	AC112A99-F
SELENIUM, FILTERED	44/71	0.875	7.2	1.46	AC112A99-F
SODIUM, FILTERED	71/71	4350	240000	45,635.56	ABG03C03GW01-F
ZINC, FILTERED	6/71	14	233	10.37	AC122A99-F
Miscellaneous Parameters (mg/L)					
ALKALINITY (MG/L)	54/54	75.2	408	235.41	AC301A99
ALKALINITY AS CACO3	18/18	125	420	272.78	ABG03C17GW01
BICARBONATE ALKALINITY	18/18	125	420	267.22	ABG03C17GW01
BICARBONATE ALKALINITY-FIELD (MG/L)	53/53	74.4	408	232.87	AC301A99
CARBON DIOXIDE (MG/L)	25/28	33.55	2000	166.80	AC112A99
CARBONATE ALKALINITY	1/18	100	100	6.50	ABG03C03GW01
CHLORIDE	58/62	1	75	11.57	AC02P23A99-AVG
CYANIDE	1/72	0.00375	0.00375	0.00	AC033A99-AVG
DISSOLVED OXYGEN-HACH (MG/L)	22/28	0.15	9	2.32	AC02P23A99-AVG
DISSOLVED OXYGEN-METER (MG/L)	72/72	0.29	28.39	5.28	AC262A99
FERROUS IRON (MG/L)	20/28	0.01	3.3	0.77	AB021A99, AB023A99, AB042A99, AB043A99
NITRATE (MG/L)	17/28	0.01	2.43	0.52	AC103A99, AC113A99, AC123A99
NITRATE, AS NITROGEN	8/18	0.8	4.7	1.09	ABG03C09P2GW01-AVG

TABLE 1-7

DETECTION STATISTICS FOR GROUNDWATER
ABG PROPER STUDYAREA
NWS CRANE, INDIANA
PAGE 2 OF 2

Parameter	Frequency	Minimum	Maximum	Average	Sample Maximum
NITRITE (MG/L)	13/28	0.001	0.012	0.00	AC112A99
OXIDATION REDUCTION POTENTIAL (MV)	72/72	-146	245.1	46.32	ABG03C09P2GW01-AVG
PH ()	72/72	3.575	11.06	7.23	AC112A99
SPECIFIC CONDUCTIVITY (MS/CM)	72/72	0.152	2.26	0.87	AC173A99
SULFATE	72/72	8	1300	228.26	AC172A99
SULFIDE	2/24	1	2	0.58	AC123A99
SULFIDE (MG/L)	15/28	0.005	0.47	0.05	AC111A99-AVG
TEMPERATURE (C)	72/72	4.1	27.08	14.06	AC263A99
TOTAL ORGANIC CARBON	51/72	0.75	11	3.09	AC09P23A99, AC203A99
TOTAL ORGANIC HALOGENS	30/72	0.02	3	0.20	AC201A99
TOTAL PHOSPHORUS AS P	12/85	0.01	0.0425	0.03	ABG03C09P2GW01-AVG
TURBIDITY (NTU)	50/72	0.5	240	5.77	AC112A99
WATER LEVEL (FT)	54/54	5.33	223.51	67.98	AC302A99

Includes samples:

AB021A99
AB021A99-F
AB022A99
AB022A99-F
AB023A99
AB023A99-F
AB041A99
AB041A99-F
AB042A99
AB042A99-F
AB043A99
AB043A99-F
ABG03B02GW01-AVG
ABG03B02GW01-F-AVG
ABG03B04GW01
ABG03B04GW01-F
ABG03C02P2GW01
ABG03C02P2GW01-F
ABG03C03GW01
ABG03C03GW01-F
ABG03C04GW01
ABG03C07GW01
ABG03C07GW01-F
ABG03C08P2GW01
ABG03C08P2GW01-F
ABG03C09P2GW01-AVG
ABG03C09P2GW01-F-AVG
ABG03C10GW01-AVG
ABG03C10GW01-F-AVG
ABG03C11GW01
ABG03C11GW01-F
ABG03C12GW01
ABG03C12GW01-F
ABG03C15GW01
ABG03C15GW01-F
ABG03C17GW01
ABG03C17GW01-F
ABG03C20GW01
ABG03C20GW01-F
ABG03C25GW01
ABG03C25GW01-F
ABG03C26GW01
ABG03C26GW01-F
ABG03C27GW01
ABG03C27GW01-F
ABG03C30GW01
ABG03C30GW01-F
AC02P21A99
AC02P21A99-F
AC02P22A99-AVG
AC02P22A99-F-AVG
AC02P23A99-AVG
AC02P23A99-F-AVG
AC031A99
AC031A99-F
AC032A99
AC032A99-F
AC033A99-AVG
AC033A99-F-AVG
AC041A99
AC041A99-F
AC042A99
AC042A99-F
AC043A99
AC043A99-F
AC071A99
AC071A99-F
AC072A99
AC072A99-F
AC073A99
AC073A99-F
AC08P21A99
AC08P21A99-F
AC08P22A99
AC08P22A99-F
AC08P22A99DI
AC08P23A99
AC08P23A99-F
AC09P21A99
AC09P21A99-F
AC09P22A99
AC09P22A99-F
AC09P23A99
AC09P23A99-F
AC101A99
AC101A99-F
AC102A99
AC102A99-F
AC103A99
AC103A99-F
AC111A99-AVG
AC111A99-F-A
AC112A99
AC112A99-F
AC113A99
AC113A99-F
AC121A99
AC121A99-F
AC122A99
AC122A99-F
AC123A99
AC123A99-F
AC151A99
AC151A99-F
AC152A99-AVG
AC152A99-F-A
AC153A99
AC153A99-F
AC171A99
AC171A99-F
AC172A99
AC172A99-F
AC173A99
AC173A99-F
AC201A99
AC201A99-F
AC202A99
AC202A99-F
AC203A99
AC203A99-F
AC251A99
AC251A99-F
AC252A99
AC252A99-F
AC253A99
AC253A99-F
AC261A99
AC261A99-F
AC262A99
AC262A99-F
AC263A99
AC263A99-F
AC271A99-AVG
AC271A99-F-AVG
AC272A99
AC272A99-F
AC273A99
AC273A99-F
AC301A99
AC301A99-F
AC302A99
AC302A99-F
AC303A99
AC303A99-F

TABLE 1-8

PROJECT TARGET PARAMETERS AND RATIONALES
JEEP TRAIL SAMPLES
NSWC CRANE, CRANE, INDIANA
PAGE 1 OF 3

Parameter	BURN AREA		BURN PIT		BURN AREA/BURN PIT			Rationale/Intended Data Use
	ENVIRONMENTAL MEDIUM(1)		ENVIRONMENTAL MEDIUM(1)		ENVIRONMENTAL MEDIUM(1)			
	SS	SU	SS	SU	GW(2)	SW(3)	SD(3)	
Appendix IX SVOCs (excluding organophosphorus pesticides)	X	X	X	X	X	X	X	To establish absence or presence and extent of contamination. Evaluate risks to potential receptors (human health and ecological) from potentially site-related contaminants.
Appendix IX VOCs			X(4)	X	X	X	X	To establish absence or presence and extent of contamination. Evaluate risks to potential receptors (human health and ecological) from potentially site-related contaminants.
Explosives (SW-846 8330 list)	X	X	X	X	X	X	X	To establish absence or presence and extent of contamination. Evaluate risks to potential receptors (human health and ecological) from potentially site-related contaminants.
Dioxins/Furans (Burn pit and LSC near JT*)			X	X	X	X	X	To establish absence or presence and extent of contamination. Evaluate risks to potential receptors (human health and ecological) from potentially site-related contaminants.
Target Analyte List (TAL) metals plus Sn, dissolved					X	X		To establish absence or presence and extent of contamination. Evaluate risks to potential receptors (human health and ecological) from potentially site-related contaminants.
Target Analyte List (TAL) metals plus Sn, total			X	X	X	X	X	To establish absence or presence and extent of contamination. Evaluate risks to potential receptors (human health and ecological) from potentially site-related contaminants.
Nitrate (f)	X	X	X	X	X	X	X	To establish absence or presence and extent of contamination. Evaluate risks to potential human receptors from potentially site-related contaminants.
Nitrite (f)	X	X	X	X	X	X	X	To evaluate fate and transport of potential contaminants as well as natural attenuation.
Depositional Environment (f)	X	X	X	X				To identify soil sampling locations in the horizontal direction for comparison to background concentrations classified according to depositional environment.

TABLE 1-8

PROJECT TARGET PARAMETERS AND RATIONALES
JEEP TRAIL SAMPLES
NSWC CRANE, CRANE, INDIANA
PAGE 2 OF 3

Parameter	BURN AREA		BURN PIT		BURN AREA/BURN PIT			Rationale/Intended Data Use
	ENVIRONMENTAL MEDIUM(1)		ENVIRONMENTAL MEDIUM(1)		ENVIRONMENTAL MEDIUM(1)			
	SS	SU	SS	SU	GW(2)	SW(3)	SD(3)	
Dissolved Oxygen (f)					X	X		To evaluate water quality. To evaluate natural attenuation and fate and transport.
Flow Rate (f)						X		To establish transient rate and absence or presence of potential contaminants for interpretation of surface water chemical concentrations. Semiquantitative parameter only.
ClO_4^- (Burn pit and LSC near JT)			X	X	X	X	X	To establish absence or presence and extent of contamination. Evaluate risks to potential receptors (human health and ecological) from potentially site-related contaminants
Grain Size (f)		X		X			X	To establish which background data set is most comparable for background comparisons. To evaluate fate and transport of potential contaminants.
Oxidation-Reduction Potential (ORP) (f)					X	X		To evaluate natural attenuation and fate and transport of potential contaminants. To evaluate water quality.
pH (f)					X	X		Measured to establish well stabilization prior to collecting ground water samples. Generally useful for data interpretation and potential future uses.
Sample Depth/location (f)	X	X	X	X	X	X	X	To identify sample locations in the vertical and horizontal direction.
Specific Conductance (f)					X	X		To establish well stabilization prior to collecting ground water samples.
Temperature (f)					X	X		To establish well stabilization prior to collecting ground water samples. Also measured because pH and specific conductivity are temperature dependent.
Turbidity (f)					X	X		To establish well stabilization prior to collecting ground water samples. Measured to determine if contaminants caused by suspended solids.
Water Level (f)					X	X		To calculate potentiometric surface, groundwater velocity and hydraulic gradient

TABLE 1-8

PROJECT TARGET PARAMETERS AND RATIONALES
JEEP TRAIL SAMPLES
NSWC CRANE, CRANE, INDIANA
PAGE 3 OF 3

(f) Field Analysis

* Dioxins/furans at the LSC near JT will only be determined if database review and first round sampling indicate a potential for their generation.

1 Springs, surface water and sediments will also be sampled as part of surface water sampling (see Table 1-9).

2 GW samples collected for Old Jeep Trail are not categorized by location relative to the Burn Pit or Burn Area. Analyte list more closely follows Burn Pit list.

3 Surface water and sediment samples are also required to be analyzed for the contaminants listed in Table 1-4B (Little Sulphur Creek samples).

4 VOC samples will not be taken in the top 6 inches of the surface soil samples.

5 Need stream elevations surveyed also (two to four points) for ground water model and flow calculations.

GW – ground water
SW – surface water
SS – surface soil
SU – subsurface soil
SD – sediment

TABLE 1-9

PROJECT TARGET PARAMETERS AND RATIONALES
LITTLE SULPHUR CREEK SAMPLES
NSWC CRANE, CRANE, INDIANA
PAGE 1 OF 2

Parameter	Environmental Medium[1]		Intended Data Use
	SW	SD	
Appendix IX herbicides	X	X	To establish absence or presence and extent of contamination. Evaluate risks to potential receptors (human health and ecological) from potentially site-related contaminants.
Appendix IX pest/PCBs	X	X	To establish absence or presence and extent of contamination. Evaluate risks to potential receptors (human health and ecological) from potentially site-related contaminants.
Appendix IX SVOCs (excluding organophosphorus pesticides)	X	X	To establish absence or presence and extent of contamination. Evaluate risks to potential receptors (human health and ecological) from potentially site-related contaminants.
Appendix IX VOCs	X	X	To establish absence or presence and extent of contamination. Evaluate risks to potential receptors (human health and ecological) from potentially site-related contaminants.
Dioxins/Furans	X	X	To establish absence or presence and extent of contamination. Qualitatively evaluate risks to potential receptors (human health and ecological) from potentially site-related contaminants.
Explosives (SW-846 8330 list)	X	X	To establish absence or presence and extent of contamination. Evaluate risks to potential receptors (human health and ecological) from potentially site-related contaminants.
Target Analyte List (TAL) metals plus Sn, dissolved	X		To establish absence or presence and extent of contamination. Evaluate risks to potential receptors (human health and ecological) from potentially site-related contaminants.
Target Analyte List (TAL) metals plus Sn, total	X	X	To establish absence or presence and extent of contamination. Evaluate risks to potential receptors (human health and ecological) from potentially site-related contaminants.
Nitrate (f)	X	X	To establish absence or presence and extent of contamination resulting from thorium nitrate burial. Evaluate risks to potential human receptors from potentially site-related contaminants.
Nitrite (f)	X	X	To evaluate fate and transport of potential contaminants as well as natural attenuation.
Total Organic Carbon (TOC)	X	X	To evaluate fate and transport of potential contaminants and to corroborate absence or presence of contamination. Indication of bioavailability of chemicals in sediment.

TABLE 1-9

PROJECT TARGET PARAMETERS AND RATIONALES
LITTLE SULPHUR CREEK SAMPLES
NSWC CRANE, CRANE, INDIANA
PAGE 2 OF 2

Parameter	Environmental Medium[1]		Intended Data Use
	SW	SD	
Depositional Environment (f)		X	To identify soil sampling locations in the horizontal direction for comparison to background concentrations classified according to depositional environment.
Dissolved Oxygen (f)	X		To evaluate water quality. To evaluate natural attenuation and fate and transport.
Flow Rate (f)	X		To establish transient rate and absence or presence of potential contaminants for interpretation of surface water chemical concentrations. Semiquantitative parameter only.
Grain Size (f)		X	To establish which background data set is most comparable for background comparisons. To evaluate fate and transport of potential contaminants.
Oxidation-Reduction Potential (ORP) (f)	X		To evaluate natural attenuation and fate and transport of potential contaminants. To evaluate water quality.
pH (f)	X		Measured to establish well stabilization prior to collecting ground water samples. Generally useful for data interpretation and potential future uses.
Sample Depth/location (f)	X	X	To identify sample locations in the vertical and horizontal direction.
Specific Conductance (f)	X		To establish well stabilization prior to collecting ground water samples.
Temperature (f)	X		To establish well stabilization prior to collecting ground water samples. Also measured because pH and specific conductivity are temperature dependent.
Turbidity (f)	X		To establish well stabilization prior to collecting ground water samples. Measured to determine if contaminants caused by suspended solids.
Soil Bulk Density		X	To evaluate fate and transport of potential contaminants.
% of Sediment coverage in Creek Bed (visual inspection during site walk-down) (f)		X	Estimating sediment loads in creek bed for risk assessment and fate and transport.
Average Sediment depth in Creek Bed (visual inspection during site walk-down) (f)		X	Estimating sediment loads in creek bed for risk assessment and fate and transport.

(f) Field analysis
1 Springs will be sampled as part of surface water sampling.
2 Ground water and subsurface soils are not of interest with respect to Little Sulphur Creek sampling. Ground water data from the OJT sampling, as well as other ABG wells, will be used to assess the impact of ground water on Little Sulphur Creek.

SW – surface water
SD – sediment

TABLE 1-10

**AQUEOUS FIELD TARGET PARAMETERS
AND METHOD DETECTION LIMITS
NSWC CRANE, CRANE, INDIANA**

Parameter	Reporting Limit (mg/L, unless otherwise noted)
Dissolved Oxygen	mg/L
Flow Rate	NA
Nitrate	0.01
Nitrite	0.005
Oxidation Reduction Potential (ORP)	NA
pH	NA
Specific Conductance	0.02 µS/cm
Temperature	°C
Turbidity	1 NTU
Water Level	0.01 foot

NA – Not applicable
mg/L = milligrams per liter
µS/cm = microSiemens per centimeter
NTU = nephelometric turbidity unit
°C = degrees Celsius

TABLE 1-11

DETCTION LIMITS VERSUS RISK CRITERIA
NSWC CRANE INDIANA
CTO 126 AMMUNITION BURNING GROUND
PAGE 1 OF 7

Parameter	CAS NUMBER	Aqueous Matrix			Solid Matrix			
		Laboratory MDL/IDL[1] (ug/L)	Laboratory RL[1] (ug/L)	Risk-Based Target Level[2] (ug/L)	Laboratory MDL/IDL[1] (mg/kg)	Laboratory RL[1] (mg/kg)	Risk-Based Soil Target Level[2] (mg/kg)	Risk-Based Sediment Target Level[2] (mg/kg)
EXPLOSIVES (SW-846 METHOD 8330)								
1,3,5-Trinitrobenzene	99-35-4	0.09	0.65	1100	0.21	0.5	1800	1800
1,3-Dinitrobenzene	99-65-0	0.14	0.65	2.36	0.17	0.5	0.6547	0.000924
2,4,6-Trinitrotoluene (TNT)	118-96-7	0.16	0.65	2.2	0.14	0.5	16	16
2,4-Dinitrotoluene	121-14-2	0.25	0.65	1.2	0.21	0.5	0.00004	0.00004
2,6-Dinitrotoluene	606-20-2	0.11	0.65	1.2	0.22	0.5	0.00003	0.00003
2-Amino-4,6-dinitrotoluene	35572-78-2	0.16	0.65	2	0.18	0.5	--[3]	--
2-Nitrotoluene	88-72-2	0.16	0.65	61	0.19	0.5	370	370
3-Nitrotoluene	99-08-1	0.3	0.65	61	0.25	0.5	370	370
4-Amino-2,6-dinitrotoluene	19406-51-0	0.18	0.65	--	0.35	0.5[4]	--	--
4-Nitrotoluene	99-99-0	0.2	0.65	61	0.22	0.5	370	370
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4	0.3	0.61	0.61	0.28	0.5[4]	4.4	4.4
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	479-45-8	0.14	0.65	360	0.47	0.5[4]	610	610
Nitrobenzene	98-95-3	0.2	0.65	3.4	0.24	0.5	0.007	0.007
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0	0.27	0.65	1800	0.2	0.5	3100	3100
Nitroglycerin	55-63-0	0.16	6.5	---	0.58	5	---	---
EXPLOSIVES (EPA METHOD 353.2/MODIFIED ARMY CORPS METHOD)								
Nitrocellulose	9004-70-0		500	---	---	---	---	---
APPENDIX IX METALS (SW-846 Method 6020 ICP/MS)(3)								
Antimony	7440-36-0	0.1	1.0	6	0.05	1	0.1423	0.3
Arsenic	7440-38-2	0.1	10	0.045	0.05	1	0.39	0.0059
Barium	7440-39-3	0.1	1.0	2000	0.05	1	1.04	82
Beryllium	7440-41-7	0.1	1.0*	4	0.05	1	0.1	0.1
Cadmium	7440-43-9	0.1	10	0.66	0.05	1	0.00222	0.4
Chromium (total)	7440-47-3	0.1	5.0	11	0.05	1*	2	2
Cobalt	7440-48-4	0.1	3.0	5	0.05	1	0.14033	50
Copper	7440-50-8	0.1	2.0	5	0.05	1*	2.96	16
Lead	7439-92-1	0.1	1.0	1.3	0.05	1	0.05373	31
Mercury (SW-846 Method 7470A/7471A)	7439-97-6	0.1	0.2[4]	0.0013	0.02	0.2	0.073	0.1
Nickel	7440-02-0	0.1	10	29	0.05	1	7	7
Selenium	7782-49-2	0.3	1.0	5	0.15	1	0.02765	0.3
Silver	7440-22-4	0.1	3.0*	1	0.05	1	2	0.5
Thallium	7440-28-0	0.1	10	0.56	0.05	1	0.04	0.04
Tin	7440-31-5	0.1	10	73	0.05	5	7.62	45000
Vanadium	7440-62-2	0.1	2	19	0.05	1	1.59	300
Zinc	7440-66-6	0.4	10	58.9	0.2	1	6.62	120
MISCELLANEOUS METALS (SW-846 METHOD 6010B Trace)[5]								
Aluminum	7429-90-5	81	10	87	8.1	20	76000	76000
Calcium	7440-70-2	150	5000	--	15	500	--	--
Iron	7439-89-6	13	100	300	1.3	10	23000	23000
Magnesium	7439-95-4	7.6	5000	--	0.76	500	--	--
Manganese	7439-96-5	0.2	15	50	0.02	1.5	1800	1800
Potassium	7440-09-7	16	5000	--	1.6	500	--	--
Sodium	7440-23-5	76	5000	--	7.6	500	--	--
APPENDIX IX VOLATILE ORGANIC COMPOUNDS (SW-846 METHOD 8260B WITH 25 mL PURGE FOR WATER, 5 g PURGE FOR SOIL or 8015B)								
1,1,1-Trichloroethane	71-55-6	0.057	1	88	0.00034	0.003	0.1	0.1
1,1,1,2-Tetrachloroethane	630-20-6	0.054	0.5	0.43	0.00023	0.003	0.05	0.01089
1,1,2,2-Tetrachloroethane	79-34-5	0.035	0.5	0.055	0.00034	0.003	0.0002	0.0002

TABLE 1-11

DETCTION LIMITS VERSUS RISK CRITERIA
NSWC CRANE INDIANA
CTO 126 AMMUNITION BURNING GROUND
PAGE 2 OF 7

Parameter	CAS NUMBER	Aqueous Matrix			Solid Matrix			
		Laboratory MDL/IDL[1] (ug/L)	Laboratory RL[1] (ug/L)	Risk-Based Target Level[2] (ug/L)	Laboratory MDL/IDL[1] (mg/kg)	Laboratory RL[1] (mg/kg)	Risk-Based Soil Target Level[2] (mg/kg)	Risk-Based Sediment Target Level[2] (mg/kg)
1,1,2-Trichloroethane	79-00-5	0.053	[illegible]	0.2	0.00045	[illegible]	0.0009	0.0009
1,2,3-Trichloropropane	96-18-4	**0.088**	[illegible]	0.0016	0.00054	[illegible]	0.0014	0.0014
1,1-Dichloroethane	75-34-3	0.065	1	47	0.00043	[illegible]	1	0.000575
1,1-Dichloroethene	75-35-4	**0.068**	[illegible]	0.046	0.00039	0.003	0.003	0.003
1,2-Dibromo-3-chloropropane	96-12-8	**0.21**	[illegible]	0.048	0.00079	0.003	0.03518	0.01998
1,2-Dibromoethane	106-93-4	**0.043**	[illegible]	0.00076	0.00031	0.003	0.0069	0.0069
1,2-Dichloroethane	107-06-2	0.076	[illegible]	0.12	0.00045	[illegible]	0.001	0.001
1,2-Dichloropropane	78-87-5	0.031	[illegible]	0.16	0.0004	[illegible]	0.001	0.001
1,4-Dioxane (8015B)	123-91-1	**44**	[illegible]	6.1	**0.039**	[illegible]	2.05	0.00000543
2-Butanone	78-93-3	1.39	5	1900	0.0033	0.015	10	0.13696
2-Chloro-1,3-butadiene (chloroprene)	126-99-8	0.085	10	14	0.00019	[illegible]	0.0029	0.00106
2-Hexanone	591-78-6	0.44	5	1500	0.0019	0.015	12.6	1.01
4-Methyl-2-pentanone	108-10-1	0.45	5	160	0.0018	0.015	443	0.54437
Acetone	67-64-1	1.20	5	610	0.0015	0.015	0.8	0.45337
Acetonitrile (8015B)	75-05-8	3.7	40	79	0.014	0.08	1.37	0.13905
Acrolein	107-02-8	**1.76**	[illegible]	0.042	**0.0049**	[illegible]	0.00027	0.0000144
Acrylonitrile	107-13-1	**2.20**	[illegible]	0.039	**0.0025**	[illegible]	0.02393	0.0000157
Allyl chloride (3-chloro-1-propene)	107-05-1	0.17	10	1800	**0.0013**	[illegible]	0.01338	0.000266
Benzene	71-43-2	0.065	[illegible]	0.41	0.00029	[illegible]	0.002	0.002
Bromodichloromethane	75-27-4	0.053	[illegible]	0.18	0.00016	[illegible]	0.03	0.00113
Bromoform	75-25-2	0.083	1	8.5	0.00045	0.003	0.04	0.04
Bromomethane	74-83-9	0.17	1	8.7	0.00046	0.003	0.01	0.01
Carbon disulfide	75-15-0	0.089	1	84.1	0.00047	0.003	0.09412	0.13397
Carbon tetrachloride	56-23-5	0.035	[illegible]	0.17	0.00039	0.003	0.003	0.003
Chlorobenzene	108-90-7	0.057	1	10	0.00014	0.003	0.07	0.06194
Chloroethane	75-00-3	0.25	1	4.6	0.00053	0.003	3	3
Chloroform	67-66-3	0.054	[illegible]	0.16	0.00024	0.003	0.03	0.027
Chloromethane	74-87-3	0.21	1	1.5	**0.00061**	[illegible]	1.2	0.0000785
cis-1,2-Dichloroethene	156-59-2	0.083	1	61	0.0003	0.003	0.02	0.02
cis-1,3-Dichloropropene	10061-01-5	0.048	[illegible]	0.081	**0.00063**	[illegible]	0.0002	0.0002
Dibromochloromethane	124-48-1	0.063	[illegible]	0.13	0.00025	0.003	0.02	0.02
Dibromomethane	74-95-3	0.048	1	61	**0.00017**	[illegible]	65	0.0000859
Dichlorodifluoromethane	75-71-8	0.28	1	390	0.00032	[illegible]	39.5	0.00133
Ethylbenzene	100-41-4	0.075	1	17.2	**0.00029**	[illegible]	0.7	0.0001
Ethyl methacrylate	97-63-2	0.26	10	550	0.00021	[illegible]	30	0.000602
Isobutanol (8015B)	78-83-1	6.3	40	1800	0.013	0.08	20.8	3.35
Methacrylonitrile	126-98-7	0.48	1	1	**0.00048**	[illegible]	0.05705	0.0000297
Methylene chloride	75-09-2	0.087	1	4.3	0.0005	[illegible]	0.001	0.001
Methyl iodide	74-88-4	0.26	10	--	0.00041	0.003	--	--
Methyl methacrylate	80-62-6	0.31	10	1400	0.00028	0.03	984	0.16756
Propionitrile (8015B)	107-12-0	4.6	40	6080	0.013	[illegible]	0.04983	0.11466
Styrene	100-42-5	0.069	1	56	0.0004	0.003	0.2	0.2
Tetrachloroethene	127-18-4	0.062	1	1.1	0.00039	0.003	0.003	0.003
Toluene	108-88-3	0.083	1	253	0.00026	0.003	0.6	0.6
trans-1,2-Dichloroethene	156-60-5	0.083	1	100	0.00042	0.003	0.03	0.03
trans-1,3-Dichloropropene	10061-02-6	0.056	[illegible]	0.081	**0.00024**	[illegible]	0.0002	0.0002
trans-1,4-Dichloro-2-butene	764-41-0	**0.62**	[illegible]	0.0012	**0.0031**	[illegible]	--	0.00182
Trichloroethene	79-01-6	0.046	1	1.6	0.00049	0.003	0.003	0.003
Trichlorofluoromethane	75-69-4	0.20	1	1300	0.00046	0.003	16.4	0.00307

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		Laboratory MDL/IDL[1] (ug/L)	Laboratory RL[1] (ug/L)	Risk-Based Target Level[2] (ug/L)	Laboratory MDL/IDL[1] (mg/kg)	Laboratory RL[1] (mg/kg)	Risk-Based Soil Target Level[2] (mg/kg)	Risk-Based Sediment Target Level[2] (mg/kg)
Vinyl acetate	108-05-4	0.12	10	248.03	0.00063	0.033	2.3	0.01295
Vinyl chloride	75-01-4	0.28	0.5[4]	0.02	0.00065	0.0033	0.0007	0.0007
Total Xylenes	1330-20-7	0.15	1	117	0.0041	0.01	9	1.88
APPENDIX IX SEMIVOLATILE ORGANIC COMPOUNDS (SW-846 METHOD 8270C OR 8270C - SELECTIVE ION MONITORING[6])								
1,2,4,5-Tetrachlorobenzene	95-94-3	0.94	10	11	0.039	0.67[8]	2.02	18
1,2,4-Trichlorobenzene	120-82-1	0.67	5	69.2	0.042	0.33	0.3	0.3
1,2-Dichlorobenzene	95-50-1	0.66	5	11	0.049	0.33	0.9	0.23132
1,3-Dichlorobenzene	541-73-1	0.59	5	5.5	0.053	0.33	0.42	0.42
1,4-Dichlorobenzene	106-46-7	0.6	2	0.5	0.056	0.33	0.1	0.1
1,4-Naphthoquinone	130-15-4	0.32	10	--	0.038	0.67[8]	--	--
1,4-Phenylenediamine	106-50-3	0.43	100	6900	0.45	0.67[8]	6.16	0.00000568
1-Naphthylamine	134-32-7	0.75	0.11	0.67	0.63	3.3	--	--
2,3,4,6-Tetrachlorophenol	58-90-2	1.3	2.5	14.06	0.041	1.6	0.19878	1.51
2,4,5-Trichlorophenol	95-95-4	1.1	5	3600	0.044	0.33	14	0.08556
2,4,6-Trichlorophenol	88-06-2	1.5	5[4]	2	0.037	0.33	0.008	0.008
2,4-Dichlorophenol	120-83-2	1	10	18	0.057	0.33	0.05	0.05
2,4-Dimethylphenol	105-67-9	0.88	5	100.17	0.066	0.33	0.01	0.30453
2,4-Dinitrophenol	51-28-5	0.79	0.1	4.07	0.044	0.33	0.01	0.00133
2,6-Dichlorophenol	87-65-0	1	10	--	0.055	0.33	1.17	0.00394
2-Acetylaminofluorene	53-96-3	0.37	10	534.97	0.048	0.67[8]	0.59634	0.01532
2-Chloronaphthalene	91-58-7	0.75	0.3	0.396	0.3	0.67[4]	0.01218	0.41723
2-Chlorophenol	95-57-8	0.97	5	8.8	0.029	0.33	0.2	0.0117
2-Methylnaphthalene (SIM)	91-57-6	0.019	0.2	329.55	0.00056	0.033	3.24	0.0202
2-Methylphenol	95-48-7	0.87	5	1800	0.032	0.33	0.8	0.000826
2-Naphthylamine	91-59-8	0.66	10	--	0.053	0.33	3.03	0.00174
2-Nitroaniline	88-74-4	0.87	2	2.1	0.051	0.33	3.5	0.000222
2-Nitrophenol	88-75-5	0.67	5	13.5	0.042	0.33	1.6	0.00777
2-Picoline	109-06-8	0.9	20	3790	0.011	1.8	9.9	0.75305
3,3'-Dichlorobenzidine	91-94-1	0.37	0.2	0.15	0.056	0.33	0.0003	0.0003
3,3'-Dimethylbenzidine	119-93-7	0.45	0.05	0.0073	0.42	3.3	0.053	0.002
3-Methylcholanthrene	56-49-5	0.36	10	0.0891	0.042	0.67[8]	0.07794	8190
3-Methylphenol[7]	108-39-4	0.86	10	1800	0.054	0.33	163	0.000808
4-Methylphenol[7]	106-44-5	1	10	180	0.135	0.33	3.49	0.000845
3-Nitroaniline	99-09-2	0.69	5	--	0.045	0.33	3.16	0.000222
4,6-Dinitro-2-methylphenol	534-52-1	0.77	10	2.3	0.041	0.33	0.14408	0.01038
4-Aminobiphenyl	92-67-1	0.35	10	--	0.035	0.67[8]	0.00305	0.00566
4-Bromophenyl phenyl ether	101-55-3	0.58	5	1.5	0.084	0.33	--	1.68
4-Chloro-3-methylphenol	59-50-7	0.51	5	20	0.045	0.33	7.95	0.38818
4-Chloroaniline	106-47-8	0.87	5	150	0.053	0.33	0.03	0.03
4-Chlorophenyl phenyl ether	7005-72-3	0.67	5	--	0.51	0.33	--	0.656112
4-Nitroaniline	100-01-6	0.81	10	--	0.075	0.33	21.9	0.000222
4-Nitrophenol	100-02-7	2.5	10	35	0.2	0.33[4]	5.12	0.00778
4-Nitroquinoline-1-oxide	56-57-5	0.78	100	--	0.12	1.7	0.12222	0.00124
5-Nitro-o-toluidine	99-55-8	0.37	10	2	0.015	1.7	8.73	0.000845
7,12-Dimethylbenz(a)anthracene	57-97-6	0.39	10	--	0.034	0.67[8]	--	--
Acenaphthene (SIM)	83-32-9	0.006	0.2	9.9	0.0008	0.033	29	0.00671
Acenaphthylene (SIM)	208-96-8	0.012	0.2	370	0.0007	0.033	682	0.00587

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		Laboratory MDL/IDL[1] (ug/L)	Laboratory RL[1] (ug/L)	Risk-Based Target Level[2] (ug/L)	Laboratory MDL/IDL[1] (mg/kg)	Laboratory RL[1] (mg/kg)	Risk-Based Soil Target Level[2] (mg/kg)	Risk-Based Sediment Target Level[2] (mg/kg)
Acetophenone	98-86-2	1.1	10	0.042	0.048	0.33	0.49	0.246
Aniline	62-53-3	0.94	10	0.44	0.058	0.33	0.05678	0.0000338
Aramite	140-57-8	1.1	10	2.7	0.063	0.67[8]	19	0.00000111
Anthracene (SIM)	120-12-7	0.012	0.02	0.029	0.001	0.033	51	0.0469
Benzo(a)anthracene (SIM)	56-55-3	0.008	0.02	0.092	0.001	0.033	0.08	0.0317
Benzo(a)pyrene (SIM)	50-32-8	0.012	0.02	0.0092	0.001	0.033	0.062	0.0319
Benzo(b)fluoranthene (SIM)	205-99-2	0.017	0.02	0.092	0.001	0.033	0.2	0.2
Benzo(g,h,i)perylene (SIM)	191-24-2	0.008	0.2	6.2	0.0013	0.033	119	0.17
Benzo(k)fluoranthene (SIM)	207-08-9	0.009	0.02	0.0056	0.0016	0.033	2	0.24
Benzyl alcohol	100-51-6	1.3	10	281.24	0.04	0.33	65.8	0.03394
Bis(2-chloroethoxy)methane	111-91-1	0.84	5	6400	0.053	0.33	0.30209	0.34971
Bis(2-chloroethyl)ether	111-44-4	1	2[4]	0.0098	0.032	0.33	0.00002	0.00002
Bis(2-chloroisopropyl)ether	108-60-1	1.1	2	0.27	0.037	0.33	0.027	0.027
Bis(2-ethylhexyl)phthalate	117-81-7	0.51	2	2.1	1.3	0.67	0.92594	0.182
Butyl benzyl phthalate	85-68-7	0.5	5	49	0.08	0.33	0.23889	4.19
Chlorobenzilate	510-15-6	0.4	2	0.25	0.046	0.67[8]	1.8	0.86029
Chrysene (SIM)	218-01-9	0.012	0.02	0.033	0.001	0.033	4.73	0.0571
Diallate	2303-16-4	0.66	10	1.1	0.051	0.67[8]	0.45214	0.00151
Di-n-butyl phthalate	84-74-2	0.27	2	3	0.037	0.33	0.14979	0.1105
Di-n-octyl phthalate	117-84-0	0.39	10	20	0.062	0.33	709	40.6
Dibenzo(a,h)anthracene (SIM)	53-70-3	0.006	0.02	0.0016	0.0011	0.033	0.062	0.00622
Dibenzofuran	132-64-9	0.76	5	20	0.036	0.33	290	1.52
Diethyl phthalate	84-66-2	0.64	2	3	0.044	0.33	23	0.00804
p-(Dimethylamino)azobenzene	60-11-7	0.17	10	--	0.061	1.7	--	--
a,a-Dimethylphenethylamine[9]	122-09-8	6.8	10	37	TBD	4	61	61
Dimethyl phthalate	131-11-3	0.76	5	73	0.03	0.33	734	0.02495
Diphenylamine[10]	122-39-4	0.59	10	412.51	0.036	0.67	1.01	0.0346
Ethyl methane sulfonate	62-50-0	0.94	10	--	0.051	1.7	--	--
Ethyl parathion	56-38-2	0.72	10	0.008	0.053	1.7	0.00034	0.00034
Fluoranthene (SIM)	206-44-0	0.008	0.2	8.1	0.001	0.033	122	0.1113
Fluorene (SIM)	86-73-7	0.006	0.2	3.9	0.0008	0.033	28	0.0212
Hexachlorobenzene	118-74-1	0.71	2	0.00024	0.05	0.33	0.1	0.02
Hexachlorobutadiene	87-68-3	0.51	10[4]	0.223	0.043	0.33	0.03976	0.1
Hexachlorocyclopentadiene	77-47-4	0.27	2	50	0.045	0.33	0.75537	0.90074
Hexachloroethane	67-72-1	0.45	2	4.8	0.061	0.33	0.02	0.02
Hexachlorophene	70-30-4	0.23	0.7	0.228	0.0023	0.017	0.19878	18
Hexachloropropene	1888-71-7	0.84	20	20	0.032	1.8	--	0.0002
Indeno(1,2,3-cd)pyrene (SIM)	193-39-5	0.008	0.02	0.092	0.001	0.033	0.62	0.2
Isodrin	465-73-6	0.42	10	0.0309	0.044	0.67[8]	0.00332	0.05516
Isophorone	78-59-1	0.91	5	71	0.054	0.33	0.03	0.03
Isosafrole	120-58-1	0.75	10	--	0.076	1.5	9.94	0.00412
Kepone	143-50-0	1.23	25	0.0037	0.3	17	0.027	0.00331
Methapyrilene	91-80-5	1.17	40	--	0.12	3.3	2.78	0.0000144
Methyl methane sulfonate	66-27-3	1	10	--	0.038	1.3	--	--
Methyl parathion	298-00-0	0.65	10	9.1	0.063	0.67[8]	0.000292	0.000755
n-Nitrosodi-n-butylamine	924-16-3	1.2	10	0.002	0.065	0.67[8]	0.024	0.024
n-Nitrosodiethylamine	55-18-5	0.64	10	0.00045	0.058	0.67[8]	0.0032	0.0032

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		Laboratory MDL/IDL[1] (ug/L)	Laboratory RL[1] (ug/L)	Risk-Based Target Level[2] (ug/L)	Laboratory MDL/IDL[1] (mg/kg)	Laboratory RL[1] (mg/kg)	Risk-Based Soil Target Level[2] (mg/kg)	Risk-Based Sediment Target Level[2] (mg/kg)
n-Nitrosodimethylamine	62-75-9	0.84	10	0.0013	0.025	0.67[6]	0.0000321	0.00000275
n-Nitrosodi-n-propylamine	621-64-7	1.2	2[4]	0.0096	0.054	0.33	0.000002	0.000002
n-Nitrosomethylethylamine	62-75-9	1.5	10	0.0031	0.048	0.67[6]	0.00166	0.00000485
n-Nitrosomorpholine	59-89-2	0.91	10[4]	--	0.04	0.67[6]	0.07057	0.0000037
n-Nitrosopiperidine	100-75-4	1.1	10	--	0.052	0.67[6]	0.00665	0.0000226
n-Nitrosopyrrolidine	930-55-2	0.95	10	0.032	0.086	0.67[6]	0.01258	0.000000908
Naphthalene (SIM)	91-20-3	0.034	0.2	6.2	0.0012	0.033	0.09939	0.0346
Pentachlorobenzene	608-93-5	0.96	10	0.47	0.0047	0.67[6]	0.49695	1.26
Pentachloroethane	76-01-7	0.79	10	56.42	0.041	0.67[6]	10.7	0.68918
Pentachloronitrobenzene	82-68-8	0.53	10	0.26	0.064	0.67[6]	1.9	1.9
Phenacetin	62-44-2	0.19	10	--	0.064	0.67[6]	11.7	0.00225
Phenanthrene (SIM)	85-01-8	0.012	0.2	2.1	0.0015	0.033	45.7	0.0419
Phenol	108-95-2	1	5	100	0.044	0.33	5	0.02726
Pronamide	23950-58-5	0.54	25	160	0.046	0.67[6]	0.0136	0.0016
Pyrene (SIM)	129-00-0	0.011	0.2	0.3	0.05	0.67[6]	78.5	0.053
Pyridine	110-86-1	1.9	10	37	0.0013	0.033	1.03	0.10617
Safrole	94-59-7	1.1	10	40	0.071	0.33	0.40398	0.16486
o-Toluidine	95-53-4	0.89	10	0.28	0.042	0.67[6]	2	0.000199
O,O,O-Triethyl phosphorothioate	126-68-1	1.1	10	58.25	0.045	0.67[6]	--	--
APPENDIX IX ORGANOCHLORINE PESTICIDES and PCBs (SW-846 METHOD 8081A and 8082)								
Aldrin	309-00-2	0.0042	0.01	0.004	0.00026	0.0017	0.00332	0.002
Alpha-BHC	319-84-6	0.0047	0.01	0.011	0.00026	0.0017	0.00003	0.00003
Alpha-chlordane	5103-71-9	0.0051	0.01	0.00029	0.00026	0.0017	0.224	0.0045
Beta-BHC	319-85-7	0.0054	0.03	0.037	0.00026	0.0017	0.0001	0.0001
4,4'-DDD	72-54-8	0.0074	0.01	0.0011	0.00026	0.0033	0.75815	0.00553
4,4'-DDE	72-55-9	0.0067	0.01	4.51E-09	0.00026	0.0033	0.59587	0.00142
4,4'-DDT	50-29-3	0.0088	0.01	0.001	0.00026	0.0033	0.0175	0.00119
Delta-BHC	319-86-8	0.0082	0.01	0.011	0.00026	0.0017	9.94	71.5
Dieldrin	60-57-1	0.0092	0.01	0.000026	0.00026	0.0033	0.0002	0.0002
Endosulfan I	115-29-7	0.0049	0.01	0.003	0.00026	0.0017	0.11927	0.000175
Endosulfan II	33213-65-9	0.0075	0.01	0.003	0.00026	0.0033	0.11927	0.000104
Endosulfan sulfate	1031-07-8	0.0079	0.1	0.22	0.00026	0.0033	0.03578	0.0346
Endrin	72-20-8	0.0074	0.01	0.002	0.00026	0.0033	0.0101	0.00267
Endrin aldehyde	7421-93-4	0.007	0.1	0.15	0.00026	0.0033	0.0105	3.2
Gamma-BHC (Lindane)	58-89-9	0.0047	0.01	0.01	0.00026	0.0017	0.0005	0.0005
Gamma-chlordane	12789-03-6	0.0041	0.01	0.00029	0.00026	0.0017	0.224	0.0045
Heptachlor	76-44-8	0.006	0.01	0.00039	0.00026	0.0017	0.00598	0.0006
Heptachlor epoxide	1024-57-3	0.0054	0.01	0.00048	0.00026	0.0017	0.03	0.0006
Methoxychlor	72-43-5	0.047	0.01	0.005	0.00026	0.017	0.01988	0.00359
Toxaphene	8001-35-2	1.1	0.01	0.0002	0.00026	0.17	0.11927	0.000109
Aroclor-1016	12674-11-2	0.043	0.1	0.000029	0.00026	0.033	0.67971	0.0341
Aroclor-1221	11104-28-2	0.084	0.1	0.000029	0.00026	0.067	0.22	0.0341
Aroclor-1232	11141-16-5	0.23	0.1	0.000029	0.00026	0.033	0.22	0.0341
Aroclor-1242	53469-21-9	0.37	0.1[4]	0.000029	0.00026	0.033	0.22	0.0341
Aroclor-1248	12672-29-6	0.11	0.1	0.000029	0.00026	0.033[4]	0.22	0.0341
Aroclor-1254	11097-69-1	0.11	0.1	0.000029	0.00026	0.033[4]	0.22	0.0341
Aroclor-1260	11096-82-5	0.034	0.1	0.000029	0.00026	0.033	0.22	0.0341

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		Laboratory MDL/IDL[1] (ug/L)	Laboratory RL[1] (ug/L)	Risk-Based Target Level[2] (ug/L)	Laboratory MDL/IDL[1] (mg/kg)	Laboratory RL[1] (mg/kg)	Risk-Based Soil Target Level[2] (mg/kg)	Risk-Based Sediment Target Level[2] (mg/kg)
APPENDIX IX HERBICIDES (SW-846 METHOD 8151A)								
2,4-D	94-75-7	0.06	0.08	70	0.00059	0.0027	0.02725	0.00579
2,4,5-T	93-76-5	0.061	0.08	360	0.00045	0.0027	0.59634	58.7
2,4,5-TP (Silvex)	93-72-1	0.011	0.08	50	0.00034	0.0027	0.1088	7.35
Dinoseb[11]	88-85-7	0.038	0.08	0.39	0.0035	0.0054	0.0218	0.01178
Pentachlorophenol	87-86-5	TBD	0.02	0.56	TBD	0.00068	0.001	0.001
DIOXINS/FURANS (SW-846 METHOD 8290)[12]								
2,3,7,8-Tetrachlorodibenzodioxin (2,3,7,8-TCDD)	1746-01-6	4.6E-6	1E-5*		5.4E-7	[illegible]	2.87E-07	2.87E-07
1,2,3,7,8-Pentachlorodibenzodioxin (1,2,3,7,8-PeCDD)	40321-76-4	1.34E-5	5E-5*		2.6E-6	[illegible]	2.87E-07	2.87E-07
1,2,3,6,7,8-Hexachlorodibenzodioxin (1,2,3,6,7,8-HxCDD)	67653-85-7	3.12E-5	5E-5*[4]		2.4E-6	[illegible]	2.87E-06	2.87E-06
1,2,3,4,7,8-Hexachlorodibenzodioxin (1,2,3,4,7,8-HxCDD)	39227-28-6	1.94E-5	5E-5*		2.1E-6	[illegible]	2.87E-06	2.87E-06
1,2,3,7,8,9-Hexachlorodibenzodioxin (1,2,3,7,8,9-HxCDD)	72918-21-9	4.21E-5	5E-5*[4]		2.4E-6	[illegible]	2.87E-06	2.87E-06
1,2,3,4,6,7,8-Heptachlorodibenzodioxin (1,2,3,4,6,7,8-HpCDD)	67562-39-4	8.4E-6	5E-5*		1.6E-6	5E-6	2.87E-05	2.87E-05
1,2,3,4,6,7,8,9-Octachlorodibenzodioxin (OCDD)	3268-87-9	3.17E-5	1E-4*		5.1E-6	1E-5[4]	2.87E-03	2.87E-03
2,3,7,8-Tetrachlorodibenzofuran (2,3,7,8-TCDF)	1746-01-6	4.7E-6	1E-5*		6.2E-7	1E-6[4]	2.87E-06	2.87E-06
1,2,3,7,8-Pentachlorodibenzofuran (1,2,3,7,8-PeCDF)	57117-41-6	1.84E-5	5E-5*		3.8E-6	5E-6[4]	5.74E-06	5.74E-06
2,3,4,7,8-Pentachlorodibenzofuran (2,3,4,7,8-PeCDF)	57117-31-4	3.37E-5	5E-5*[4]		3.0E-6	[illegible]	5.74E-07	5.74E-07
1,2,3,6,7,8-Hexachlorodibenzofuran (1,2,3,6,7,8-HxCDF)	57117-44-9	8.1E-6	5E-5		1.4E-6	[illegible]	2.87E-06	2.87E-06
1,2,3,7,8,9-Hexachlorodibenzofuran (1,2,3,7,8,9-HxCDF)	19408-74-3	7.5E-6	5E-5		1.9E-6	[illegible]	2.87E-06	2.87E-06
1,2,3,4,7,8-Hexachlorodibenzofuran (1,2,3,4,7,8-HxCDF)	70648-26-9	3.05E-5	5E-5		2.7E-6	[illegible]	2.87E-06	2.87E-06
2,3,4,6,7,8- Hexachlorodibenzofuran (2,3,4,6,7,8-HxCDF)	60851-34-5	9.01E-5	5E-5[4]		1.4E-6	[illegible]	2.87E-06	2.87E-06
1,2,3,4,6,7,8-Heptachlorodibenzofuran (1,2,3,4,6,7,8-HpCDF)	67562-39-4	1.08E-5	5E-5*		3.1E-6	5E-6[4]	2.87E-05	2.87E-05
1,2,3,4,7,8,9- Heptachlorodibenzofuran (1,2,3,4,7,8,9-HpCDF)	55673-89-7	7.78E-5	5E-5*[4]		9.5E-6	5E-6[4]	2.87E-04	2.87E-04
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	39001-02-00	3.88E-5	1E-4		4.1E-6	1E-5	2.87E-03	2.87E-03
Total Tetrachlorodibenzodioxin (Total TCDD)		NA[6]	1E-5		NA	[illegible]	2.87E-07	2.87E-07
Total Pentachlorodibenzodioxin (Total PCDD)		NA	5E-5		NA	[illegible]	2.87E-07	2.87E-07
Total Hexachlorodibenzodioxin (Total HxCDD)		NA	5E-5		NA	[illegible]	2.87E-06	2.87E-06
Total Heptachlorodibenzodioxin (Total HpCDD)		NA	5E-5		NA	5E-6	2.87E-05	2.87E-05
Total Tetrachlorodibenzofuran (Total TCDF)		NA	1E-5		NA	1E-6	2.87E-06	2.87E-06
Total Pentachlorodibenzofuran (Total PCDF)		NA	5E-5		NA	5E-6	5.74E-06	5.74E-06
Total Hexachlorodibenzofuran (Total HxCDF)		NA	5E-5		NA	5E-6	2.87E-06	2.87E-06
Total Heptachlorodibenzofuran (Total HpCDF)		NA	5E-5		NA	5E-6	2.87E-03	2.87E-03
MISCELLANEOUS PARAMETERS								
Bromide (SW-846 Method 9056)	24959-67-9	11	100		---	---	---	
Perchlorate (EPA Method 314.0)	14797-73-0			18		---	---	---
Nitrate (SW-846 Method 9056)	14797-55-8			---		4	---	---
Nitrite (SW-846 Method 9056)	14797-65-0			---		0.1	---	---

MDL = method detection limit
IDL = instrument detection limit
RL = reporting limit
µg/L = micrograms per liter.
mg/kg = milligrams per kilogram.
mg/L = milligrams per liter.

TBD = To Be Determined
NA = Not Applicable
ANR = Analyte Not Required

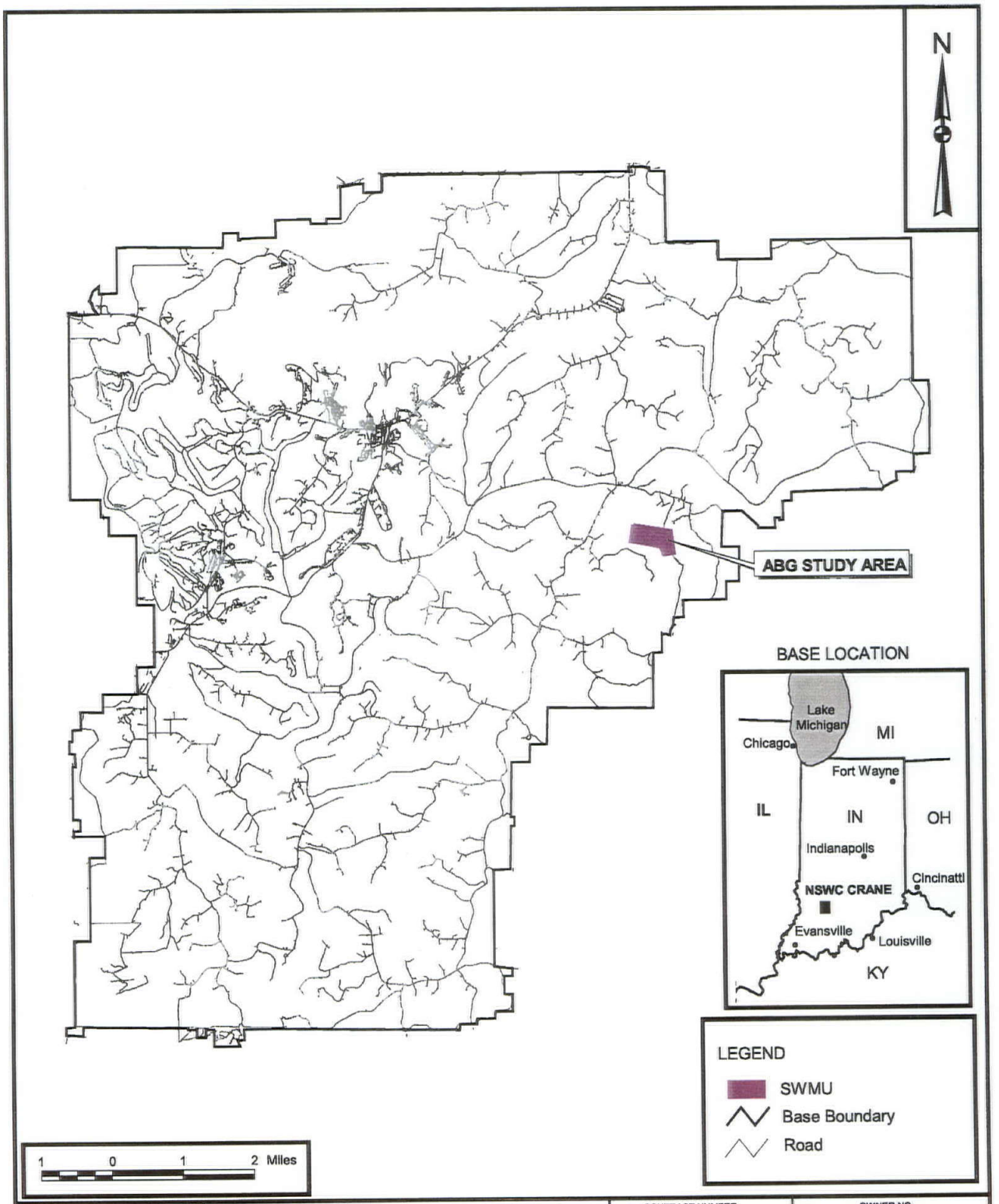
Shaded cells indicate laboratory MDLs that exceed a risk-based target level for the project.

TABLE 1-11

DETCTION LIMITS VERSUS RISK CRITERIA
NSWC CRANE INDIANA
CTO 126 AMMUNITION BURNING GROUND
PAGE 7 OF 7

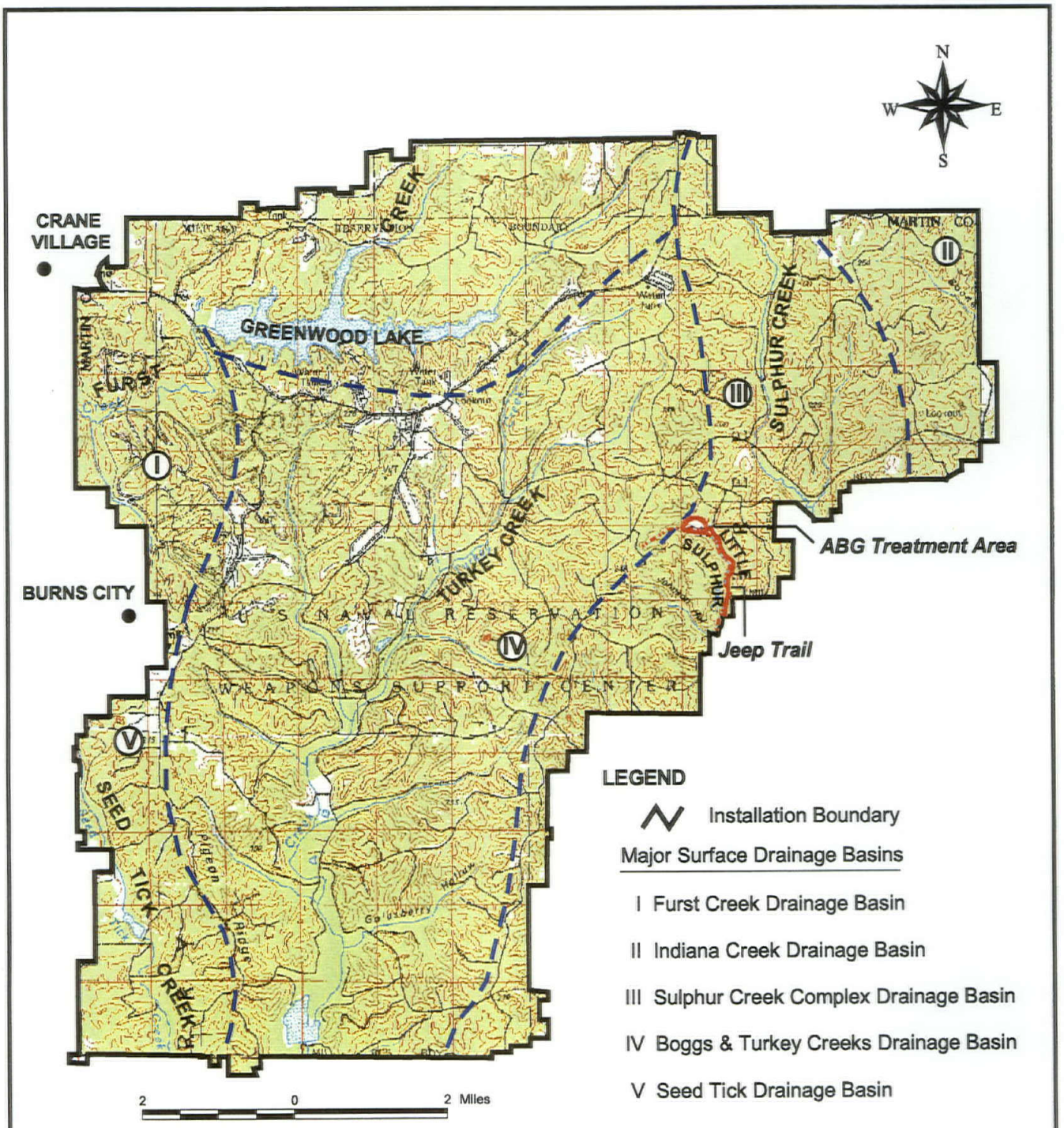
Parameter	CAS NUMBER	Aqueous Matrix			Solid Matrix			
		Laboratory MDL/IDL[1] (ug/L)	Laboratory RL[1] (ug/L)	Risk-Based Target Level[2] (ug/L)	Laboratory MDL/IDL[1] (mg/kg)	Laboratory RL[1] (mg/kg)	Risk-Based Soil Target Level[2] (mg/kg)	Risk-Based Sediment Target Level[2] (mg/kg)

* Asterisks indicate those chemicals for which the laboratory RL exceeds the risk-based target level for the project.
1 Method Detection Limits (MDLs) (all parameters except metals), instrument detection limits (IDLs) (metals only), and reporting limits (R+A4OLs) as provided by Laucks Testing Laboratories, Inc. and Triangle Laboratories, Inc. (dioxins/furans only). The values may change prior to the SWMU investigations as laboratory MDLs and IDLs are updated.
2 Value is based on the lowest human health or ecological risk-based criteria as presented in Appendix B, Tables B-1 (aqueous) and B-2 (solids).
3 Risk-based target level is not provided because human and ecological risk-based criteria are not available for this parameter.
4 Laucks Testing Laboratories is confident that it can reliably report to this PQL, even though this value is less than two times the MDL and/or IDL.
5 These are not Appendix 9 metals. They are being analyzed for general ground water quality information.
If these elements are within linear range on the ICPMS analysis, they will be quantitated by ICPMS, rather than ICP Trace.
6 Laucks Low Cal. Standard is 0.04 for these SIM analytes, but Laucks prefers not to report below 0.08.
7 3-Methylphenol and 4-methylphenol coelute; therefore, one analytical result for 3-, 4-methylphenol will be reported.
8 These reporting limits are estimated only, as Laucks Testing Laboratories has not developed Appendix 9 RLs on soils.
9 This compound does not recover well through the extraction technique. Periodically, the extraction exhibits zero recoveries at low spiking levels (typical of MDL determination levels).
10 N-Nitrosodiphenylamine is more toxic than diphenylamine.
However, n-nitrosodiphenylamine rapidly degrades to diphenylamine.
Therefore, only diphenylamine will be reported, but results for diphenylamine will be treated as n-nitrosodiphenylamine during risk assessment.
11 Laucks Low Cal. Standard is 2.7 ug/kg (soil) for Dinoseb, but Laucks prefers not to report below 5.4 ug/kg (soil)
12 The target level is calculated using the target level for 2,3,7,8-TCDD and the toxicity equivalent factor (TEF) presented in current U.S. EPA guidance (U.S. EPA, March 1989).



DRAWN BY J. LAMEY — DATE 6/6/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0514	OWNER NO. CTO 126
CHECKED BY — DATE —	SITE LOCATION MAP AMMUNITION BURNING GROUNDS NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY — DATE —	
COST/SCHEDULE-AREA		APPROVED BY — DATE —	
SCALE AS NOTED		DRAWING NO. FIGURE 1-1	REV 0

P:\GIS\NSWC_CRANE\7651.APR SITE LOCATION 6/6/00 JAL



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

DRAWN BY J. LAMEY / DATE 6/1/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0514	OWNER NO. CTO 126
CHECKED BY — / DATE —	AOC LOCATIONS AND DRAINAGE BASINS NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY — / DATE —	
COST/SCHEDULE-AREA		APPROVED BY — / DATE —	
SCALE AS NOTED		DRAWING NO. FIGURE 1-2	REV 0

P:\GIS\NSWC_CRANE\7651.APR AOC LOCATIONS AND DRAINAGE BASINS 6/6/00 JAL

USGS Topographic Quadrangles:
Indian Springs Quadrangle, Indiana - Martin Co.
Williams Quadrangle, Indiana

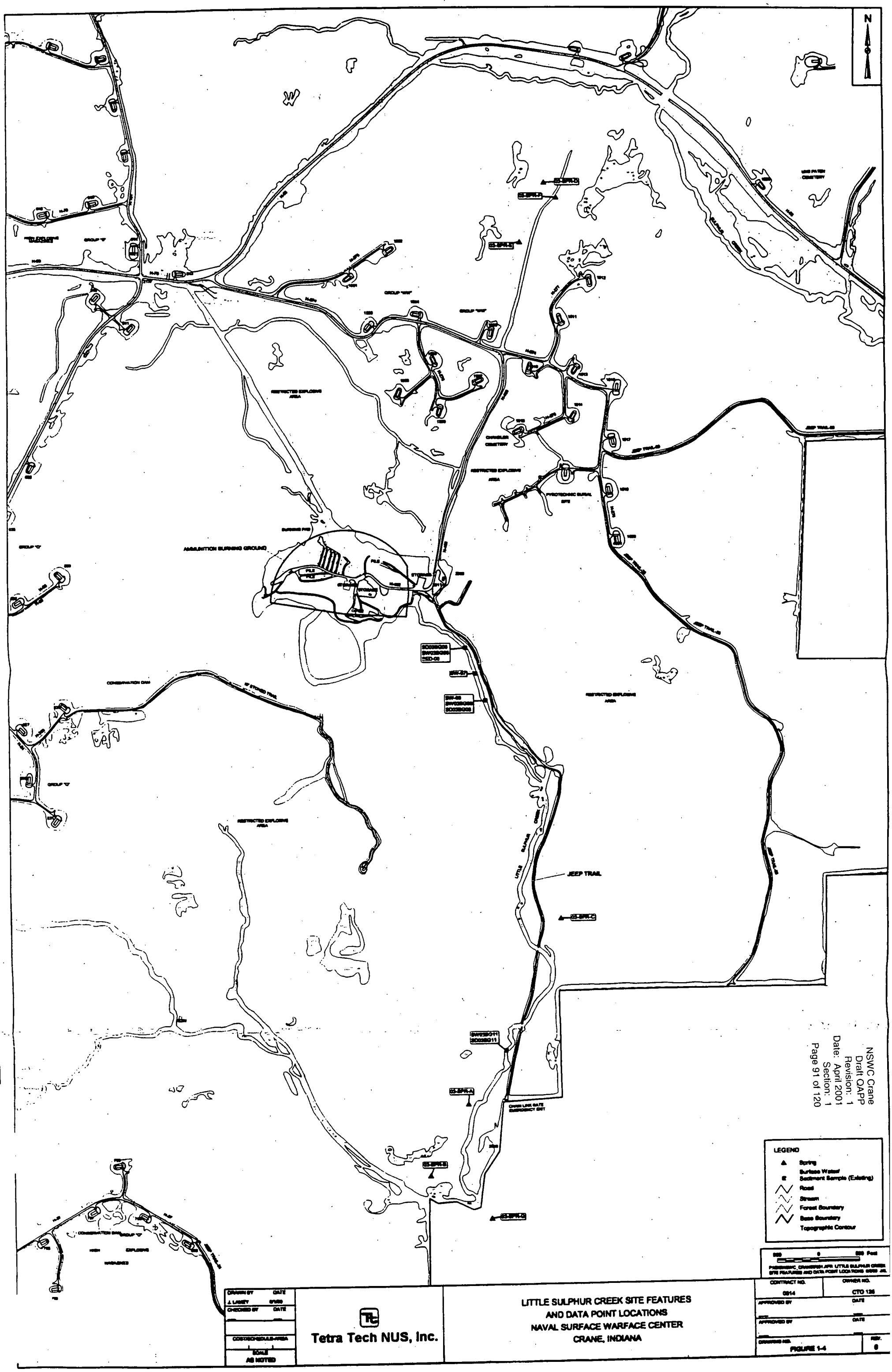
DRAWN BY	DATE
J. LAMEY	4/20/00
CHECKED BY	DATE
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

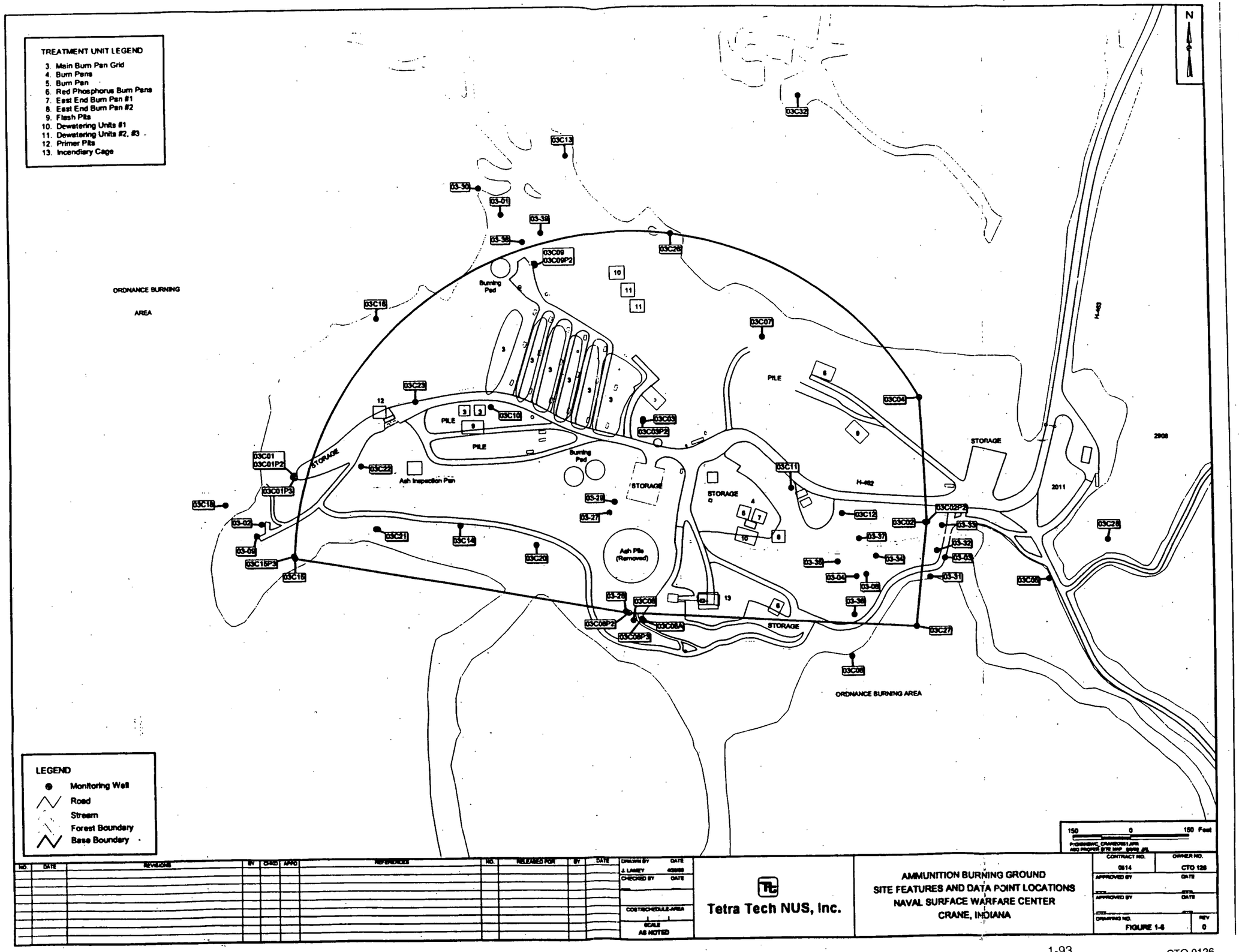
Tetra Tech NUS, Inc.

SITE MAP
AMMUNITION BURNING GROUND/JEEP TRAIL STUDY AREA
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

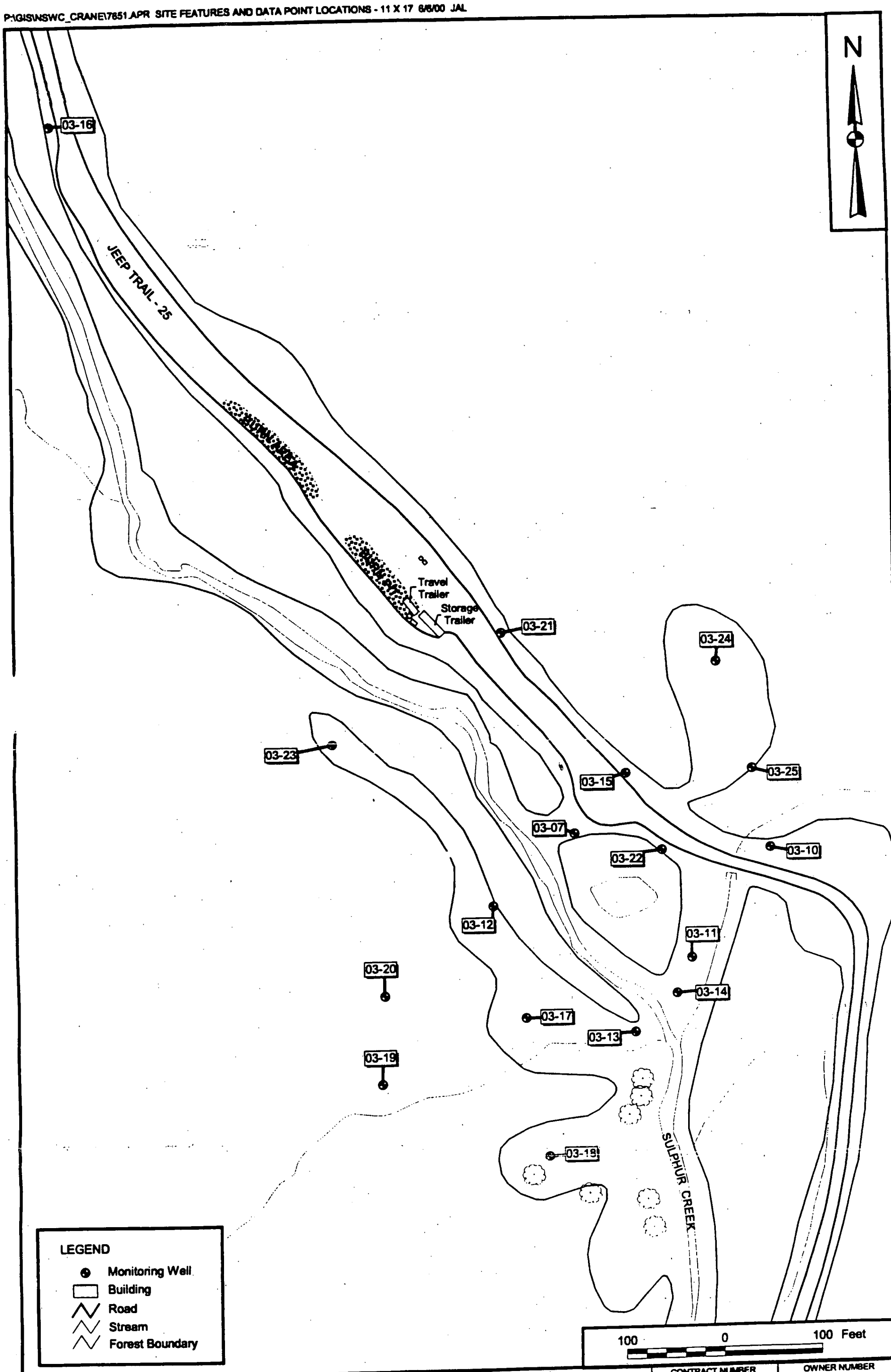
CONTRACT NO.	OWNER NO.
0514	CTO 126
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING NO.	REV.
FIGURE 1-3	0

NSWC Crane
Draft QAPP
Revision: 1
Date: April 2001
Section: 1
Page 89 of 120


N
AMMUNITION BURNING GROUND
RESTRICTED EXPLOSIVE AREA
PYROTECHNIC BURIAL SITE
JEEP TRAIL
CONSERVATION DAM
LITTLE SULPHUR CREEK
LEGEND
Spring
Surface Water
Sediment Sample (Existing)
Road
Stream
Forest Boundary
Base Boundary
Topographic Contour
Tetra Tech NUS, Inc.
LITTLE SULPHUR CREEK SITE FEATURES
AND DATA POINT LOCATIONS
NAVAL SURFACE WARFACE CENTER
CRANE, INDIANA
FIGURE 1-4
AS NOTED

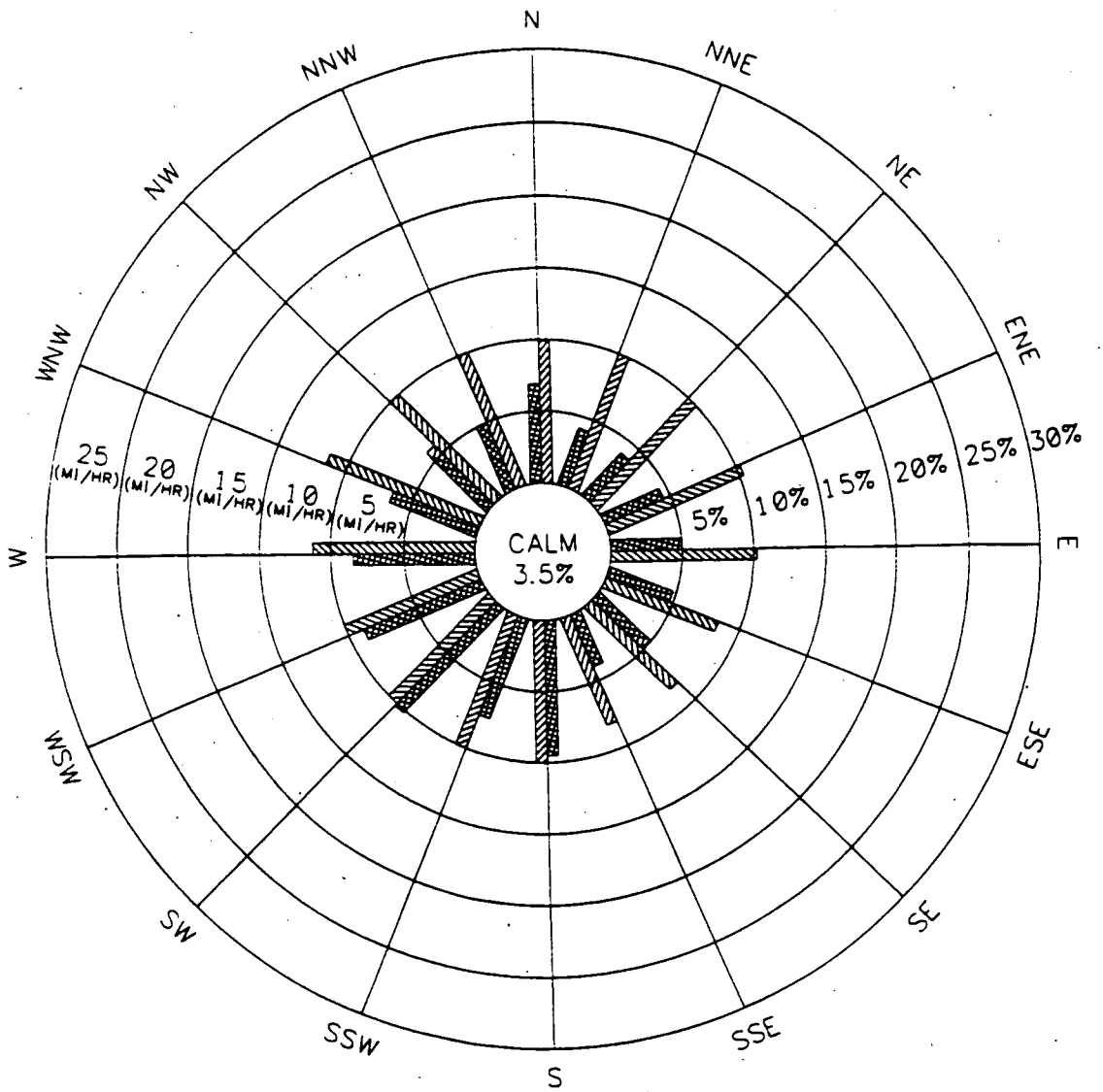

TREATMENT UNIT LEGEND
3. Main Burn Pan Grid
4. Burn Pans
5. Burn Pan
6. Red Phosphorus Burn Pans
7. East End Burn Pan #1
8. East End Burn Pan #2
9. Flash Pits
10. Dewatering Units #1
11. Dewatering Units #2, #3
12. Primer Pits
13. Incendiary Cage
N
ORDNANCE BURNING AREA
Burning Pad
PILE
STORAGE
Ash Inspection Pan
Ash Pile (Removed)
H-482
2011
2908
03C32
03C13
03-30
03-01
03-38
03-39
03C26
03C09
03C09P2
03C16
03C07
03C04
03C23
03C10
03C03
03C03P2
03C01
03C01P2
03C01P3
03C22
03C11
03C12
03C02P2
03C02
03-33
03-32
03-03
03-31
03-37
03-34
03-36
03-04
03-08
03-35
03C18
03-02
03-09
03C18P3
03C21
03C14
03C20
03-28
03-27
03C08
03C08P2
03C08A
03C08P3
03C27
03C05
03C06
03C28
ORDNANCE BURNING AREA
LEGEND
Monitoring Well
Road
Stream
Forest Boundary
Base Boundary
150 0 150 Feet
Tetra Tech NUS, Inc.
AMMUNITION BURNING GROUND
SITE FEATURES AND DATA POINT LOCATIONS
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA
CONTRACT NO. 0514
OWNER NO. CTO 126
FIGURE 1-6
REV 0
SCALE AS NOTED

P:\GIS\NSWC_CRANE\7651.APR SITE FEATURES AND DATA POINT LOCATIONS - 11 X 17 6/6/00 JAL



DRAWN BY	DATE	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0514	OWNER NUMBER CTO 126
J. LAMEY	6/6/00		APPROVED BY —	DATE —
CHECKED BY —	DATE —	JEEP TRAIL SITE FEATURES AND DATA POINT LOCATIONS NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY —	DATE —
COST/SCHEDULE-AREA			DRAWING NO. FIGURE 1-6	REV 0
SCALE AS NOTED				

ACAD:0514KM01.dwg 06/07/00 DT



LEGEND

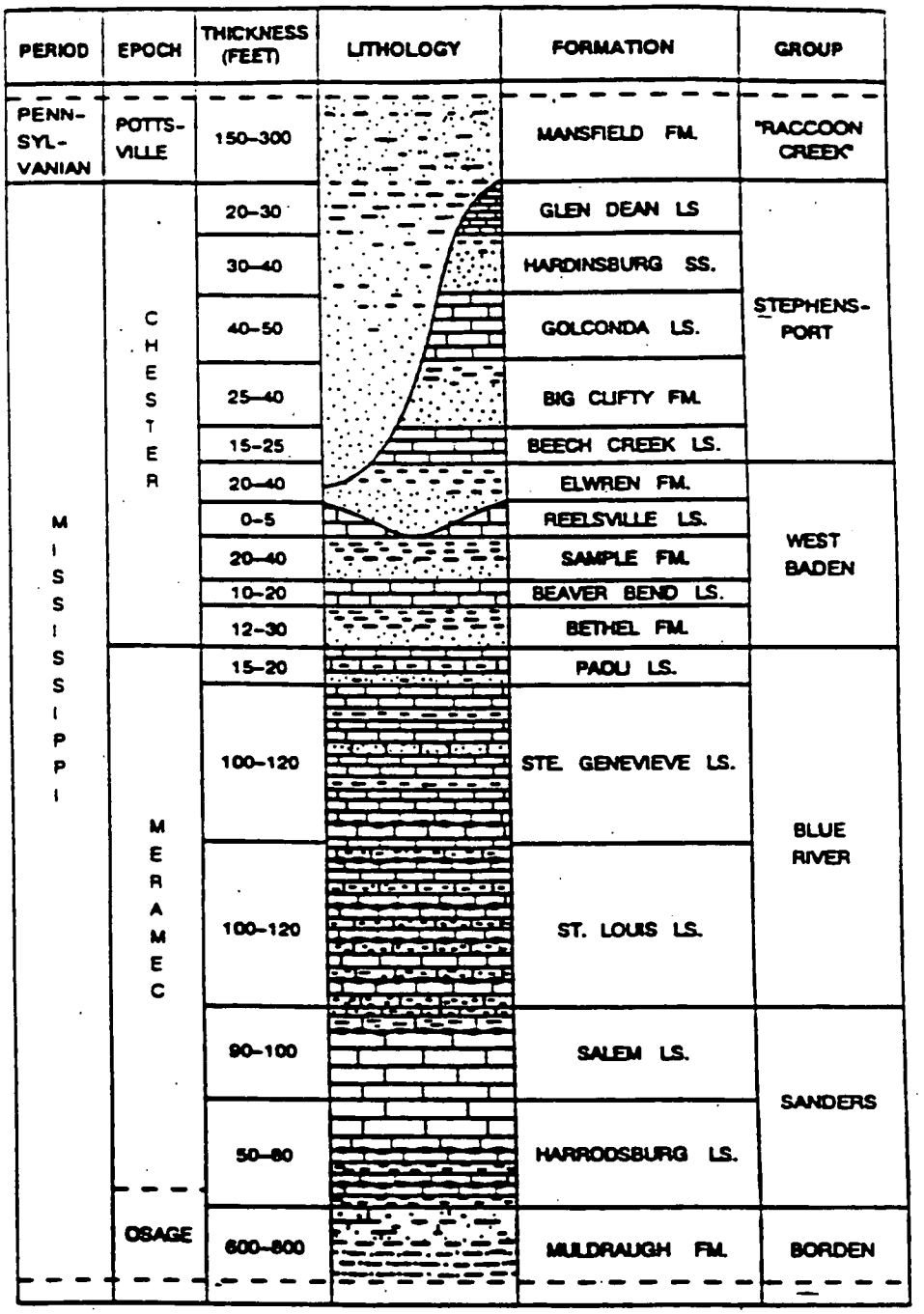
WIND DIRECTION FREQUENCY (PERCENT)
(DIRECTION FROM WHICH THE WIND IS BLOWING)

MEAN WIND SPEED (MI/HR)

DATA SOURCE: INDIANAPOLIS, INDIANA AIRPORT
PERIOD OF RECORD: 1985–1989
43,824 OBSERVATIONS

DRAWN BY DLT DATE 6/7/00			CONTRACT NO. 0514
CHECKED BY DATE		FIVE-YEAR WINDROSE SUMMARY FOR INDIANAPOLIS, INDIANA NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY DATE
COST/SCHED-AREA			APPROVED BY DATE
SCALE NOT TO SCALE			DRAWING NO. FIGURE 1-7 REV. 1

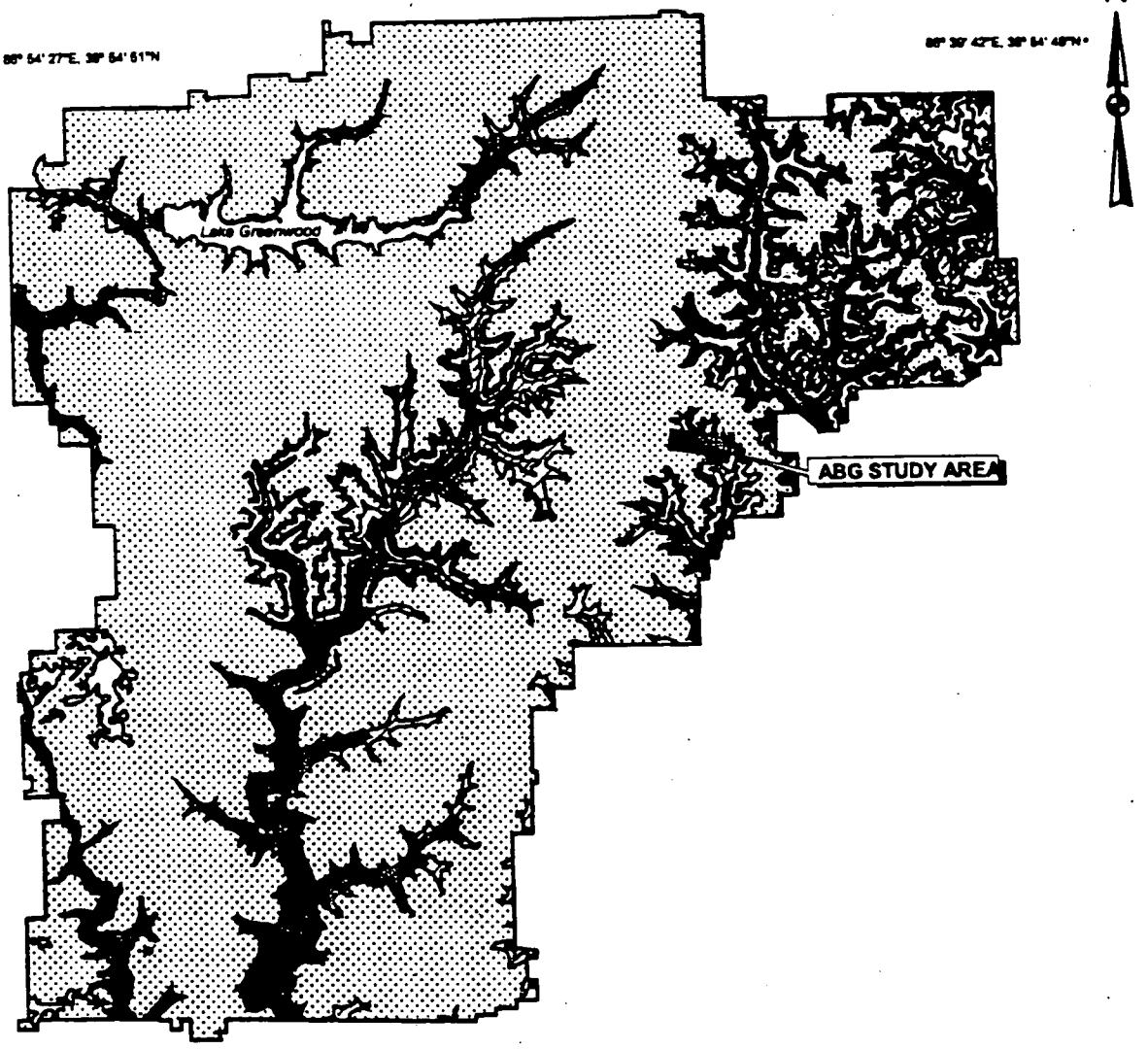
FORM CADD NO. SDIV_AV.DWG - REV 0 - 1/20/98



Source: Draft Report, RCRA Facility Investigation
Phase II Groundwater Release Assessment, SWMU 08/09
Demolition Area and Phase III Release
Characterization SWMU 07/09 Old Rifle Range
November 1995 - Figure 13
by William L. Murphy and Roy Wade

DRAWN BY / DATE	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0514	OWNER NO. CTO 126
CHECKED BY / DATE	STRATIGRAPHIC COLUMN FOR ROCK UNITS ENCOUNTERED AT THE NAVAL SURFACE WARFARE CENTER (SOURCE: PALMER, 1969; CITED IN MURPHY AND WADE, 1995) NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY / DATE	
COST/SCHEDULE-AREA		APPROVED BY / DATE	
SCALE: AS NOTED		DRAWING NO. FIGURE 1-8	REV 0

P:\GIS\NWC_CRANE\GIS\APR STRATIGRAPHIC COLUMN 6/99 JAL



86° 54' 29"E, 38° 44' 8"N

Explanation of Geology

86° 46' 4"E, 38° 44' 7"N

- Alluvium
- Loess
- Glacial Outwash
- Raccoon Creek Group and undifferentiated
- Sandstone-dominated horizon of Lower Pennsylvanian
- 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
- Select Solid Waste Management Units (SWMUs)

12000 0 12000 Feet

(Modified from Blunck, 1995)

DRAWN BY D. PERRY	DATE 15-MAR-99	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0514 / OWNER NO. CTO 126
CHECKED BY —	DATE —	SURFICIAL GEOLOGY MAP NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY — / DATE —
COST/SCHEDULE-AREA			APPROVED BY — / DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 1-9 / REV 0

P:\GEN\NWC_CRANE\007 APR 99\00 JAL SURFICIAL GEOLOGY MAP LAYOUT

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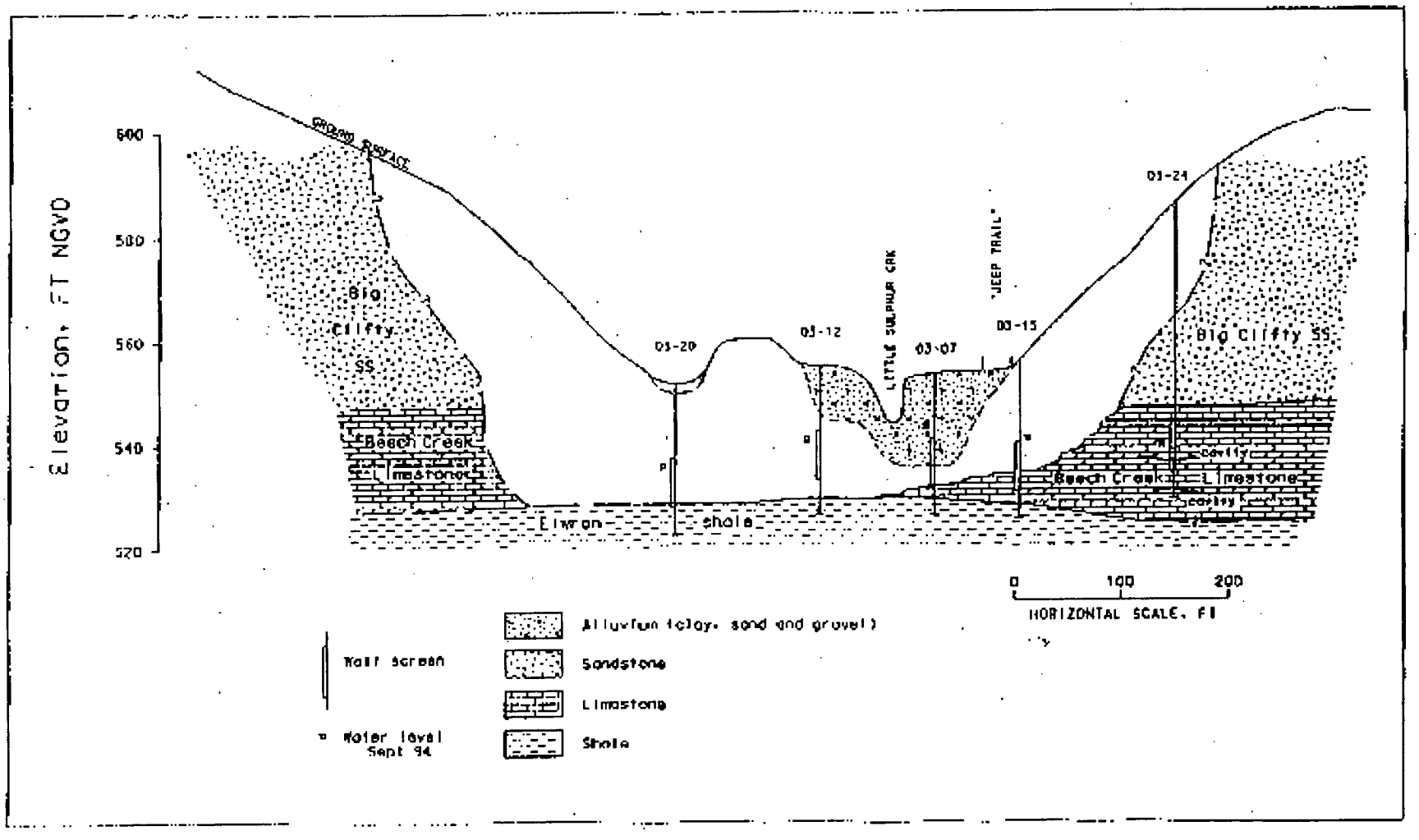
FIGURE 1-10

GEOLOGIC PROFILE FOR THE JEEP TRAIL SITE



Obtained from "Letter Report: Preliminary Assessment of Geology, Groundwater Hydrology, and Groundwater Contaminant Distribution of Jeep Trail 25 Area, Ammunition Burning Ground, Naval Warfare Center, Crane, Indiana".

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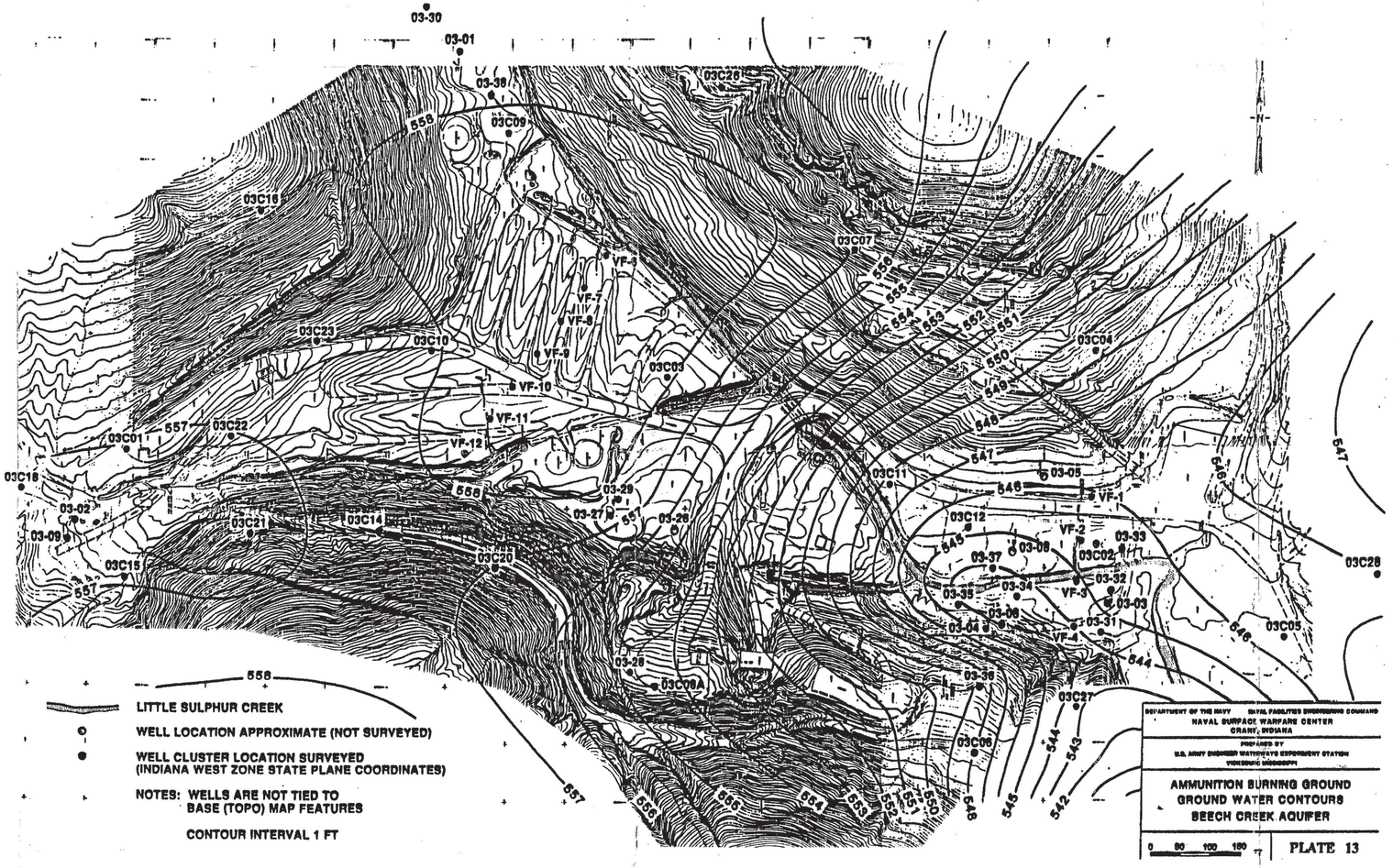


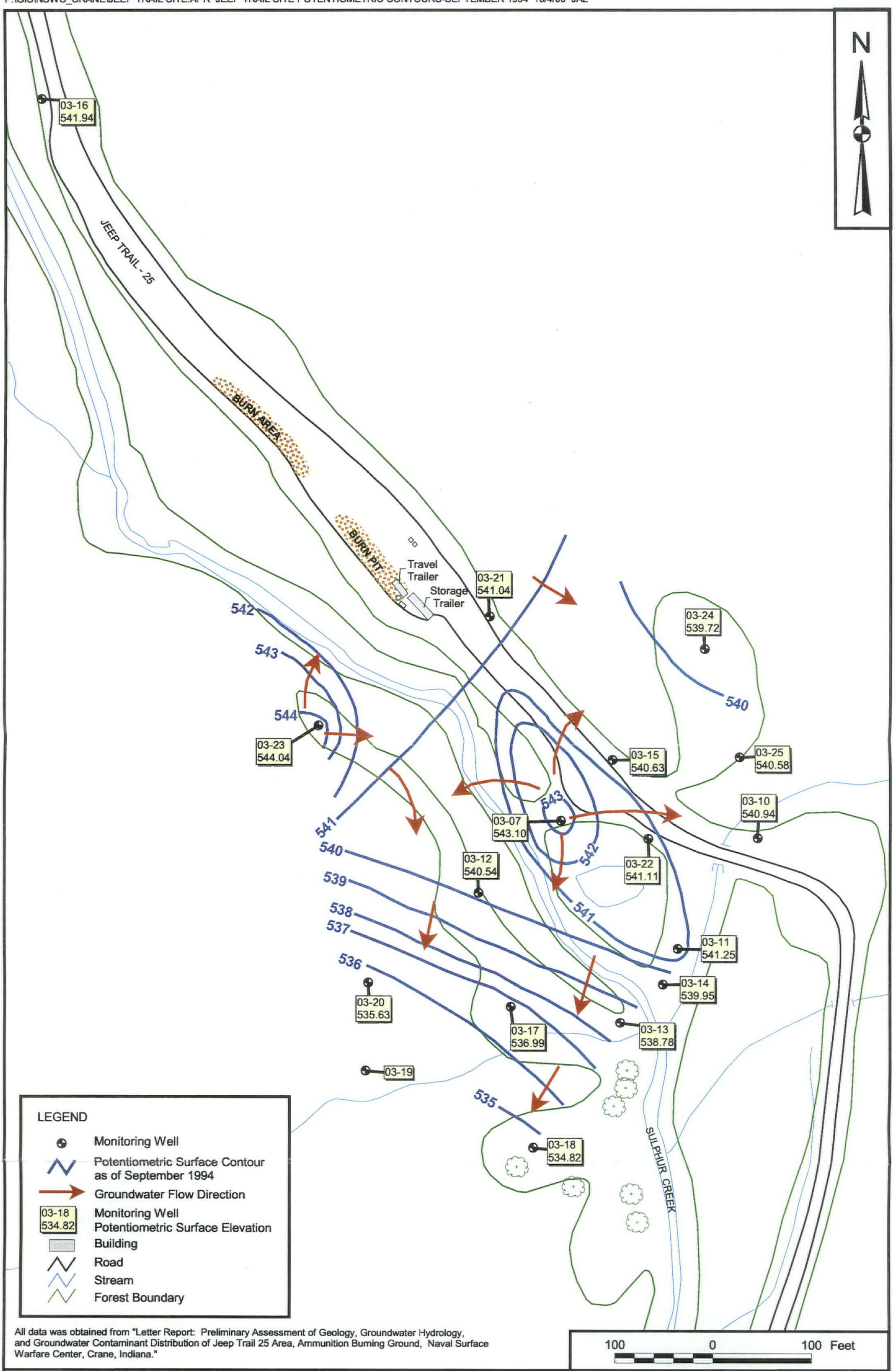
MAP SOURCE: FINAL PHASE III FRI REPORT.

000631J01X

DRAWN BY MF	DATE 06/08/00	AMMUNITION BURNING GROUND GROUND WATER CONTOURS BEECH CREEK AQUIFER NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	CONTRACT NO. 0514
CHECKED BY	DATE		OWNER NO.
REVISED BY	DATE		APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIG. 1-11 / REV. 0

DRAWING NO. FIG. 1-10 REV. 0

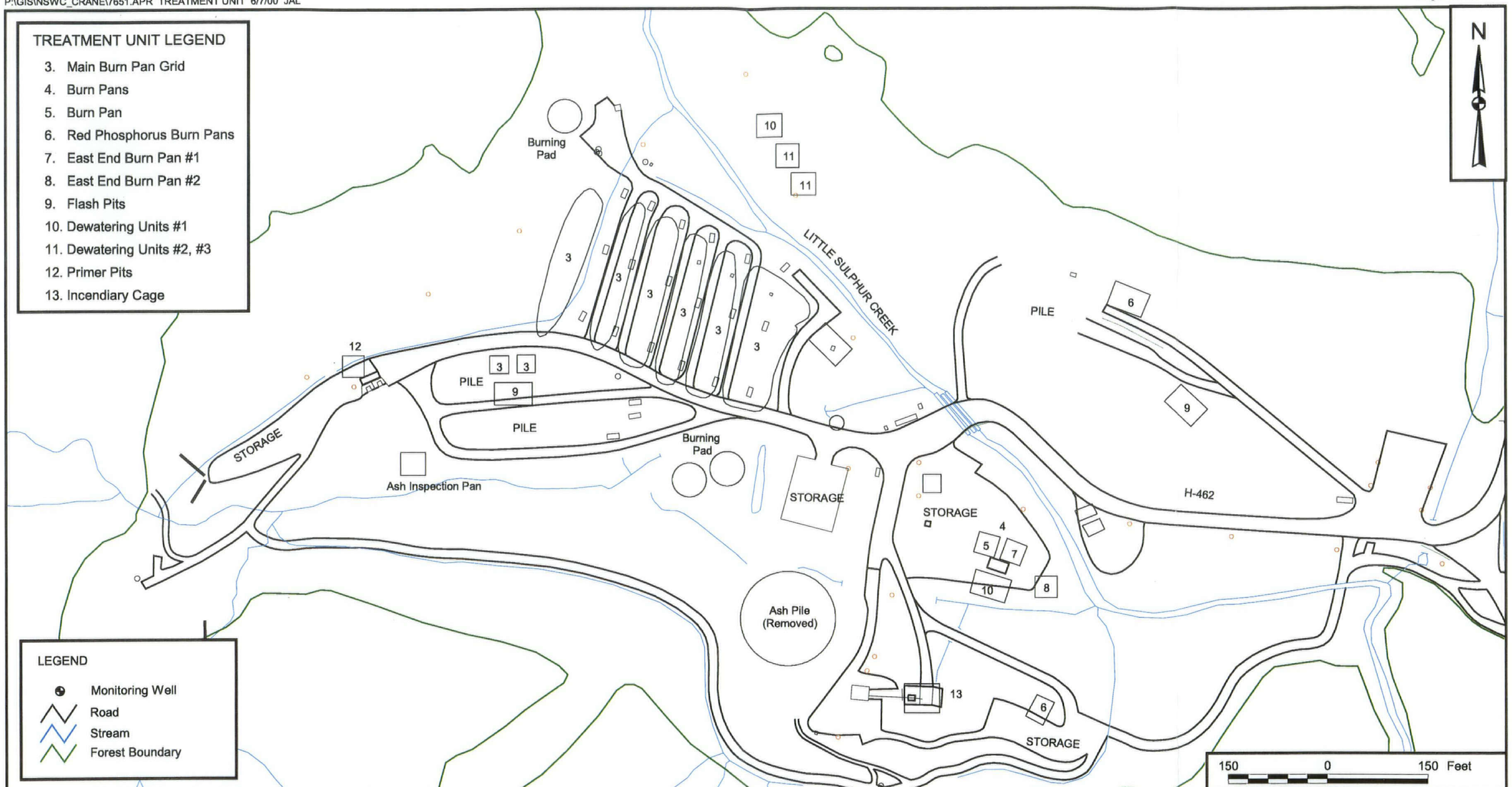
P:\GIS\NSWC_CRANE\JEEP TRAIL SITE.APR JEEP TRAIL SITE POTENTIOMETRIC CONTOURS-SEPTEMBER 1994 10/4/00 JAL



All data was obtained from "Letter Report: Preliminary Assessment of Geology, Groundwater Hydrology, and Groundwater Contaminant Distribution of Jeep Trail 25 Area, Ammunition Burning Ground, Naval Surface Warfare Center, Crane, Indiana."

DRAWN BY J. LAMEY — DATE 9/21/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0514	OWNER NUMBER CTO 126
CHECKED BY — DATE —	JEEP TRAIL SITE POTENTIOMETRIC SURFACE CONTOURS NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY — DATE —	
COST/SCHEDULE-AREA		APPROVED BY — DATE —	
SCALE AS NOTED		DRAWING NO. FIGURE 1-12	REV 0

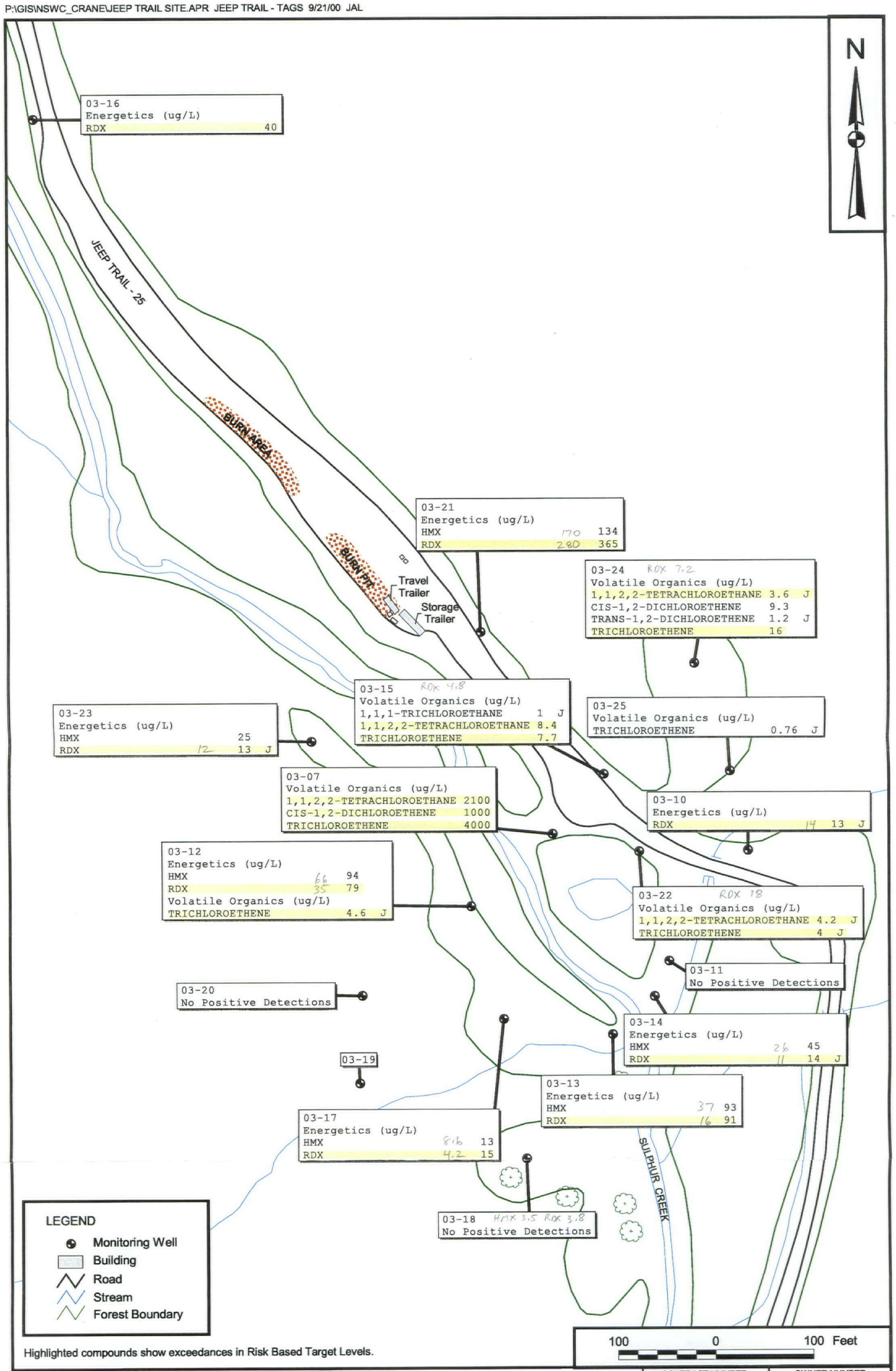
P:\GIS\NSWC_CRANE\7651.APR TREATMENT UNIT 6/7/00 JAL



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY J. LAMEY	DATE 6/6/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0514 / OWNER NUMBER CTO 126
CHECKED BY	DATE	AMMUNITION BURNING GROUNDS - TREATMENT UNIT NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY — / DATE —
COST/SCHEDULE-AREA			APPROVED BY — / DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 1-13 / REV 0

P:\GIS\NSWC_CRANE\JEEP TRAIL SITE.APR JEEP TRAIL - TAGS 9/21/00 JAL

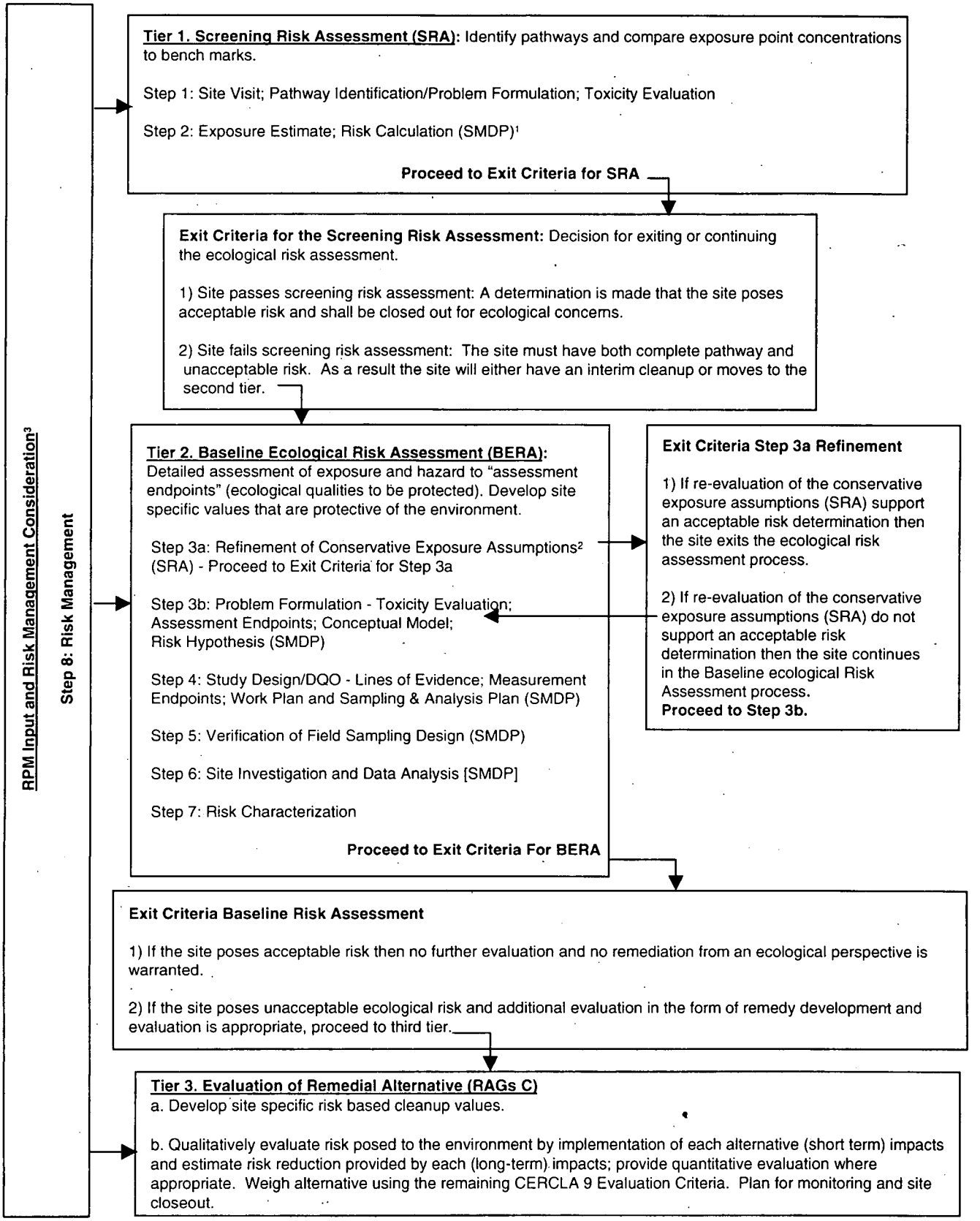


Highlighted compounds show exceedances in Risk Based Target Levels.

DRAWN BY J. LAMEY	DATE 9/5/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0514	OWNER NUMBER CTO 126
CHECKED BY —	DATE —	JEEP TRAIL SITE ORGANIC POSITIVE DETECTIONS IN GROUNDWATER NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY —	DATE —
COST/SCHEDULE-AREA			APPROVED BY —	DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 1-14	REV 0

FIGURE 1-15

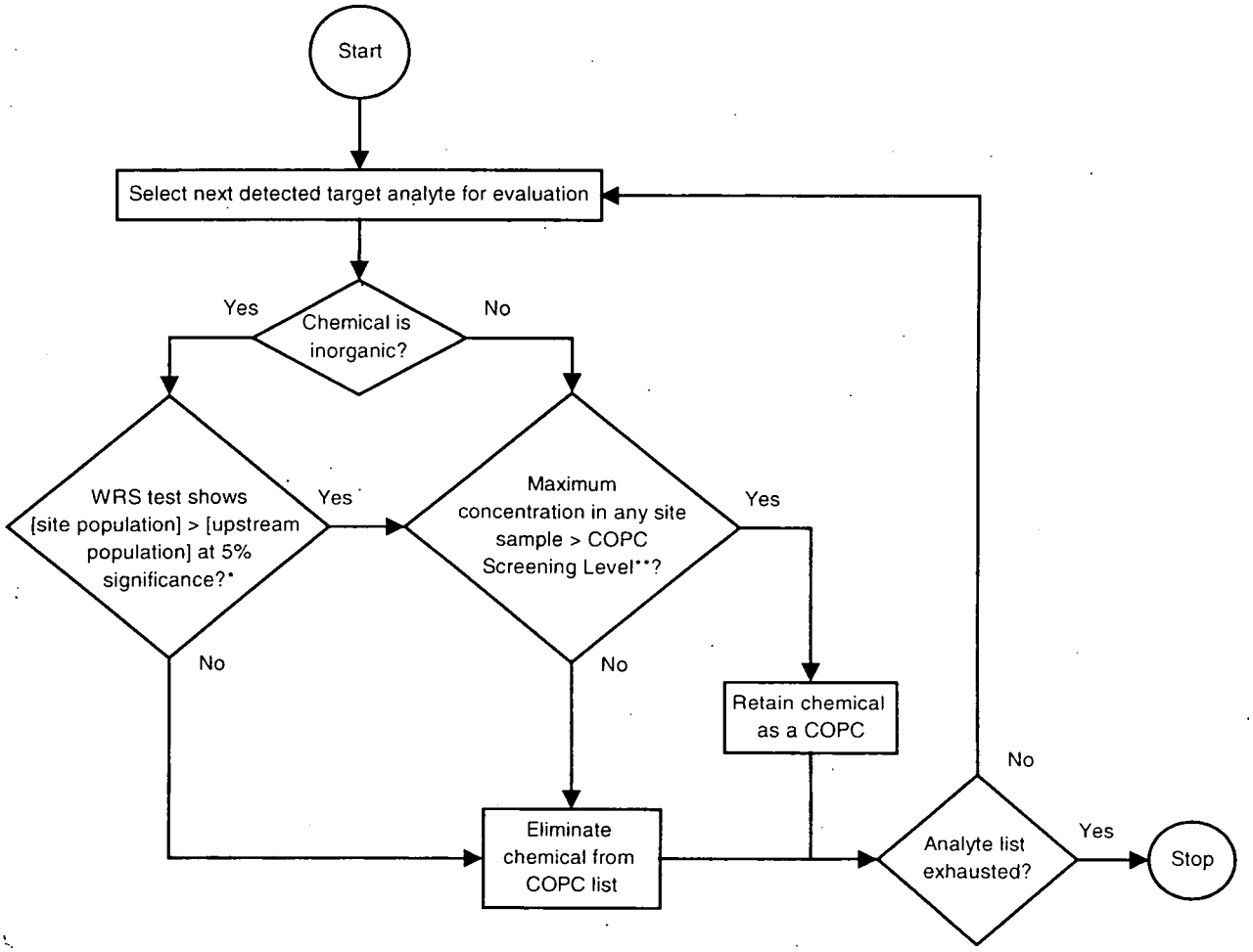
NAVY'S ECOLOGICAL RISK ASSESSMENT TIERED APPROACH
NSWC CRANE, CRANE INDIANA



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 1-16

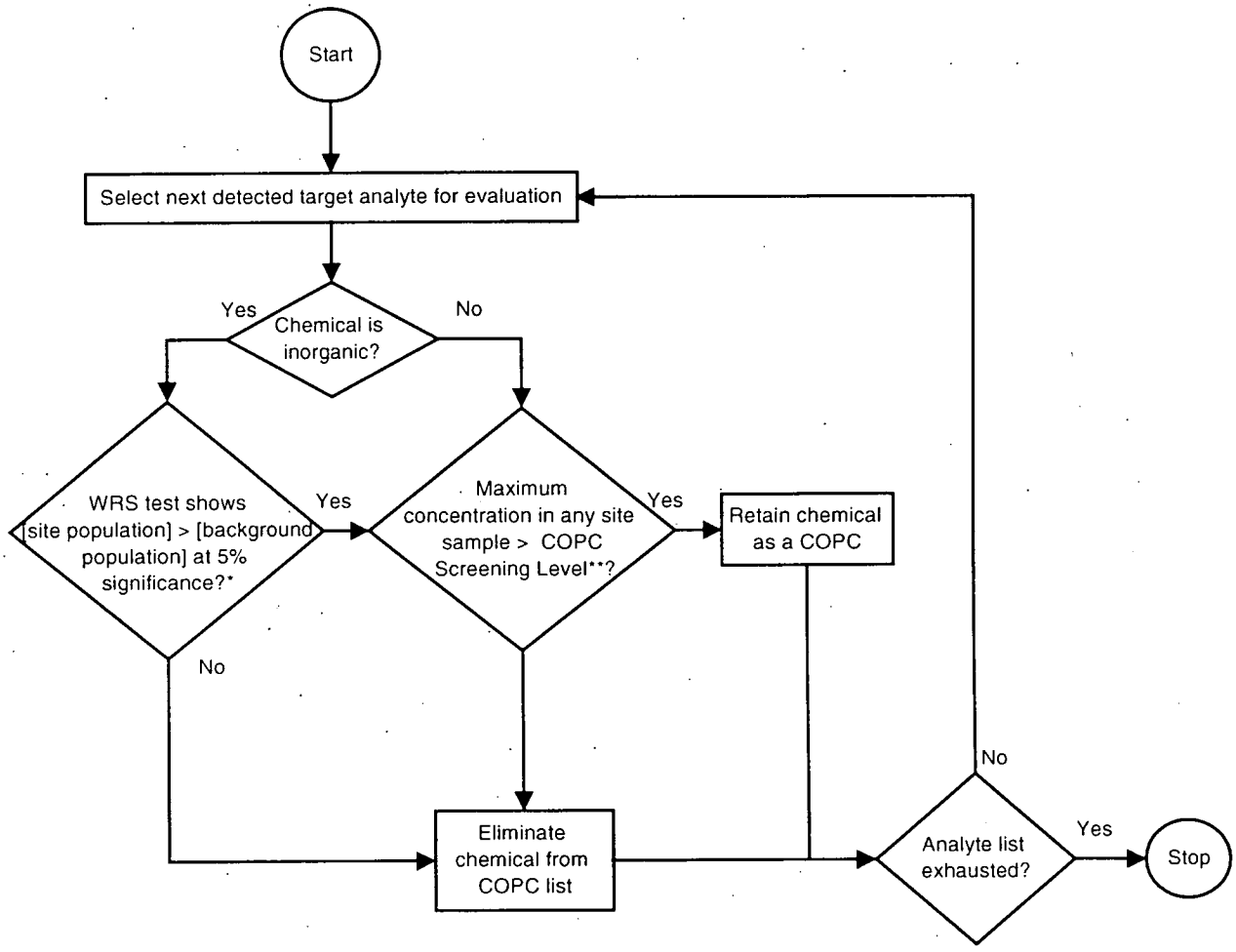
HUMAN HEALTH RISK ASSESSMENT COPC SELECTION FOR SURFACE WATER AND SEDIMENT NSWC CRANE, CRANE, INDIANA



COPC = Chemical of potential concern
RBTL = Risk-based target level
WRS = Wilcoxon Rank Sum
*The upstream population will be represented by samples collected upstream of the Ammunition Burning Ground
**See Appendix C, Section C.1.2.1, for details

FIGURE 1-17

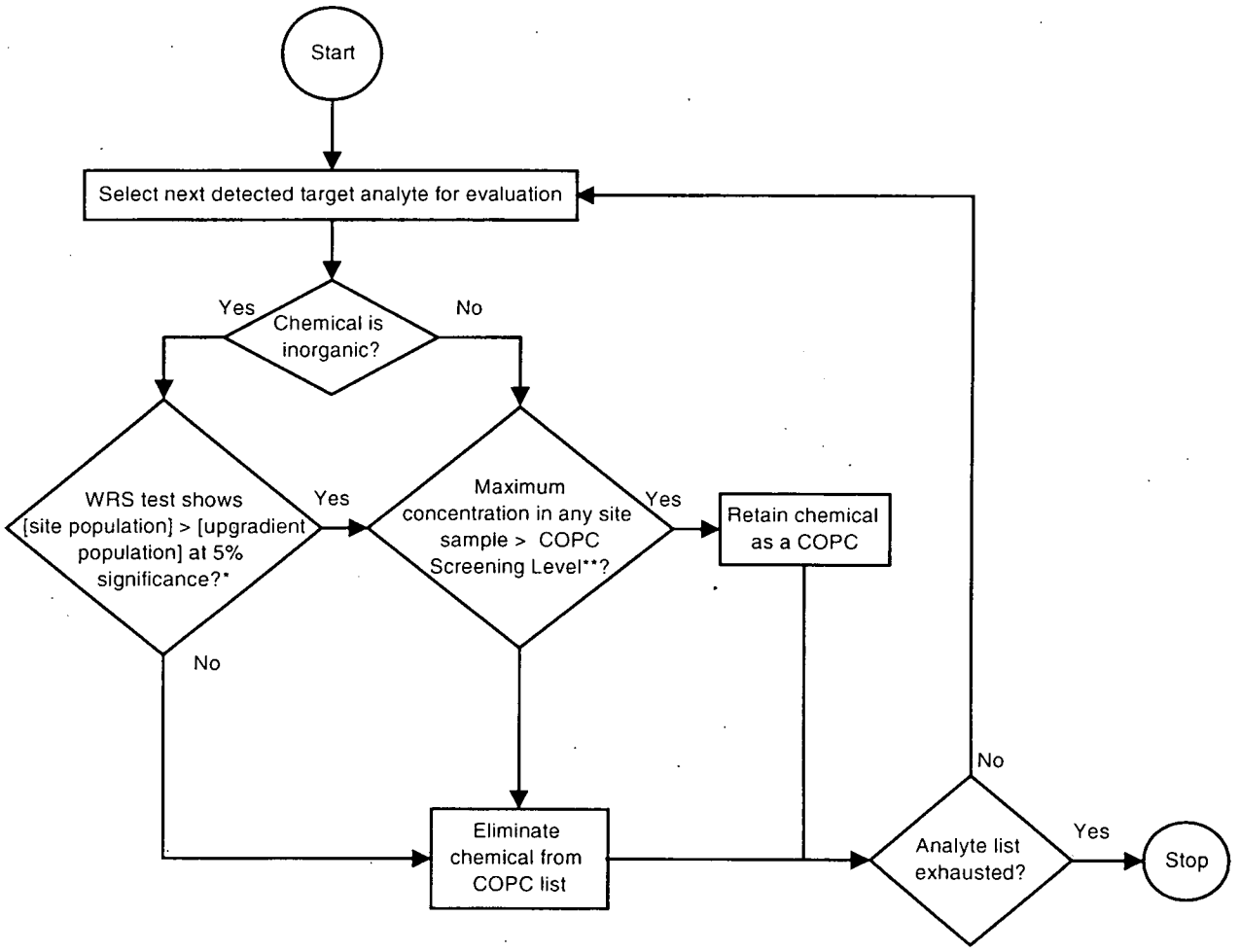
HUMAN HEALTH RISK ASSESSMENT COPC SELECTION FOR SURFACE AND SUBSURFACE SOIL NSWC CRANE, CRANE, INDIANA



COPC = Chemical of potential concern
RBTL = Risk-based target level
WRS = Wilcoxon Rank Sum
*The background population will be represented by soil data from the NSWC Basewide Background Soil Investigation that most closely matches the site soil in terms of depositional environment, depth and grain size. If multiple soil types are present at the site, multiple background soil types will be used, as necessary, to obtain a reasonable match for each site soil type.
**See Appendix C, Section C.1.2.1, for details.

FIGURE 1-18

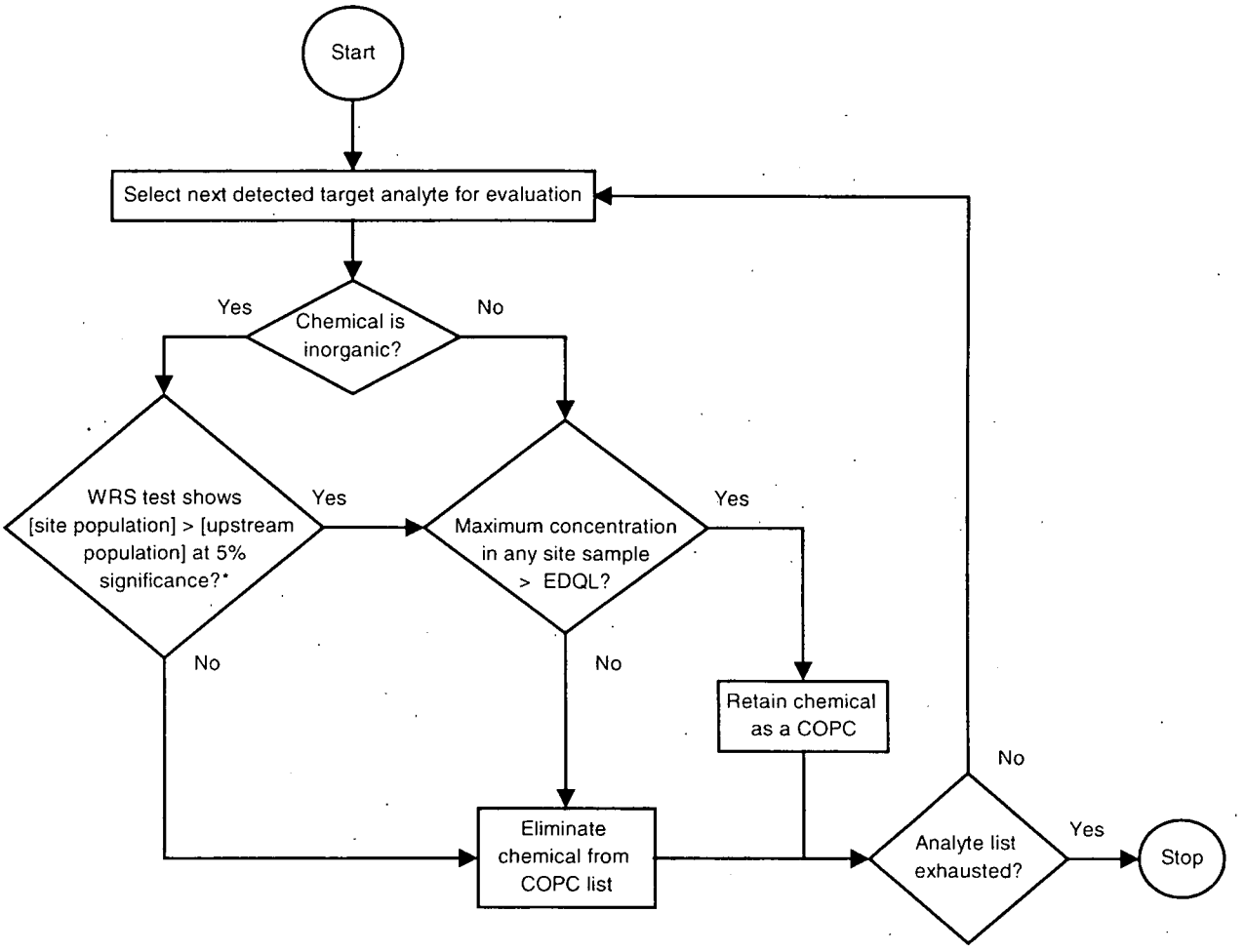
HUMAN HEALTH RISK ASSESSMENT COPC SELECTION FOR GROUND WATER NSWC CRANE, CRANE, INDIANA



COPC = Chemical of potential concern
RBTL = Risk-based target level
WRS = Wilcoxon Rank Sum
*The upgradient population will be represented by samples from upgradient monitoring wells. Sample depths (shallow or deep) for site and upgradient will be matched to represent corresponding aquifers/depths.
**See Appendix C, Section C.1.2.1, for details.

FIGURE 1-19

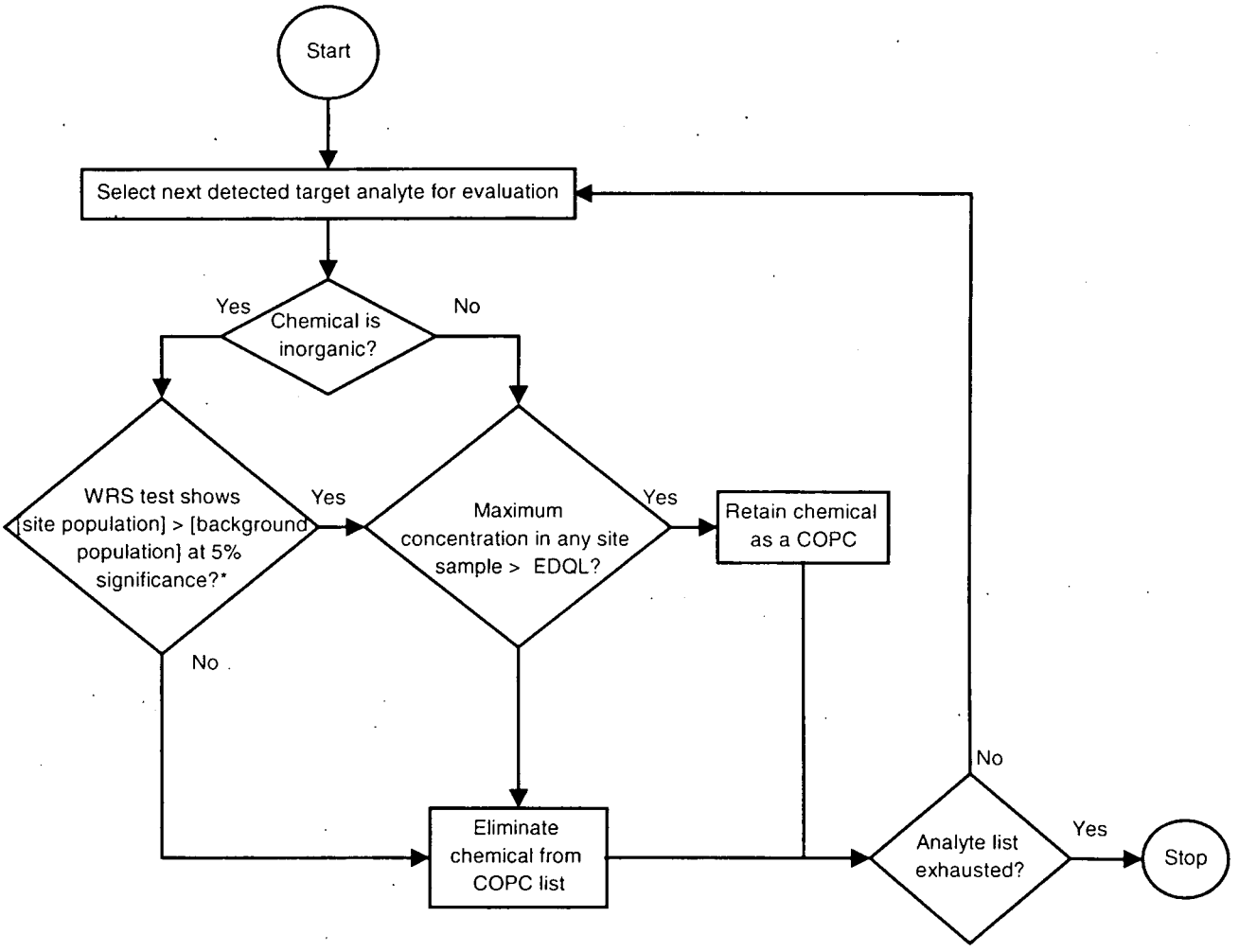
ECOLOGICAL RISK ASSESSMENT COPC SELECTION FOR SURFACE WATER AND SEDIMENT NSWC CRANE, CRANE, INDIANA



COPC = Chemical of potential concern
EDQL = Ecological data quality level
WRS = Wilcoxon Rank Sum
*The upstream population will be represented by samples collected upstream of the Ammunition Burning Ground

FIGURE 1-20

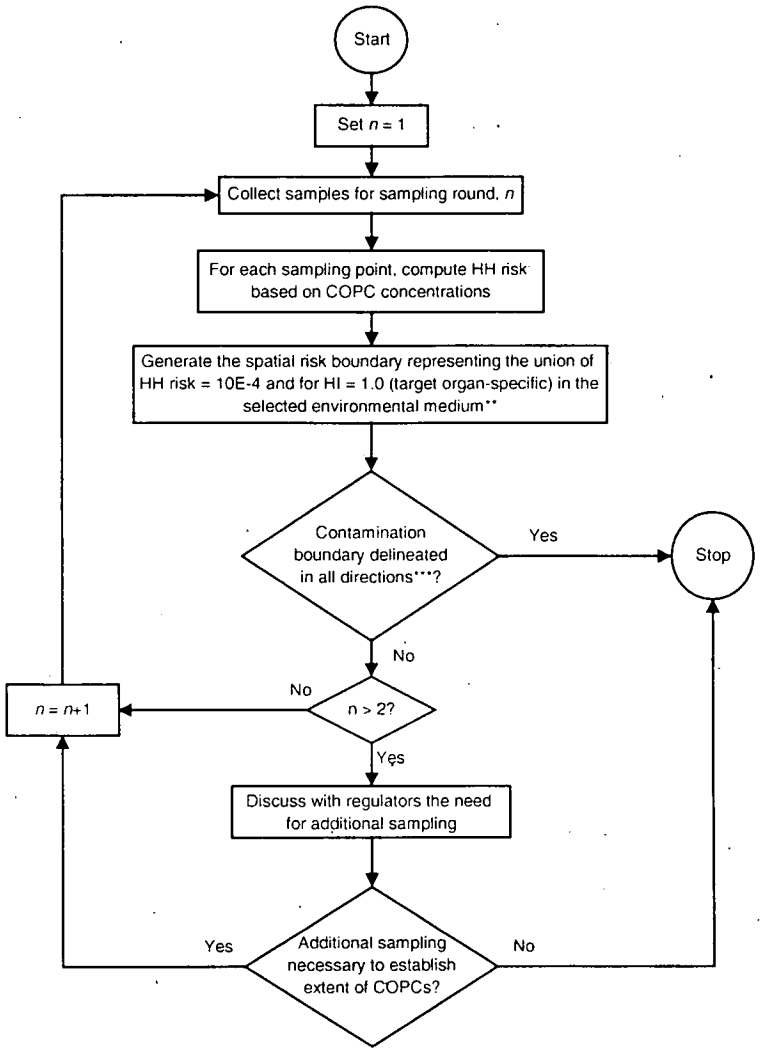
ECOLOGICAL RISK ASSESSMENT COPC SELECTION FOR SURFACE SOIL NSWC CRANE, CRANE, INDIANA



COPC = Chemical of potential concern
EDQL = Ecological data quality level
WRS = Wilcoxon Rank Sum
*The background population will be represented by soil data from the NSWC Basewide Background Soil Investigation that most closely matches the site soil in terms of depositional environment, depth and grain size. If multiple soil types are present at the site, multiple background soil types will be used, as necessary, to obtain a reasonable match for each site soil type.

FIGURE 1-21

DECISION RULE FOR ESTABLISHING NATURE AND EXTENT OF COPCS IN GROUND WATER AND SOILS* NSWC CRANE, CRANE, INDIANA



*This decision diagram will be applied to each environmental medium individually.
** For surface soils, the risk boundary will be a two-dimensional boundary based on COPC concentrations to a depth of 2 feet. For subsurface soils, the risk boundary will be a three-dimensional boundry based on [COPC]s at > 2 feet deep. For ground water, risk will be computed for each well location based on [COPC]s in the ground water.
***The spatial risk boundary representing 1E-4 human health (HH) cumulative cancer risk and the spatial boundary representing a hazard index (HI) of 1.0 will each be generated and plotted separately. Once plotted, the best fit boundary including both the spatial HH cumulative cancer risk boundary and spatial HI boundry will be generated to represent the union of 1.4E-4 HH cumulative cancer risk and HI=1.0.

FIGURE 1-22

DECISION RULE FOR ESTABLISHING NATURE AND EXTENT OF COPCS IN SURFACE WATER AND SEDIMENT NSWC CRANE, CRANE, INDIANA

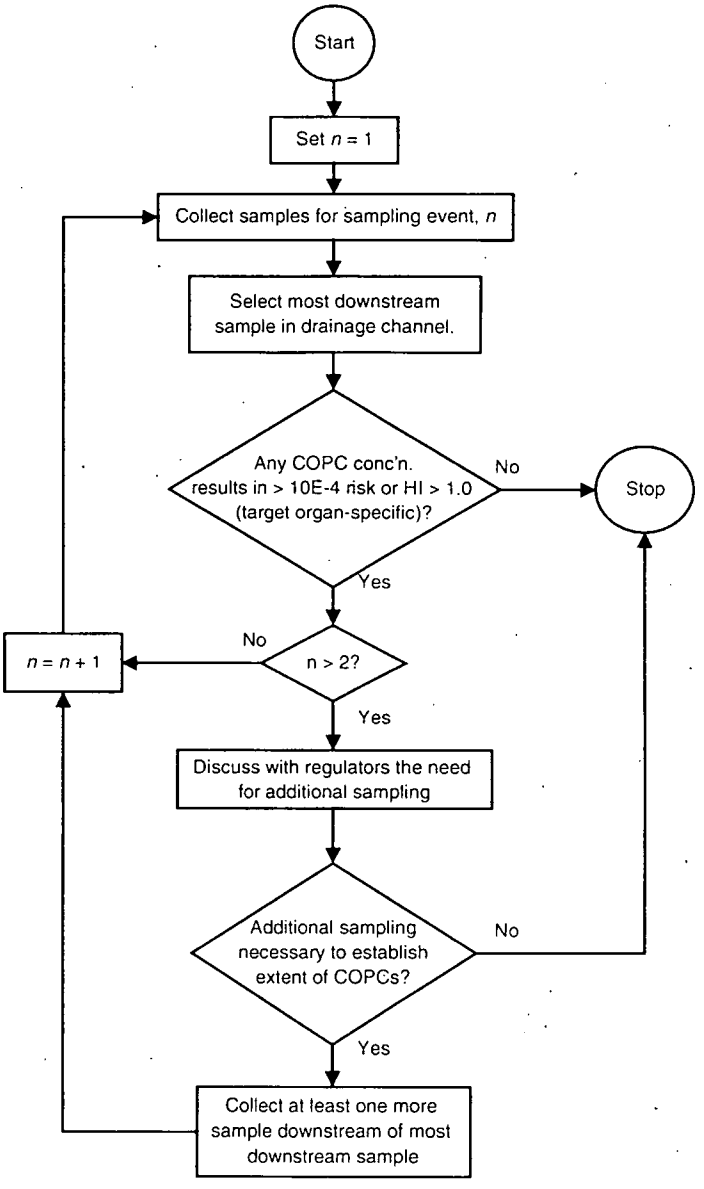
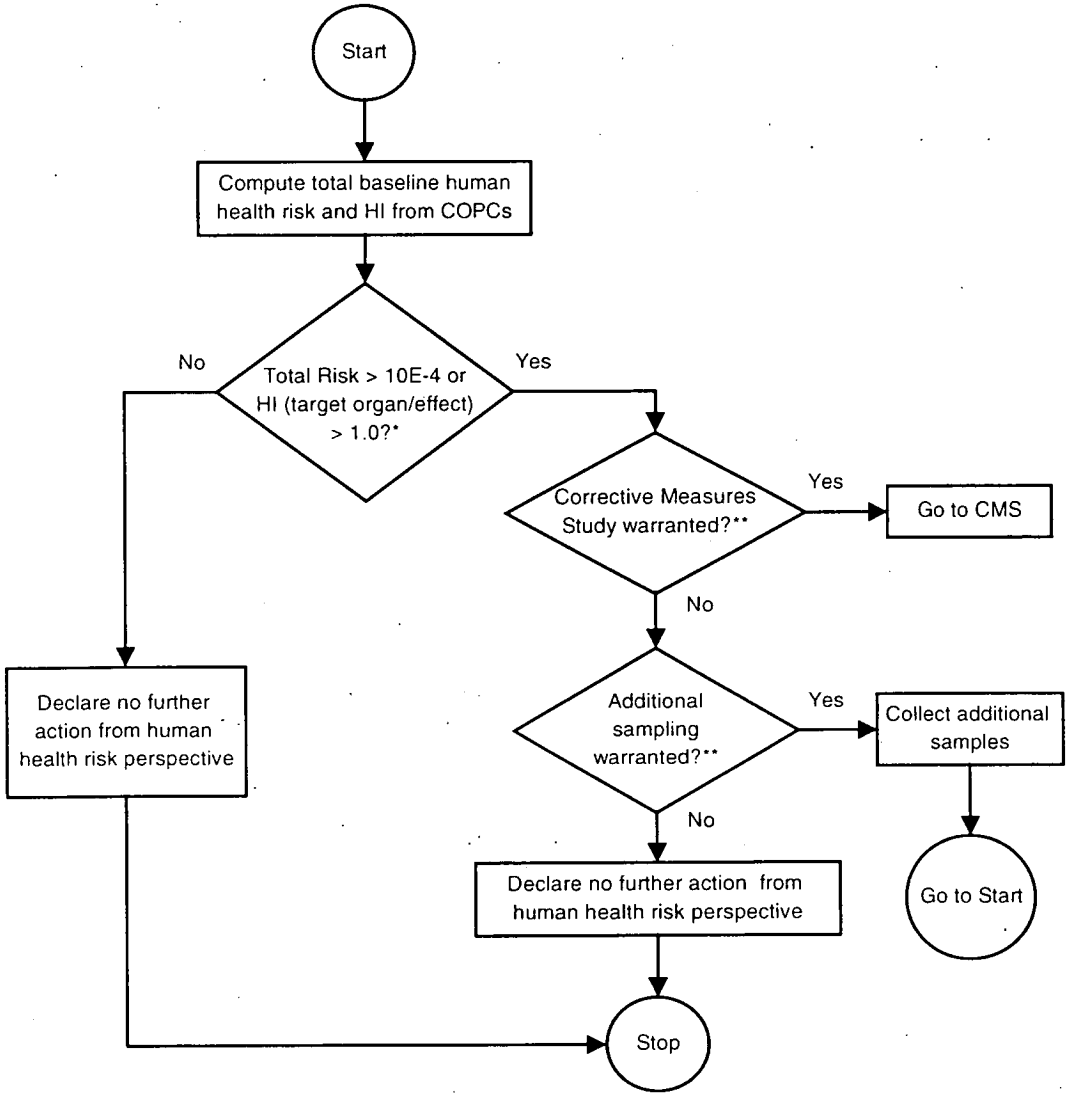


FIGURE 1-23

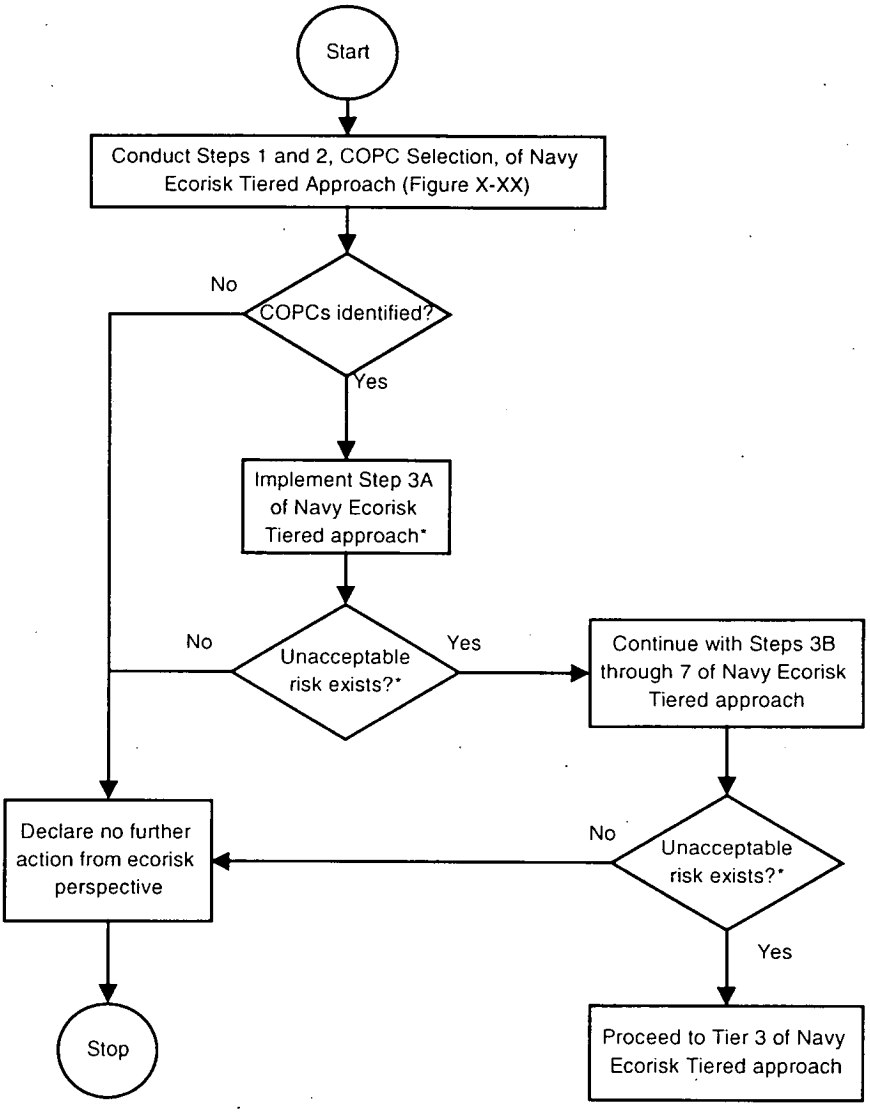
BASELINE HUMAN HEALTH RISK ASSESSMENT DECISION FLOW NSWC CRANE, CRANE, INDIANA



* Computed total risk values are the cumulative chemical risks for all media over applicable the exposure unit.
** Additional sampling may be warranted to better define the degree of 10E-4 or HI=1.0 exceedance.

FIGURE 1-24

SCREENING-LEVEL AND STEP 3A ECOLOGICAL RISK ASSESSMENT DECISION FLOW NSWC CRANE, CRANE, INDIANA



* This evaluation will include, but not be limited to, consideration of habitat, magnitude of risk-level exceedences, bioavailability of COPCs, and frequency of COPC detection

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

This section presents the project management and organization for this Phase III multimedia RFI at the ABG (SWMU 03/0) Little Sulphur Creek/Jeep Trail at NSWC Crane. Discussed in the following subsections are the staffing and coordination requirements.

2.1 MANAGEMENT

TtNUS, on behalf of the U.S. Navy, is responsible for the overall management, implementation of contract field activities, and preparation of the ABG Little Sulphur Creek/Jeep Trail Phase III multimedia RFI QAPP. Personnel from the Navy will be actively involved and will coordinate with TtNUS personnel in a number of areas. The authorities and organizational relationships of key personnel are depicted on Figure 2-1. Corresponding addresses and telephone numbers of key personnel are listed by organization in Table 2-1. Responsibilities for program management, project management, field operations, and laboratory operations are discussed in the following sections. It is intended that the individuals named will perform the designated responsibilities to the extent that the specific person is available to perform the stated activities.

2.1.1 U.S. EPA Project Manager

The U.S. EPA Project Manager (PM), Mr. Peter Ramanauskas, will oversee the implementation of the ABG Little Sulphur/Jeep Trail Phase III multimedia RFI at NSWC Crane. The U.S. EPA PM represents the Agency's interests and will provide input from this perspective and lend general historical and technical assistance to NSWC Crane field activities.

2.1.2 Indiana Department of Environmental Management

The IDEM Hazardous Waste representatives, Mr. Doug Griffin and Mr. Marty Harmless, will oversee the implementation of this Phase III RFI investigation. They represent IDEM's interests and will provide input from this perspective.

2.1.3 Navy Project Managers

The Navy remedial Project Manager (RPM), Mr. Bill Gates, acts as the focal representative for the U.S. Navy, providing management, technical direction, and oversight for all NSWC Crane project activities performed by contractors (i.e., TtNUS) and their subcontractors. In matters such as facilitation of site

access, and oversight, etc., the Navy RPM is assisted by the NSWC Environmental Site Manager (ESM), Mr. Tom Brent. Additional responsibilities of the RPM are as follows:

- Define project objectives and develop a detailed QAPP schedule
- Establish project policy and procedures to address the specific needs of the project as a whole, as well as the objectives of each task
- Acquire and apply technical resources (i.e., contractors) as needed to ensure performance within budget and schedule constraints
- Review the work performed on each task to ensure its quality, responsiveness, and timeliness
- Review and analyze overall task performance with respect to planned requirements and authorizations
- Approve all reports (deliverables) before their submittal to U.S. EPA Region 5
- Ultimately be responsible for the preparation and quality of interim and final reports
- Represent the project team at meetings and public hearings

2.1.4 Contractor Project Management

Program Manager

The TtNUS Navy Southern Division Comprehensive Long-Term Environmental Action Navy (CLEAN) Program Manager, Ms. Debbie Wroblewski, provides operations, technical, and administrative leadership, and oversees and supports quality policies. The Program Manager assigns project Task Order Managers (TOMs) and oversees their performance. The Program Manager also ensures the availability of technical and support resources for program operations, and maintains consistency in procedures and projects among CTO assignments. In these matters, the Program Manager is assisted by the TOM.

Task Order Manager

The TtNUS TOM, Mr. Ralph Basinski, has overall responsibility for ensuring that the project meets U.S. EPA and IDEM objectives, and Navy and TtNUS quality standards. The TOM is responsible for the preparation and distribution of the QAPP at the direction of the Navy RPM to all parties connected with the project, including any subcontractors. The TOM will report to the Navy RPM and is responsible for technical QC and project oversight. Additional responsibilities of the TOM are as follows:

- Ensuring timely resolution of project-related technical, quality, safety, or waste management issues
- Functioning as the primary interface with the Navy RPM and NSWC Crane ESM, field and office personnel, and subcontractor points-of-contact
- Ensuring that health and safety issues related to this project are communicated effectively to all personnel and off-site laboratories
- Monitoring and evaluating subcontractor laboratory performance
- Coordinating and overseeing work performed by field and office technical staff (including data validation, statistical evaluations, and report preparation)
- Coordinating and overseeing maintenance of all project records
- Coordinating and overseeing review of project deliverables
- Preparing and issuing final deliverables to the Navy
- Approving the implementation of corrective actions

Project Chemist

The TtNUS Project Chemist, Ms. Linda Karsonovich has the overall responsibility for ensuring that the project meets objectives from the standpoint of laboratory performance. The Project Chemist is responsible for the technical preparation of laboratory statements of work (SOWs) and work releases. All subcontractor Laboratory Project Managers will report to the Project Chemist. The Project Chemist will report to the TOM. Additional responsibilities of the Project Chemist are:

- Providing technical advice to the team on matters of project chemistry
- Monitoring and evaluating subcontractor laboratory performance
- Ensuring timely resolution of laboratory-related technical, quality, or other issues effecting project goals
- Functioning as the primary interface with all subcontracted laboratories and the TOM
- Coordinating and overseeing work performed by all subcontracted laboratories
- Coordinating and overseeing review of laboratory deliverables
- Recommending appropriate laboratory corrective actions

Health and Safety Manager

The TtNUS Health and Safety Manager (HSM), Mr. Matt Soltis, is responsible for the following:

- Providing technical advice to the TOM on matters of health and safety
- Overseeing the development and review of the Health and Safety Plan (HASP)
- Implementing the HASP
- Assigning the Site Safety Officer (SSO) and supervising his/her performance
- Conducting Health and Safety audits
- Preparing Health and Safety reports for management

2.2 QUALITY ASSURANCE

This section identifies the QA responsibilities for this Phase III RFI. Responsibilities of U.S. EPA Region 5, TtNUS, and the analytical laboratories are discussed.

2.2.1 U.S. EPA Region 5 Quality Assurance Coordinator

The U.S. EPA Region 5 RCRA Quality Assurance Coordinator (RQAC), Mr. Allen Debus, has the responsibility to review and approve the QAPP and to provide overall QA support and review. Additional responsibilities may include the following:

- Coordinating external performance and system audits of the contracted laboratory
- Reviewing and evaluating analytical field and laboratory procedures

2.2.2 TtNUS QA Manager

The TtNUS Quality Assurance Manager (QAM), Mr. Paul Frank, is responsible for overall QA for the project, and reports directly to the TtNUS Program Manager. He acts on behalf of the U.S. Navy for project quality assurance. The QAM is responsible for the following:

- Developing, maintaining, and monitoring QA policies and procedures
- Providing training to TtNUS staff in QA/QC policies and procedures
- Conducting systems and performance audits to monitor compliance with environmental regulations, contractual requirements, QAPP requirements, and corporate policies and procedures
- Auditing project records
- Monitoring subcontractor quality controls and records
- Assisting in the development of corrective action plans and ensuring correction of nonconformances reported in internal or external audits
- Overseeing the implementation of the QAPP
- Overseeing and reviewing the development and revision of the QAPP
- Overseeing the responsibilities of the TtNUS Site QA/QC Advisor
- Preparing QA reports for management

2.2.3 TtNUS Project QA Chemist

The TtNUS Project Chemist, Ms. Linda Karsonovich, supports the TOM in preparing and reviewing the QAPP, coordinating work performed by office technical staff, and resolving matters concerning project chemistry. The Project Chemist also supports the Project QA Advisor on matters of QA/QC.

2.2.4 TtNUS Project QA Advisor

The TtNUS Project QA Advisor, Dr. Tom Johnston, supports the TOM in preparing and reviewing the QAPP, and conducting data assessments. The Project QA Advisor communicates directly with the QAM on matters of QA/QC.

2.2.5 Laboratory Responsibilities

Laucks Testing Laboratories, Inc., of Seattle, Washington, will perform all sample analyses for this field activity, with the exception of dioxin and perchlorate analysis. Dioxin analysis will be performed by Triangle Laboratories as a subcontractor to Laucks Testing. Perchlorate analysis will be conducted by APC Laboratories as a subcontractor of TtNUS.

The subcontracted laboratories are responsible for analyzing all samples in accordance with the analytical methods and additional requirements specified in the attendant QAPP. It also will be the analytical laboratory's responsibility to properly dispose of unused sample aliquots. Responsibilities of key laboratory personnel are outlined in the following paragraphs.

Laboratory Project Manager

The Laucks Testing Laboratory Project Manager and APC Laboratories will interface directly to the TtNUS TOM and QA Advisor and will perform the following:

- Ensure that method and project-specific requirements are properly communicated and understood by laboratory personnel
- Ensure that all laboratory resources are available on an as-required basis
- Monitor analytical and project QA requirements
- Review data packages for completeness, clarity, and compliance with project requirements
- Inform the TtNUS TOM of project status and any sample receipt or analytical problems

Laboratory Operations Manager

Responsibilities of the Laboratory Operations Manager include the following:

- Support the QA program within the laboratory
- Provide management overview of both production and quality-related laboratory activities
- Maintain adequate staffing to meet project analytical and quality objectives

- Approve all laboratory SOPs and QA documents
- Supervise in-house chain-of-custody documentation
- Oversee the preparation of, and approving, final analytical reports before submittal to TtNUS

Laboratory Quality Assurance Officer (QAO)

The Laboratory QAO will report directly to the Laboratory Operations Manager. The Laboratory QAO will be independent of laboratory production management to ensure that laboratory quality performance is assessed without schedule and cost considerations. Responsibilities of the Laboratory QAO include the following:

- Define appropriate laboratory QA procedures and monitor overall laboratory QA
- Stop work if a condition adverse to the quality of work is encountered, if QA or quality control (QC) procedures are not followed, or if analytical out-of-control events are encountered that have not been corrected
- Approve and maintain document control of all QA documents and SOPs
- Perform and/or implement internal system and performance audits and verify completion of corrective actions cited in audits
- Direct laboratory participation in laboratory accreditation and certification programs

Laboratory Sample Custodian

The Laboratory Sample Custodian will report to the Laboratory Operations Manager. Responsibilities of the laboratory Sample Custodian include the following:

- Receive and inspect the incoming sample containers
- Record the condition of the incoming sample containers
- Sign appropriate documents
- Verify chain-of-custody
- Notify laboratory project manager of sample receipt and inspection
- Assign a unique identification number and customer number, and enter each into the sample receiving log

- With the help of the laboratory project manager, initiate transfer of the samples to appropriate lab sections
- Control and monitor access/storage of samples and extracts

Laboratory Technical Staff

The laboratory technical staff will be responsible for sample analysis based on the analytical methods and requirements specified in the attendant QAPP.

2.3 FIELD INVESTIGATION

TtNUS will be responsible for all field activities related to this Phase III RFI. The TtNUS field team will be organized according to the activities planned. Field team members will be selected based on the type and extent of effort required. All team members will be appropriately skilled and trained for the tasks they are assigned to perform. The team will consist of a combination of the following personnel:

- Field Operations Leader (FOL)
- Site QA/QC Advisor
- Site Safety Officer (SSO)
- Site UXO Specialist
- Field Technical Staff

2.3.1 Field Operations Leader

The FOL is responsible for coordinating all on-site personnel and for providing technical assistance, when required. The FOL, or designee, will coordinate and lead all sampling activities and will ensure the availability and maintenance of all sampling materials and equipment. The FOL is responsible for completing all sampling, field and chain of custody documentation, will assume custody of all samples, and will ensure the proper handling and shipping of samples. The FOL will report directly to the TtNUS TOM. Specific FOL responsibilities include the following:

- Ensuring that all Health and Safety requirements unique to this site are implemented

- Functioning as the communications link between field staff members, SSO, UXO Specialist, the NSWC Crane Environmental Site Manager, and the TOM

- Alerting off-site analytical laboratories of any special health and safety hazards associated with environmental samples

- Overseeing the mobilization and demobilization of all field equipment and subcontractors

- Coordinating and managing the Field Technical Staff

- Adhering to the work schedules provided by the TOM

- Ensuring the proper maintenance of the site logbook, field logbook, and field recordkeeping

- Initiating field task modification requests when necessary

- Identifying and resolving problems in the field; resolving difficulties via consultation with the NSWC Crane Environmental Site Manager; implementing and documenting corrective action procedures; and providing communication between the field team and project management

2.3.2 Site QA/QC Advisor

The FOL (or designee) will act as the site QA/QC Advisor, and will be responsible for ensuring adherence to all QA/QC requirements as defined in the QAPP. Strict adherence to these procedures is critical to the collection of acceptable and representative data. The following is a summary of the Site QA/QC Advisor's responsibilities:

- Ensuring that field QC samples are collected at the proper frequency

- Ensuring that additional volumes of sample are supplied to the analytical laboratory with the proper frequency to accommodate laboratory QA/QC analyses

- Ensuring that measuring and test equipment are calibrated, used, and maintained in accordance with applicable procedures and technical standards

- Acting as liaison between site personnel, laboratory personnel, and the QAM

- Managing bottleware shipments and overseeing field preservation

2.3.3 Site Safety Officer

The FOL (or designee) will also serve as the SSO. The duties of the SSO are detailed in the Health and Safety Plan (HASP). The SSO has stop work authority, which can be executed upon the determination of an imminent safety hazard.

2.3.4 Site UXO Specialist

Based on the potential for UXO hazards associated with this investigation, a TtNUS UXO Specialist will be on-site at all times that invasive activities are being conducted at the Burn Pit area of the Jeep Trail. The duties of the UXO Specialist are detailed in the HASP. The UXO Specialist has stop-work authority, which can be executed upon the determination of an imminent UXO safety hazard.

2.3.5 Field Technical Staff

The field technical staff for this project will be drawn from TtNUS's pool of qualified personnel. All of the designated field team members will be experienced professionals who possess the degree of specialization and technical competence required to effectively and efficiently perform the required work.

Field staff are responsible for complying with field-related requirements as presented in the QAPP and the HASP.

2.4 SPECIAL TRAINING REQUIREMENTS AND CERTIFICATIONS

All field personnel will have appropriate training to conduct the field activities to which they are assigned. Additionally, each site worker will be required to have completed a 40-hour course (and 8-hour refresher, if applicable) in Health and Safety Training as described under Occupational Safety and Health Administration (OSHA) 29 CFR 1910.120(b)(4). The UXO Specialist will be certified in accordance with TtNUS SOP HS-2.0, which is appended to the HASP.

TABLE 2-1
KEY LITTLE SULPHUR CREEK/JEEP TRAIL PROJECT PERSONNEL
NAMES, PHONE NUMBERS AND ADDRESSES
NSWC CRANE, CRANE, INDIANA
PAGE 1 OF 3

PERSON / TITLE / ORGANIZATION	ADDRESS	TELEPHONE
Peter Ramanauskas Project Manager U.S. EPA Region 5	EPA Region 5 77 West Jackson Blvd. Chicago, Illinois 60604	Phone: (312) 886-7890 FAX: (312) 353-4788
Allen Debus QA Coordinator U.S. EPA Region 5	EPA Region 5 77 West Jackson Blvd. Chicago, IL 60604	Phone: (312) 886-6186
Marty Harmless Office of Solid and Hazardous Waste Management IDEM	Office of Solid and Hazardous Waste Management 100 N. Senate Avenue Indianapolis, Indiana 46206-6015	Phone: (317) 234-0597
Doug Griffin Corrective Action Section Office of Land Quality Hazardous Waste Permits IDEM	Corrective Action Section Office of Land Quality Hazardous Waste Permits 100 N. Senate Avenue P. O. Box 6015 Indianapolis, IN 46206-6015	Phone: (317) 233-2710
Bill Gates Remedial Project Manager U.S. Navy SOUTHNAVFACENGCOM	Department of Navy SOUTHNAVFACENGCOM Code 1864 2155 Eagle Drive Charleston, SC 29406	Phone: (843) 820-7360 FAX: (843) 820-7465
Tom Brent Environmental Site Manager NSWC Crane	NSWC Crane Code 095 B-3245 300 Highway 361 Crane, Indiana 47522-5009	Phone:(812) 854-6160 FAX: (812) 854-3981
Debbie Wroblewski Program Manager Tetra Tech NUS	Tetra Tech NUS 661 Andersen Drive Pittsburgh, PA 15220-2745	Phone: (412) 921-8968 FAX: (412) 921-4040
Paul Frank Quality Assurance Manager Tetra Tech NUS	Tetra Tech NUS 661 Andersen Drive Pittsburgh, PA 15220-2745	Phone: (412) 921-8950 FAX: (412) 921-4040
Matt Soltis Health and Safety Manager Tetra Tech NUS	Tetra Tech NUS 661 Andersen Drive Pittsburgh, PA 15220-2745	Phone: (412) 921-8912 FAX: (412) 921-4040
Ralph Basinski Task Order Manager Tetra Tech NUS	Tetra Tech NUS 661 Andersen Drive Pittsburgh, PA 15220-2745	Phone: (412) 921-8308 FAX: (412) 921-4040
Keith Simpson Field Operations Leader Tetra Tech NUS	Tetra Tech NUS 661 Andersen Drive Pittsburgh, PA 15220-2745	Phone: (412) 921-8131 FAX: (412) 921-4040

TABLE 2-1
KEY LITTLE SULPHUR CREEK/JEEP TRAIL PROJECT PERSONNEL NAMES, PHONE NUMBERS AND ADDRESSES
NSWC CRANE, CRANE, INDIANA
PAGE 2 OF 3

PERSON / TITLE / ORGANIZATION	ADDRESS	TELEPHONE
Joseph Samchuck Data Validation Manager Tetra Tech NUS	Tetra Tech NUS 661 Anderson Drive Pittsburgh, PA 15220	Phone: (412) 921-8510 FAX: (412) 921-4040
Keith Henn Program Geologist Tetra Tech NUS	Tetra Tech NUS 661 Andersen Drive Pittsburgh, PA 15220-2745	Phone: (412) 921-8146 FAX: (412) 921-4040
Linda Karsonovich Project Chemist Tetra Tech NUS	Tetra Tech NUS 661 Andersen Drive Pittsburgh, PA 15220-2745	Phone: (412) 921-8729 FAX: (412) 921-4040
Dr. Tom Johnston Quality Assurance Advisor Tetra Tech NUS	Tetra Tech NUS 661 Anderson Drive Pittsburgh, PA 15220	Phone: (412) 921-8615 FAX: (412) 921-4040
Brian Lewis Statistician Tetra Tech NUS	Tetra Tech NUS 661 Anderson Drive Pittsburgh, PA 15220	Phone: (412) 921-8714 Fax: (412) 921-4040
Hugh Prentice Project Manager Laucks Testing	Laucks Testing 940 South Harney Street Seattle, WA 98053	Phone: (206) 767-5060 FAX: (206)767-5491
Harry Romberg Lab QA Manager Laucks Testing	Laucks Testing 940 South Harney Street Seattle, WA 98053	Phone: (206) 767-5060 FAX: (206)767-5491
Kathy Krepps Lab Operations Manager Laucks Testing	Laucks Testing 940 South Harney Street Seattle, WA 98053	Phone: (206) 767-5060 FAX: (206)767-5491
Mike Baxter/Ted Matts Lab Sample Custodian Laucks Testing	Laucks Testing 940 South Harney Street Seattle, WA 98053	Phone: (206) 767-5060 FAX: (206)767-5491
Mary McDonald Project Manager Triangle Laboratories	Triangle Laboratories, Inc. 801 Capitola Drive Durham, NC 27713	Phone: (919) 544-5729 FAX: (919) 544-5491
Linda Brown Lab QA Manager Triangle Laboratories	Triangle Laboratories, Inc. 801 Capitola Drive Durham, NC 27713	Phone: (919) 544-5729 FAX: (919) 544-2113
Belen Reuda Lab Operations Manager Triangle Laboratories	Triangle Laboratories, Inc. 801 Capitola Drive Durham, NC 27713	Phone: (919) 544-5729 FAX: (919) 544-5491
Bill Hurst Sample Custodian Triangle Laboratories	Triangle Laboratories, Inc. 801 Capitola Drive Durham, NC 27713	Phone: (919) 544-5729 FAX: (919) 544-5491

TABLE 2-1
KEY LITTLE SULPHUR CREEK/JEEP TRAIL PROJECT PERSONNEL
NAMES, PHONE NUMBERS AND ADDRESSES
NSWC CRANE, CRANE, INDIANA
PAGE 3 OF 3

PERSON / TITLE / ORGANIZATION	ADDRESS	TELEPHONE
Eric Wendland Project Manager	APLC Laboratories, Inc. 13760 Magnolia Avenue Chino, CA 91710	Phone: 909-590-1828 Ext. 104 Fax: 909-590-1498
Kevin XIE Lab QA Officer	APLC Laboratories, Inc. 13760 Magnolia Avenue Chino, CA 91710	Phone: 909-590-1828 Ext. 162 Fax: 909-590-1498
Dominic Lau Laboratory Director	APLC Laboratories, Inc. 13760 Magnolia Avenue Chino, CA 91710	Phone: 909-590-1828 Ext. 164 Fax: 909-590-1498
Paul Kon Sample Custodian	APLC Laboratories, Inc. 13760 Magnolia Avenue Chino, CA 91710	Phone: 909-590-1828 Ext. 168 Fax: 909-590-1498

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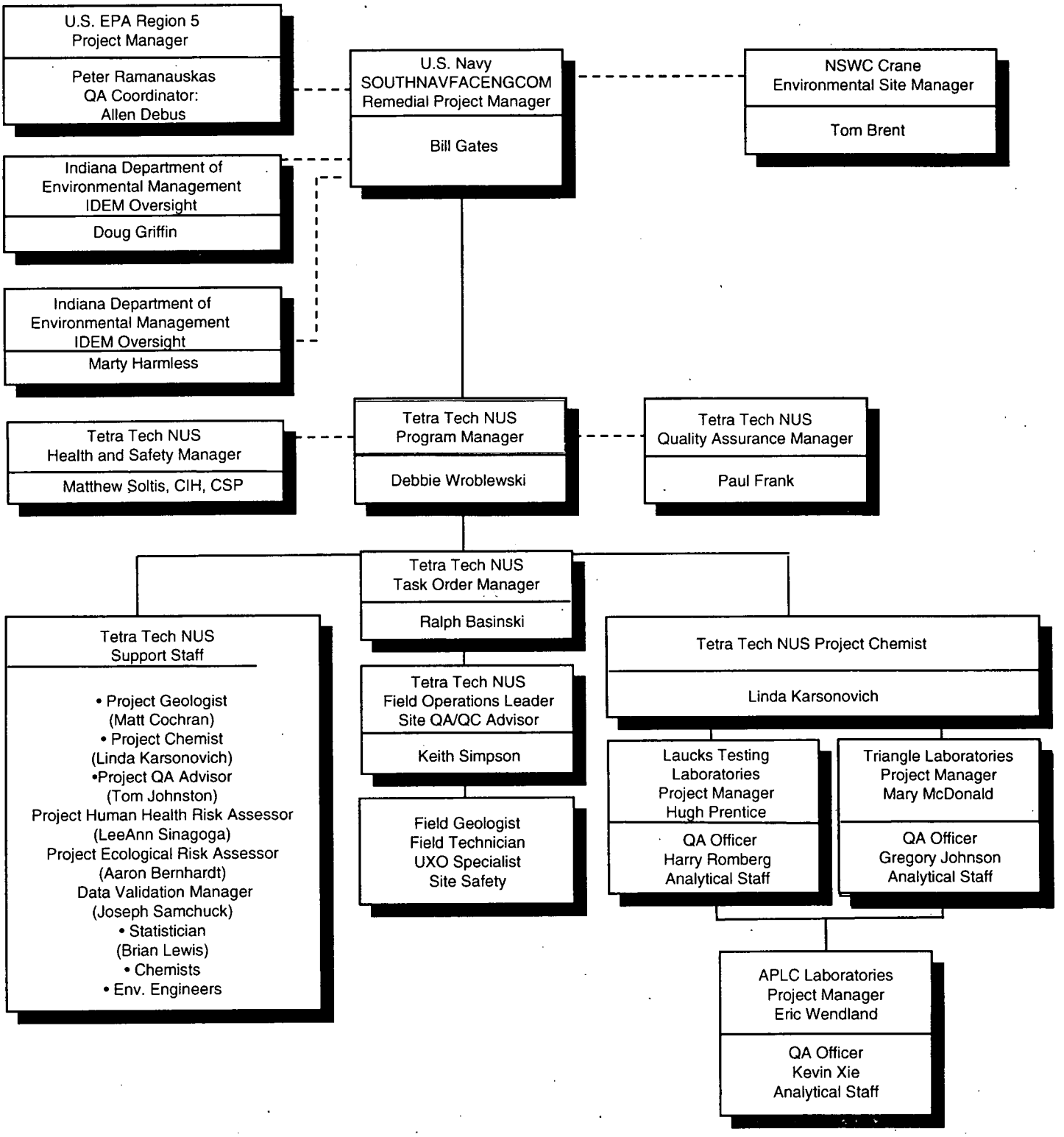
FIGURE 2-1

PROJECT ORGANIZATION CHART
ABG LITTLE SULPHUR CREEK/JEEP TRAIL
NSWC CRANE, CRANE, INDIANA



3.0 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT DATA

The overall QA objective for this project is to develop and implement procedures for field sampling, chain-of-custody, laboratory analysis, data management and reporting that will yield results sufficient to support the attainment of the project objectives specified in Section 1.0. Intended data uses, including the list of project target parameters, are described in Section 1.4 of this QAPP. How decision-making will be based on data comparisons is described in Sections 1.4.4 and 12.4. Specific procedures for sampling, chain-of-custody, laboratory instrument calibration, laboratory analysis, internal QC, reporting of data, audits, preventive maintenance of field and laboratory equipment, data management, corrective action, and reporting to management are described in the remaining sections of this QAPP. As part of those evaluations, statistical parameters such as data set variances will be computed that provide direct insight into the variability of target analyte data in soils and ground water. Overall QC level of effort is described in Section 3.6.

The PARCC parameters (precision, accuracy, representativeness, comparability, and completeness) are qualitative and quantitative statements regarding the quality characteristics of the data used to support project objectives and ultimately, environmental decisions. These parameters are presented in the remainder of this section. QC samples used to evaluate performance and their frequencies of use are described in Section 8.1 (field QC samples), and Section 8.2 (laboratory QC samples). Equations used to compute accuracy, precision, and completeness values are provided in Sections 12.1 through 12.3.

3.1 PRECISION

3.1.1 Definition

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. A fundamental tenet of using precision measurements for QC is that precision will be bounded by known limits. Results outside these predetermined limits trigger corrective actions.

By definition, chemical solutions are uniform in composition. Therefore, ignoring any imprecision caused by the sample matrix, the variability of analytical results for water samples should be relatively low unless suspended material or sample handling and storage introduce additional imprecision. Precision acceptance criteria for aqueous and soil/sediment duplicate samples have been assigned accordingly in Tables 3-2, 3-4, 3-6, 3-8, 3-10, 3-12, 3-14, 3-16. Results outside of these limits will trigger corrective actions, which are also presented in Table 3-1.

Because of the inherent and unknown heterogeneity of soil samples, the precision of soil field duplicate samples will not be used for QC, but will be compared to laboratory precision estimates to gain a perspective on the natural heterogeneity of the soil.

3.1.2 Field Precision Objectives

Field precision is assessed by collecting and measuring field duplicates at a rate of 1 duplicate per 10 environmental samples. Acceptance limits for field duplicate precision are provided in Table 3-1. This precision estimate encompasses 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 (as applicable), and analysis uncertainties. Consequently, the field precision estimates [i.e., relative percent difference (RPD) values] should equal or exceed the laboratory precision estimates, on average, for each analyte. If field duplicate precision is significantly different from laboratory duplicate precision, the underlying cause will be investigated to determine whether the observed difference could be artifacts of sampling and analysis. Considerations given to this effort include:

- The scale of subsampling for laboratory precision estimates relative to the scale of field duplicate sample size
- Analytical measurement precision
- Precision for repeat analysis of the same solid laboratory control sample (LCS)
- Estimated environmental sample grain size relative to LCS grain size
- Potential natural soil heterogeneity
- Concentration level of the analyte

3.1.3 Laboratory Precision Objectives

Laboratory precision QC samples [i.e., laboratory duplicates for inorganic chemicals and matrix spike duplicates (MSDs) for organic chemicals] will be analyzed with a minimum frequency of 5 percent (i.e., 1 QC sample per 20 environmental samples). Laboratory precision is measured by comparing RPD values with precision control limits specified in Table 3-1.

3.2 ACCURACY

3.2.1 Definition

Accuracy is the degree of agreement between an observed value and an accepted reference value. This parameter is assessed by measuring spiked samples [e.g., surrogate spikes or matrix spikes (MSs)] or well-characterized samples of certified analyte concentrations (e.g., LCSs) and by measuring blanks. Accuracy measurements are designed to detect biases resulting from the sample handling and analysis processes. The equations for determining accuracy of an individual MS and a surrogate spike or LCS for this project are provided in Section 12.1. The equations in Section 12.1 do not apply to blank samples, however, because division by zero (the expected amount or added amount) causes the calculated value to be infinite. Instead, acceptance criteria are designed to limit the tolerable amount of contamination while recognizing that non-zero results for blanks are likely, if only because of random error in the measurement process. The laboratory analytical SOPs (Appendix I) limit tolerable blank concentrations. The bias computations for individual MSs, LCSs and method blanks will be used to control the analysis process by triggering corrective actions as specified in Table 3-1.

3.2.2 Field Accuracy Objectives

Field test kits are operated in accordance with the manufacturer's instructions that accompany the test kit. Accuracy requirements for field measurements are typically ensured through control over the sample collection and handling and through routine instrument calibration. In addition, after completing field measurements for specific conductance, pH, and turbidity, a check standard is analyzed to verify continued acceptable calibrations. The acceptance criteria for field measurement accuracy are specified in the field SOPs (included in Appendix H). Accuracy of grain size and depositional environment classifications is ensured by requiring that a qualified field geologist makes those classifications.

Accuracy is also typically monitored through the use of blanks to detect cross-contamination and by monitoring adherence to procedures that prevent sample contamination or degradation. Equipment rinsate blanks shall be collected for this investigation to assess cross-contamination via non-disposable sample collection equipment. Ambient condition blanks will not be collected unless site conditions during sampling (e.g., generation of fugitive dust) indicate a need to assess infiltration of airborne contaminants into sampling containers. Source water blanks will be collected to monitor the purity of water used to decontaminate sampling equipment. Accuracy also shall be assured qualitatively through adherence to all sample handling, preservation, and holding-time requirements.

3.2.3 Laboratory Accuracy Objectives

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 is also assessed by monitoring the analytical recovery of select surrogate compounds added to samples that are analyzed by organic chromatographic methods. MS and surrogate compound analyses measure the combined accuracy effects of the sample matrix, sample preparation and sample measurement. LCSs are used to assess the accuracy of laboratory operations with minimal sample matrix effects. Post-digestion spikes (PDSs) are used to assess the accuracy of the analytical measurement on the sample extract or digestate. Each spiked sample shall be spiked with representative target analytes for the analysis being performed to ensure that accuracy measures are obtained for each target analyte. Spiking concentrations shall equal or approximate the default concentrations detailed in the applicable sample preparation SOPs. LCS and MS analyses are performed at a frequency no less than 1 per 20 associated samples of like matrix. Laboratory accuracy is assessed via comparison of calculated %R values to accuracy control limits specified in Tables 3-1 through 3-17.

3.3 COMPLETENESS

3.3.1 Definition

Completeness is a measure of the amount of usable, valid analytical data obtained compared to the amount expected to be obtained. Completeness is expressed as a percentage.

3.3.2 Field Completeness Objectives

Field completeness is a measure of the amount of valid field measurements obtained from all the field measurements taken in the project. Documentation of sample location and depth is planned for each soil and ground water sample. Documentation of grain size and depositional environment is also planned for each soil sample. A completeness criterion of 100% applies to these measurements. However, the 100% completeness criterion for depositional environment and grain size may be reduced, depending on whether these factors are significant for background comparisons, as determined under the Base-Wide Background Soil Investigation for NSWC Crane. Furthermore, failure to document grain size and depositional environment may be recoverable by inspecting field logs and site maps, or through laboratory measurement once the samples are received by the laboratory. Failure to obtain 100% of these measurements for field samples will indicate a need for corrective actions designed to recover the missing information. Failure to recover the information will constitute a need to resample, unless the missing data are judged not to adversely affect attainment of project objectives.

Turbidity is a critical parameter that must be determined prior to sampling to establish attainment of equilibrium, and its completeness criterion is 100%. There are no completeness criteria for dissolved oxygen, nitrate, flow rate, oxidation-reduction potential, water level, alkalinity, carbon dioxide, ferrous iron, hydrogen sulfide, nitrite, sulfate, pH, specific conductance, and temperature. These are non-critical parameters which are generally determined to verify that appropriate sampling conditions exist prior to sampling, or to provide data to evaluate the potential efficacy of Monitored Natural Attenuation (MNA) as a remedial option.

3.3.3 Laboratory Completeness Objectives

Laboratory completeness is a measure of the amount of usable, valid laboratory measurements per matrix obtained for each of the target analytes. Usable, valid results are those that are judged, after data assessment, to represent the sampling populations and to have not been disqualified for use through data validation or data assessment.

Laboratory completeness objectives are 90 percent for each critical target analyte per sample matrix (soil and water). The use of kriging (i.e., geostatistical contouring), which can interpolate missing values may mitigate some of the adverse effects experienced from loss of data. Furthermore, the impact of missing soil data cannot be quantified in advance of sampling because the impact will depend on which data are missing. The impact of the loss of any other particular datum on attainment of project objectives will be evaluated during data assessment.

Qualifications on the use of data caused by incomplete data sets will be documented in the RFI report.

3.4 REPRESENTATIVENESS

3.4.1 Definition

Representativeness is an expression of the degree to which the data accurately and precisely represent a characteristic of a population or environmental condition existing at the site. Adherence to the SAP (Section 4) and use of standardized sampling, handling, preparation, analysis, and reporting procedures ensures that the final data accurately represent the desired populations. Representativeness will be evaluated during data assessment to determine whether each datum belongs to the observed data distribution through outlier testing. The statistical tests to be used are described in Section 12.4. Any anomalies will be investigated to assess their impact on statistical computations.

3.4.2 Measures to Ensure Representativeness of Field Data

Representativeness depends upon the proper design of the sampling program and will be satisfied by ensuring that the SAP (Section 4) is followed and that proper sampling techniques are used. Strict adherence to soil type descriptions and care to ensure that a soil sample representing the appropriate depth interval is placed into each sample container will be ensured during sample collection. Well stabilization parameters (See Table 1-7) will be monitored to ensure that ground water wells have attained equilibrium prior to sampling.

3.4.3 Measures to Ensure Representativeness of Lab Data

Representativeness in the laboratory is ensured or evaluated by using the proper analytical procedures, meeting sample holding times, and analyzing and evaluating field duplicate samples relative to laboratory duplicates. During development of this QAPP, measures to ensure representativeness of the data generated included consideration of past operations, aerial photographs, existing analytical data, physical setting, depositional environments, monitoring well placement, spatial coverage of the proposed sampling locations, accessibility to sampling locations, and constraints inherent to the RCRA program. The rationale of the sampling network is presented in detail in Sections 1.5 and 4.

3.5 COMPARABILITY

3.5.1 Definition

Comparability is defined as the confidence with which one data set can be compared to another (e.g., between sampling points; between sampling events). Comparability is achieved by using standardized sampling and analysis methods and data reporting formats (including use of consistent units of measure), and by ensuring that reporting and detection limits are sufficiently low to satisfy project detection and quantitation criteria for the duration of the project. The RLs anticipated for this project are presented in Tables 1-8 and 1-9. Additionally, consideration was given to seasonal conditions and other environmental variations that could exist to influence analytical results, but no such influences appear to exist for this investigation that would indicate a need to collect samples at times other than those planned for this investigation.

3.5.2 Measures to Ensure Comparability of Field Data

Comparability depends upon the proper design of the sampling program and will be satisfied by ensuring that Section 4 of this QAPP is followed and that proper sampling techniques are used. The rationale behind the SAP design is found in Sections 1.5 and 4.

3.5.3 Measures to Ensure Comparability of Laboratory Data

Planned analytical data will be comparable when similar sampling and analytical methods are used and documented. The use of sampling and analysis methods in this investigation that are comparable in performance to those used in the Base-Wide Background Soil Investigation for NSWC Crane should limit the need to consider biases when making soil data set comparisons for metals. Results will be reported in units that ensure comparability with previous data. The units used for the laboratory measurements are further explained in Section 9.1.2 of this QAPP.

3.6 LEVEL OF QUALITY CONTROL EFFORT

Several QC samples will be analyzed for this project to provide a means to assess field and laboratory performance. Field QC samples consist of field duplicates, equipment rinsate blanks, source water blanks, temperature blanks, and, at the discretion of the FOL, ambient condition blanks. These QC checks are described in Section 8.1. Each type of field QC sample undergoes the same preservation, analysis, and reporting procedures as the related environmental samples. Frequencies of field QC sample collection and analysis are presented in Table 3-1. The types and numbers of QC samples to be collected in the field are presented in Table 4-2.

Laboratory QC encompasses a host of other checks performed during sample preparation and analysis, as described in Section 8.2. Frequencies for laboratory QC checks are provided in Table 3-1 and in the method-specific laboratory SOPs appended to this QAPP (Appendix I).

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TABLE 3-1

NON-CALIBRATION QC SAMPLE USAGE FREQUENCIES, ACCEPTANCE LIMITS AND CORRECTIVE ACTIONS NSWC CRANE, CRANE, INDIANA PAGE 1 OF 2

QC Sample Type	Collection Frequency	Acceptance Limits	Corrective Action
Field Duplicate*	1 per 10 investigative samples collected.	Aqueous = 20% RPD Soil/Sediment = 50% RPD	Qualify data according to data validation requirements.
Equipment Rinsate Blank	1 per 10 investigative samples collected, with a minimum of one per day of sampling, per non-disposable sampling device/instrument. For pre-cleaned, dedicated, and/or disposable equipment (i.e., disposable plastic trowels, etc.), one rinsate blank will be collected and analyzed at a frequency of one per lot or "batch blank" for a specific equipment type.	< RL (soil and water)	Identify source of contamination, if possible. Qualify data according to validation criteria. Qualify use of data if contamination appears to have adversely affected its usability.
Source Water Blank	1 per each source of water used for sampling equipment decontamination.	< RL (soil and water)	Identify source of contamination, if possible. Qualify data according to validation criteria. Qualify use of data if contamination appears to have adversely affected its usability.
Ambient Condition Blanks	At discretion of FOL	< RL (soil and water)	Identify source of contamination, if possible. Qualify data according to validation criteria. Qualify use of data if contamination appears to have adversely affected its usability.
Trip Blanks	1 per cooler containing samples for volatile organics analysis	< RL (soil and water)	Identify source of volatiles contamination, if possible. Qualify data according to validation criteria. Qualify use of data if contamination appears to have adversely affected its usability.
Internal Standard	At least one internal standard per sample for GC/MS analyses.	Retention times stable to ±30 seconds; area counts stable to within factor of 2.	Laboratory action taken per LTL-1008. TtNUS action taken per validation protocols, and Section 12.4.
Laboratory Control Sample	1 per 20 environmental samples per matrix	See Tables 3-3, 3-5, 3-7, 3-9, 3-11, 3-13, 3-15, 3-17	Laboratory action taken per LTL-1008. TtNUS action taken per validation protocols, and Section 12.4.

TABLE 3-1

NON-CALIBRATION QC SAMPLE USAGE FREQUENCIES, ACCEPTANCE LIMITS AND CORRECTIVE ACTIONS NSWC CRANE, CRANE, INDIANA PAGE 2 OF 2

QC Sample Type	Collection Frequency	Acceptance Limits	Corrective Action
Laboratory Duplicate	1 per 20 environmental samples analyzed for inorganic target analytes	See Tables 3-4, 3-16	Laboratory action taken per LTL-1008. TtNUS action taken per validation protocols, and Section 12.4.
Laboratory Method Blank	1 per 20 environmental samples or per preparation batch, whichever is more frequent	< RL (soil and water)	Laboratory action taken per LTL-1008. TtNUS action taken per validation protocols, and Section 12.4.
Matrix Spike**	1 per 20 environmental samples	See Tables 3-2, 3-4, 3-6, 3-8, 3-10, 3-12, 3-14, 3-16	Laboratory action taken per LTL-1008. TtNUS action taken per validation protocols, and Section 12.4.
Matrix Spike Duplicate**	1 per 20 environmental samples analyzed for organic target analytes	See Tables 3-2, 3-6, 3-8, 3-10, 3-14, 3-16	Laboratory action taken per LTL-1008. TtNUS action taken per validation protocols, and Section 12.4.
Post-digestion Spike	Only if out-of-control matrix spike exists (metals only)	100 ± 20%	Laboratory action taken per LTL-1008. TtNUS action taken per validation protocols, and Section 12.4.
Surrogate	At least one per sample for organic chromatographic analyses (GC, GC/MS, and HPLC)	See Tables 3-2, 3-6, 3-8, 3-10, 3-12, 3-14, 3-16	Laboratory action taken per LTL-1008. TtNUS action taken per validation protocols, and Section 12.4.
Temperature Blank	One blank per sample cooler.	4 ± 2 °C	Laboratory action taken per LTL-1008. TtNUS action taken per validation protocols, and Section 12.4.

* Refer to Section 3.1.2 for the strategy for obtaining precision estimates for ground water.

** Matrix spikes and matrix spike duplicates are not analyzed in the field, but additional sample material must be collected in the field to ensure that the laboratory has enough material for spiking and duplicate analysis. See Table 4-3 for details regarding extra volume required.

TABLE 3-2

QUALITY CONTROL LIMITS[1]
MATRIX SPIKE/MATRIX SPIKE DUPLICATE SAMPLES AND SURROGATE SPIKES
EXPLOSIVES ANALYSES
NSWC CRANE, INDIANA

Chemical	Solid Matrix		Aqueous Matrix	
	Accuracy (%R)	Precision (RPD)	Accuracy (%R)	Precision (RPD)
EXPLOSIVES BY SW-846 METHOD 8330 AND MODIFIED ARMY METHOD				
1,3,5-Trinitrobenzene	65-152	50	44-142	30
1,3-Dinitrobenzene	65-135	50	32-122	30
2,4,6-Trinitrotoluene	65-138	50	59-114	30
2,4-Dinitrotoluene	65-135	50	42-110	30
2,6-Dinitrotoluene	65-139	50	38-106	30
HMX	64-137	50	10-96	30
2-Nitrotoluene	65-139	50	30-99	30
3-Nitrotoluene	50-144	50	28-105	30
4-Nitrotoluene	32-160	50	31-100	30
4-Amino-2,6-dinitrotoluene	68-139	50	58-117	30
2-Amino-4,6-dinitrotoluene	74-134	50	58-117	30
Tetryl	20-152	50	27-109	30
Nitrobenzene	25-144	50	31-99	30
RDX	65-142	50	47-125	30
Nitroglycerin	30-150[2]	50[2]	30-150[2]	50[2]
Nitrocellulose (Modified Army Method)	30-150	50	30-150	50
1,2-Dinitrobenzene (surrogate)	60-140	NA[3]	60-140	NA[3]

1 In-house QC limits provided by Laucks Testing Laboratories, Inc.
2 Laucks Testing Laboratories, Inc. will perform the preparative extraction for these analytes in the same manner as the remaining analytes but will analyze for them using a 210 nm wavelength (similar to SW-846 Method 8332) rather than a wavelength of 254 nm. Statistical QC limits will be developed when 20 data points are obtained. The default limits presented will be used until that time.
3 Not applicable.

%R = Percent Recovery
RPD = Relative Percent Difference

TABLE 3-3

QUALITY CONTROL LIMITS[1]
LABORATORY CONTROL SAMPLES
EXPLOSIVES ANALYSES
NSWC CRANE, INDIANA

Chemical	Solid Matrix Accuracy (%R)	Aqueous Matrix Accuracy (%R)
EXPLOSIVES BY SW-846 METHOD 8330 AND MODIFIED ARMY METHOD		
1,3,5-Trinitrobenzene	65-152	52-125
1,3-Dinitrobenzene	65-135	53-122
2,4,6-Trinitrotoluene	65-138	51-134
2,4-Dinitrotoluene	65-135	55-129
2,6-Dinitrotoluene	65-139	49-132
HMX	64-137	29-135
2-Nitrotoluene	65-139	41-140
3-Nitrotoluene	50-144	40-145
4-Nitrotoluene	32-160	39-142
4-Amino-2,6-dinitrotoluene	68-139	60-125
2-Amino-4,6-dinitrotoluene	74-134	61-125
Methyl-2,4,6-Trinitrophenylnitramine	20-152	33-138
Nitrobenzene	25-144	40-134
RDX	65-142	44-125
Nitroglycerin	30-150[2]	30-150[2]
Nitrocellulose	30-150	30-150

1 In-house QC limits provided by Laucks Testing Laboratories, Inc.
2 Laucks Testing Laboratories, Inc will perform the preparative extraction for this analyte in the same manner as the remaining analytes but will analyze for them using a 210 nm wavelength (similar to SW-846 Method 8332) rather than a wavelength of 254 nm. Statistical QC limits will be developed when 20 data points are obtained. The default limits presented will be used until that time.

%R = Percent Recovery

TABLE 3-4

QUALITY CONTROL LIMITS[1]
MATRIX SPIKE AND LABORATORY DUPLICATE SAMPLES
METALS ANALYSES
NSWC CRANE, INDIANA

Chemical	Solid Matrix		Aqueous Matrix	
	Accuracy[2] (%R)	Precision[3] (RPD)	Accuracy[2] (%R)	Precision[3] (RPD)
APPENDIX IX METALS BY SW-846 METHOD 6020 (UNLESS OTHERWISE NOTED)				
Antimony	75-125	50	75-125	30
Arsenic	75-125	50	75-125	30
Barium	75-125	50	75-125	30
Beryllium	75-125	50	75-125	30
Cadmium	75-125	50	75-125	30
Chromium (total)	75-125	50	75-125	30
Cobalt	75-125	50	75-125	30
Copper	75-125	50	75-125	30
Lead	75-125	50	75-125	30
Mercury (SW-846 Method 7070A)	75-125	50	75-125	30
Nickel	75-125	50	75-125	30
Selenium	75-125	50	75-125	30
Silver	75-125	50	75-125	30
Thallium	75-125	50	75-125	30
Tin	75-125	50	75-125	30
Vanadium	75-125	50	75-125	30
Zinc	75-125	50	75-125	30
MISCELLANEOUS METALS BY SW-846 METHOD 6010B				
Aluminum	75-125	50	75-125	30
Calcium	75-125	50	75-125	30
Iron	75-125	50	75-125	30
Magnesium	75-125	50	75-125	30
Manganese	75-125	50	75-125	30
Potassium	75-125	50	75-125	30
Sodium	75-125	50	75-125	30

1 In-house QC limits provided by Laucks Testing Laboratories, Inc.
2 These acceptance limits apply to spikes that augment the native sample analyte concentration by at least 25 percent.
3 These acceptance limits apply to original and duplicate sample concentrations >5x RL. If one or both of the results is <5x RL, the acceptance criterion is ± RL. If one of the results is a non-detect, the reported %RPD will be 200%.

%R = Percent Recovery RPD = Relative Percent Difference

TABLE 3-5

QUALITY CONTROL LIMITS[1]
LABORATORY CONTROL SAMPLES
METALS ANALYSES
NSWC CRANE, INDIANA

Chemical	Solid Matrix Accuracy (%R)[2]	Aqueous Matrix Accuracy (%R)[2]
APPENDIX IX METALS BY SW-846 METHOD 6020 (UNLESS OTHERWISE NOTED)		
Antimony	75-125	75-125
Arsenic	80-120	80-120
Barium	80-120	80-120
Beryllium	80-120	80-120
Cadmium	80-120	80-120
Chromium (total)	80-120	80-120
Cobalt	80-120	80-120
Copper	80-120	80-120
Lead	80-120	80-120
Mercury (SW-846 Method 7470A)	80-120	80-120
Nickel	80-120	80-120
Selenium	80-120	80-120
Silver	75-125	75-125
Thallium	80-120	80-120
Tin	80-120	80-120
Vanadium	80-120	80-120
Zinc	80-120	80-120
MISCELLANEOUS METALS BY SW-846 METHOD 6010B		
Aluminum	80-120	80-120
Calcium	80-120	80-120
Iron	80-120	80-120
Magnesium	80-120	80-120
Manganese	80-120	80-120
Potassium	80-120	80-120
Sodium	80-120	80-120

1 In-house QC limits provided by Laucks Testing Laboratories, Inc.
2 As noted in the laboratory SOPs, the laboratory may use a purchased standard reference material (SRM) in place of a LCS. If an SRM is used, the acceptance limits provided by the supplier of the SRM may be used unless the SRM limits are wider than the acceptance limits provided in this table. If the SRM limits are wider, the laboratory must use the acceptance limits provided in this table.

%R = Percent Recovery

TABLE 3-6

QUALITY CONTROL LIMITS[1]
MATRIX SPIKE/MATRIX SPIKE DUPLICATE SAMPLES AND SURROGATE SPIKES
VOLATILE ORGANIC COMPOUND ANALYSES
NSWC CRANE, INDIANA
PAGE 1 OF 2

Chemical	Solid Matrix		Aqueous Matrix	
	Accuracy (%R)	Precision (RPD)	Accuracy (%R)	Precision (RPD)
VOLATILE ORGANIC COMPOUNDS BY SW-846 METHOD 8260B				
1,1,1-Trichloroethane	65-135	50	75-125	30
1,1,2,2-Tetrachloroethane	64-135	50	74-125	30
1,1,2-Trichloroethane	65-135	50	75-127	30
1,1-Dichloroethane	62-135	50	72-125	30
1,1-Dichloroethene	65-135	50	59-145	30
1,2-Dichloroethane	58-137	50	68-127	30
1,2-Dichloropropane	60-135	50	70-125	30
2-Butanone	60-135	50	70-125	30
2-Hexanone	60-135	50	70-125	30
4-Methyl-2-pentanone	60-135	50	70-125	30
Acetone	60-135	50	70-125	30
Benzene	65-135	50	62-142	30
Bromodichloromethane	65-135	50	75-125	30
Bromoform	65-135	50	75-125	30
Bromomethane	62-135	50	72-175	30
Carbon disulfide	60-135	50	70-125	30
Carbon tetrachloride	52-135	50	62-125	30
Chlorobenzene	65-135	50	62-135	30
Chloroethane	55-135	50	65-125	30
Chloroform	64-135	50	74-125	30
Chloromethane	65-135	50	75-125	30
cis-1,2-Dichloroethene	65-135	50	75-125	30
trans-1,2-Dichloroethene	65-135	50	75-125	30
cis-1,3-Dichloropropene	64-135	50	74-125	30
trans-1,3-Dichloropropene	56-135	50	66-125	30
Dibromochloromethane	63-135	50	75-125	30
Ethylbenzene	65-135	50	75-125	30
Methylene chloride	65-135	50	75-125	30
Styrene	65-135	50	75-125	30
Tetrachloroethene	61-135	50	71-125	30
Toluene	64-135	50	59-139	30
Toluene-D8 (surrogate)	65-135	NA	75-125	NA
Trichloroethene	61-135	50	54-141	30

TABLE 3-6

QUALITY CONTROL LIMITS(1)
MATRIX SPIKE/MATRIX SPIKE DUPLICATE SAMPLES AND SURROGATE SPIKES
VOLATILE ORGANIC COMPOUND ANALYSES
NSWC CRANE, INDIANA
PAGE 2 OF 2

Chemical	Solid Matrix		Aqueous Matrix	
	Accuracy (%R)	Precision (RPD)	Accuracy (%R)	Precision (RPD)
Vinyl chloride	36-144	50	46-134	30
Xylenes (Total)	65-135	50	75-125	30
1,2-Dichloroethane-D4 (surrogate)	52-149	NA	62-139	NA
4-Bromofluorobenzene (surrogate)	65-135	NA	75-125	NA
ADDITIONAL VOLATILE ORGANIC COMPOUNDS BY SW-846 METHOD 8015B				
1,4-Dioxane	30-140(2)	50	30-140(3)	50
Acetonitrile	30-140(2)	50	57-126	20
Isobutyl alcohol	30-140(2)	50	63-130	18
Propionitrile	30-140(2)	50	73-124	15
4-Bromofluorobenzene (surrogate)	70-130	NA	70-130	NA

1 In-house QC limits provided by Laucks Testing Laboratories, Inc.
2 Statistical QC limits will be developed when 20 data points are obtained. The default limits presented will be used until that time.

%R = Percent Recovery
RPD = Relative Percent Difference
NA = Not Applicable

TABLE 3-7

QUALITY CONTROL LIMITS[1]
LABORATORY CONTROL SAMPLES
VOLATILE ORGANIC COMPOUND ANALYSES
NSWC CRANE, INDIANA

Chemical	Solid Matrix Accuracy (%R)	Aqueous Matrix Accuracy (%R)
VOLATILE ORGANIC COMPOUNDS BY SW-846 METHOD 8260B		
1,1-Dichloroethene	30-160	70-130
Benzene	63-141	70-130
Chlorobenzene	61-143	70-130
Trichloroethene	65-146	70-130
Toluene	62-148	70-130
ADDITIONAL VOLATILE ORGANIC COMPOUNDS BY SW-846 METHOD 8015B		
Acetonitrile	30-140[2]	65-133
Isobutyl alcohol	30-140[2]	68-131
Propionitrile	30-140[2]	77-121

1 In-house QC limits provided by Laucks Testing Laboratories, Inc.
2 Statistical QC limits will be developed when 20 data points are obtained. The default limits presented will be used until that time.

TABLE 3-8

QUALITY CONTROL LIMITS[1]
MATRIX SPIKE/MATRIX SPIKE DUPLICATE SAMPLES AND SURROGATE SPIKES
SEMIVOLATILE ORGANIC COMPOUND ANALYSES
NSWC CRANE, INDIANA
PAGE 1 OF 3

Chemical	Solid Matrix		Aqueous Matrix	
	Accuracy (%R)	Precision (RPD)	Accuracy (%R)	Precision (RPD)
SEMIVOLATILE ORGANIC COMPOUNDS BY SW-846 METHOD 8270C				
1,2,4-Trichlorobenzene	40-121	50	43-103	30
1,2-Dichlorobenzene	32-135	50	42-155	30
1,3-Dichlorobenzene	26-135	50	36-125	30
1,4-Dichlorobenzene	25-135	50	33-96	30
2-Chloronaphthalene	50-135	50	60-125	30
2-Chlorophenol	40-106	50	41-115	30
2-Methylphenol	25-135	50	25-125	30
2-Nitroaniline	40-135	50	50-125	30
2-Nitrophenol	34-135	50	44-125	30
2,4-Dichlorophenol	36-135	50	46-125	30
2,4-Dimethylphenol	35-149	50	45-139	30
2,4-Dinitrophenol	25-161	50	30-151	30
2,4,5-Trichlorophenol	25-175	50	25-175	30
2,4,6-Trichlorophenol	29-138	50	39-128	30
3-Nitroaniline	41-135	50	51-125	30
3,3'-Dichlorobenzidine	25-175	50	29-175	30
4-Bromophenyl phenyl ether	43-137	50	53-127	30
4-Chloroaniline	35-146	50	45-136	30
4-Chloro-3-methylphenol	55-120	50	49-121	30
4-Chlorophenyl phenyl ether	41-142	50	51-132	30
4-Methylphenol	25-135	50	33-125	30
4-Nitroaniline	30-153	50	40-143	30
4-Nitrophenol	23-143	50	38-134	30
4,6-Dinitro-2-methylphenol	25-144	50	26-134	30
Bis(2-chloroethoxy)methane	39-135	50	49-125	30
Bis(2-chloroethyl)ether	34-135	50	44-125	30
Bis(2-chloroisopropyl)ether	26-175	50	36-166	30
Bis(2-ethylhexyl)phthalate	25-139	50	33-129	30
Butyl benzyl phthalate	25-135	50	26-125	30
Di-n-butyl phthalate	25-136	50	34-126	30
Di-n-octyl phthalate	28-137	50	38-127	30
Dibenzofuran	42-135	50	52-125	30

TABLE 3-8

QUALITY CONTROL LIMITS[1]
MATRIX SPIKE/MATRIX SPIKE DUPLICATE SAMPLES AND SURROGATE SPIKES
SEMIVOLATILE ORGANIC COMPOUND ANALYSES
NSWC CRANE, INDIANA
PAGE 2 OF 3

Chemical	Solid Matrix		Aqueous Matrix	
	Accuracy (%R)	Precision (RPD)	Accuracy (%R)	Precision (RPD)
Diethyl phthalate	27-135	50	37-125	30
Dimethyl phthalate	25-175	50	25-175	30
Hexachlorobenzene	36-143	50	46-133	30
Hexachlorobutadiene	25-135	50	25-125	30
Hexachlorocyclopentadiene	31-135	50	41-125	30
Hexachloroethane	25-163	50	25-153	30
Isophorone	25-175	50	26-175	30
n-Nitrosodi-n-propylamine	48-118	50	53-128	30
n-Nitrosodiphenylamine	25-135	50	27-125	30
Pentachlorophenol	20-159	50	60-131	30
Phenol	41-109	50	33-112	30
2,4,6-Tribromophenol (surrogate)	19-122	NA	10-123	NA
2-Fluorobiphenyl (surrogate)	32-99	NA	45-88	NA
2-Fluorophenol (surrogate)	25-108	NA	21-100	NA
Nitrobenzene-D5 (surrogate)	24-102	NA	35-105	NA
Phenol-D5 (surrogate)	24-112	NA	10-94	NA
Terphenyl-D14 (surrogate)	31-109	NA	33-129	NA
POLYNUCLEAR AROMATIC HYDROCARBONS BY SW-846 METHOD 8270C WITH SIM				
2-Methylnaphthalene	20-160[2]	50	20-160[2]	30
Acenaphthylene	20-160[2]	50	20-160[2]	30
Acenaphthene	20-160[2]	50	20-160[2]	30
Anthracene	20-160[2]	50	20-160[2]	30
Benzo(a)anthracene	20-160[2]	50	20-160[2]	30
Benzo(a)pyrene	20-160[2]	50	20-160[2]	30
Benzo(b)fluoranthene	20-160[2]	50	20-160[2]	30
Benzo(k)fluoranthene	20-160[2]	50	20-160[2]	30
Benzo(g,h,i)perylene	20-160[2]	50	20-160[2]	30
Chrysene	20-160[2]	50	20-160[2]	30
Dibenzo(a,h)anthracene	20-160[2]	50	20-160[2]	30
Fluoranthene	20-160[2]	50	20-160[2]	30
Fluorene	20-160[2]	50	20-160[2]	30
Indeno(1,2,3-c,d)pyrene	20-160[2]	50	20-160[2]	30
Naphthalene	20-160[2]	50	20-160[2]	30

TABLE 3-8

QUALITY CONTROL LIMITS[1]
MATRIX SPIKE/MATRIX SPIKE DUPLICATE SAMPLES AND SURROGATE SPIKES
SEMIVOLATILE ORGANIC COMPOUND ANALYSES
NSWC CRANE, INDIANA
PAGE 3 OF 3

Chemical	Solid Matrix		Aqueous Matrix	
	Accuracy (%R)	Precision (RPD)	Accuracy (%R)	Precision (RPD)
Phenanthrene	20-160[2]	50	20-160[2]	30
Pyrene	20-160[2]	50	20-160[2]	30
POLYNUCLEAR AROMATIC HYDROCARBONS BY SW-846 METHOD 8270C WITH SIM				
1-Fluoronaphthalene (surrogate)	20-160[2]	NA[2]	20-160[2]	NA
Fluorene-D10 (surrogate)	20-160[2]	NA[2]	20-160[2]	NA
Pyrene-D10 (surrogate)	20-160[2]	NA[2]	20-160[2]	NA

1 In-house QC limits provided by Laucks Testing Laboratories, Inc.
2 Statistical QC limits will be developed when 20 data points are obtained. The default limits presented will be used until that time.

%R = Percent Recovery
RPD = Relative Percent Difference
NA = Not Applicable

TABLE 3-9

QUALITY CONTROL LIMITS[1]
LABORATORY CONTROL SAMPLES
SEMIVOLATILE ORGANIC COMPOUND ANALYSES
NSWC CRANE, INDIANA

Chemical	Solid Matrix Accuracy (%R)	Aqueous Matrix Accuracy (%R)
SEMIVOLATILE ORGANIC COMPOUNDS BY SW-846 METHOD 8270C		
1,2,4-Trichlorobenzene	40-121	44-110
1,4-Dichlorobenzene	34-107	20-108
2-Chlorophenol	40-106	31-126
4-Chloro-3-methylphenol	55-120	56-115
4-Nitrophenol	23-143	10-110
n-Nitrosodi-n-propylamine	48-118	50-127
Pentachlorophenol	20-159	30-123
Phenol	41-109	10-112
POLYNUCLEAR AROMATIC HYDROCARBONS BY SW-846 METHOD 8270C WITH SIM		
2-Methylnaphthalene	20-160[2]	20-160[2]
Acenaphthylene	20-160[2]	20-160[2]
Acenaphthene	20-160[2]	20-160[2]
Anthracene	20-160[2]	20-160[2]
Benzo(a)anthracene	20-160[2]	20-160[2]
Benzo(a)pyrene	20-160[2]	20-160[2]
Benzo(b)fluoranthene	20-160[2]	20-160[2]
Benzo(k)fluoranthene	20-160[2]	20-160[2]
Benzo(g,h,i)perylene	20-160[2]	20-160[2]
Chrysene	20-160[2]	20-160[2]
Dibenzo(a,h)anthracene	20-160[2]	20-160[2]
Fluoranthene	20-160[2]	20-160[2]
Fluorene	20-160[2]	20-160[2]
Indeno(1,2,3-c,d)pyrene	20-160[2]	20-160[2]
Naphthalene	20-160[2]	20-160[2]
Phenanthrene	20-160[2]	20-160[2]
Pyrene	20-160[2]	20-160[2]

1 In-house QC limits provided by Laucks Testing Laboratories, Inc.
2 Statistical QC limits will be developed when 20 data points are obtained. The default limits presented will be used until that time.

%R = Percent Recovery

TABLE 3-10

QUALITY CONTROL LIMITS[1]
MATRIX SPIKE/MATRIX SPIKE DUPLICATE SAMPLES AND SURROGATE SPIKES
ORGANOCHLORINE PESTICIDE AND PCB ANALYSES
NSWC CRANE, INDIANA

Chemical	Solid Matrix		Aqueous Matrix	
	Accuracy (%R)	Precision (RPD)	Accuracy (%R)	Precision (RPD)
ORGANOCHLORINE PESTICIDES AND PCBs BY SW-846 METHOD 8081A/8082				
α-BHC	65-135	50	75-125	30
β-BHC	41-133	50	51-125	30
δ-BHC	65-136	50	75-126	30
γ-BHC (Lindane)	20-128	50	33-141	36
α-Chlordane	35-135	50	41-125	30
γ-Chlordane	35-135	50	41-125	30
4,4'-DDD	38-146	50	48-136	30
4,4'-DDE	35-149	50	45-139	30
4,4'-DDT	25-153	50	35-143	28
Aldrin	20-138	50	24-128	27
Dieldrin	32-142	50	40-135	23
Endosulfan I	39-153	50	49-143	30
Endosulfan II	65-169	50	75-159	30
Endosulfan sulfate	36-151	50	46-141	30
Endrin	33-144	50	44-140	34
Endrin aldehyde	65-160	50	75-150	30
Heptachlor	20-131	50	30-123	29
Heptachlor epoxide	43-144	50	53-134	30
Methoxychlor	63-152	50	73-142	30
Aroclor-1260	31-136	50	40-126	30
Toxaphene				
Decachlorobiphenyl (surrogate)	20-160	NA	30-160	NA
Tetrachloro-m-xylene (surrogate)	20-150	NA	25-139	NA

1 In-house QC limits provided by Laucks Testing Laboratories, Inc.

%R = Percent Recovery
RPD = Relative Percent Difference
NA = Not Applicable

TABLE 3-11

QUALITY CONTROL LIMITS[1]
LABORATORY CONTROL SAMPLES
ORGANOCHLORINE PESTICIDE AND PCB ANALYSES
NSWC CRANE, INDIANA

Chemical	Solid Matrix Accuracy (%R)	Aqueous Matrix Accuracy (%R)
ORGANOCHLORINE PESTICIDES AND PCBs BY SW-846 METHOD 8081A/8082		
γ-BHC (Lindane)	20-128	20-159
Aldrin	20-138	34-127
Heptachlor	20-131	29-122
Aroclor-1260	20-160	39-149

1 In-house QC limits provided by Laucks Testing Laboratories, Inc.

%R = Percent Recovery

TABLE 3-12

QUALITY CONTROL LIMITS[1]
MATRIX SPIKE/MATRIX SPIKE DUPLICATE SAMPLES AND SURROGATE SPIKES
HERBICIDE ANALYSES
NSWC CRANE, INDIANA

Chemical	Solid Matrix		Aqueous Matrix	
	Accuracy (%R)	Precision (RPD)	Accuracy (%R)	Precision (RPD)
HERBICIDES BY SW-846 METHOD 8151A				
2,4-D	20-160	50	41-140	30
2,4,5-T	20-160	50	32-140	30
2,4,5-TP (Silvex)	20-160	50	45-140	30
Dinoseb	20-160	50	7-140	30
2,6-Dichlorobenzoic acid (surrogate)	20-160	NA	45-140	NA
2,4-Dichlorophenylaceticacid (surrogate)	20-160	NA	50-140	NA

1 In-house QC limits provided by Laucks Testing Laboratories, Inc.

%R = Percent Recovery
RPD = Relative Percent Difference
NA = Not Applicable

TABLE 3-13

QUALITY CONTROL LIMITS[1]
LABORATORY CONTROL SAMPLES
HERBICIDE ANALYSES
NSWC CRANE, INDIANA

Chemical	Solid Matrix Accuracy (%R)	Aqueous Matrix Accuracy (%R)
HERBICIDES BY SW-846 METHOD 8151A		
2,4-D	20-160	38-140
2,4,5-TP (Silvex)	20-160	45-140

1. In-house QC limits provided by Laucks Testing Laboratories, Inc.

%R = Percent Recovery

TABLE 3-14

QUALITY CONTROL LIMITS[1]
MATRIX SPIKE/MATRIX SPIKE DUPLICATE SAMPLES AND SURROGATE SPIKES
POLYCHLORINATED DIBENZODIOXIN/FURAN ANALYSES
NSWC CRANE, INDIANA

Chemical	Solid Matrix	
	Accuracy (%R)	Precision (RPD)
2,3,7,8-TCDD	70 - 130	50
1,2,3,7,8-PeCDD	70 - 130	50
1,2,3,6,7,8-HxCDD	70 - 130	50
1,2,3,4,7,8-HxCDD	70 - 130	50
1,2,3,7,8,9-HxCDD	70 - 130	50
1,2,3,4,7,8,9-HpCDD	70 - 130	50
OCDD	70 - 130	50
2,3,7,8-TCDF	70 - 130	50
1,2,3,7,8-PeCDF	70 - 130	50
2,3,4,7,8-PeCDF	70 - 130	50
1,2,3,6,7,8-HxCDF	70 - 130	50
1,2,3,7,8,9-HxCDF	70 - 130	50
1,2,3,4,7,8-HxCDF	70 - 130	50
1,2,3,4,6,7,8-HpCDF	70 - 130	50
OCDF	70 - 130	50
Total TCDD	70 - 130	50
Total PeCDD	70 - 130	50
Total HxCDD	70 - 130	50
Total HpCDD	70 - 130	50
Total TCDF	70 - 130	50
Total PeCDF	70 - 130	50
Total HxCDF	70 - 130	50
Total HpCDF	70 - 130	50
Total OCDD	70 - 130	50
Total OCDF	70 - 130	50

1 In-house QC limits provided by Triangle Laboratories, Inc.

%R = Percent Recovery
RPD = Relative Percent Difference

TABLE 3-15

QUALITY CONTROL LIMITS[1]
LABORATORY CONTROL SAMPLES
POLYCHLORINATED DIBENZODIOXIN/FURAN ANALYSES
NSWC CRANE, INDIANA

Chemical	Solid Matrix Accuracy (%R)
2,3,7,8-TCDD	70 - 130
1,2,3,7,8-PeCDD	70 - 130
1,2,3,6,7,8-HxCDD	70 - 130
1,2,3,4,7,8-HxCDD	70 - 130
1,2,3,7,8,9-HxCDD	70 - 130
1,2,3,4,7,8,9-HpCDD	70 - 130
OCDD	70 - 130
2,3,7,8-TCDF	70 - 130
1,2,3,7,8-PeCDF	70 - 130
2,3,4,7,8-PeCDF	70 - 130
1,2,3,6,7,8-HxCDF	70 - 130
1,2,3,7,8,9-HxCDF	70 - 130
1,2,3,4,7,8-HxCDF	70 - 130
1,2,3,4,6,7,8-HpCDF	70 - 130
OCDF	70 - 130
Total TCDD	70 - 130
Total PeCDD	70 - 130
Total HxCDD	70 - 130
Total HpCDD	70 - 130
Total TCDF	70 - 130
Total PeCDF	70 - 130
Total HxCDF	70 - 130
Total HpCDF	70 - 130
Total OCDD	70 - 130
Total OCDF	70 - 130

1 In-house QC limits provided by Triangle Laboratories, Inc.
%R = Percent Recovery

TABLE 3-16

QUALITY CONTROL LIMITS
MATRIX SPIKE AND LABORATORY DUPLICATE SAMPLES
MISCELLANEOUS PARAMETERS
NSWC CRANE, INDIANA

Chemical	Solid Matrix		Aqueous Matrix	
	Accuracy (%R)	Precision (RPD)(2)	Accuracy (%R)	Precision (RPD)(2)
MISCELLANEOUS PARAMETERS				
Total Organic Carbon (EPA 415.1)(1)	50-150	30	70-119	11
pH (SW-846 Method 9045C)(1)	NA	10	ANR	ANR
Bromide (SW-846 method 9056)(1)	ANR	ANR		
Nitrate (SW-846 method 9056)(1)				
Nitrite (Sw-846 Method 9056)(1)				
Perchlorate(3)	ANR	ANR	75 - 125	20

1 In-house QC limits provided by Laucks Testing Laboratories, Inc.
2 These acceptance limits apply to original and duplicate sample concentrations >5x RL. If one or both of the results is <5x RL, the acceptance criterion is ± 5x RL. If one of the results is a non-detect, the reported percent RPD will be 200%.
3 In-house QC limits provided by APC Laboratory, Inc.

%R = Percent Recovery
RPD = Relative Percent Difference
NA = Not Applicable
ANR = Analyte Not Required

TABLE 3-17

QUALITY CONTROL LIMITS[1]
LABORATORY CONTROL SAMPLES
MISCELLANEOUS PARAMETERS
NSWC CRANE, INDIANA

Chemical	Solid Matrix Accuracy (%R)[2]	Aqueous Matrix Accuracy (%R)[2]
MISCELLANEOUS PARAMETERS		
Total Organic Carbon (EPA 415.1)[1]	50-150	80-120
pH (SW-846 Method 9045C)[1]	NA	ANR
Bromide (SW-846 method 9056)[1]	ANR	
Nitrate (SW-846 method 9056)[1]		
Nitrite (SW-846 Method 9056)[1]		
Perchlorate[3]	ANR[4]	80 - 120

1 In-house QC limits provided by Laucks Testing Laboratories, Inc.
2 As noted in the laboratory SOPs, the laboratory may use a purchased standard reference material (SRM) in place of a LCS. If a SRM is used, the acceptance limits provided by the supplier of the SRM may be used unless the SRM limits are wider than the acceptance limits provided in this table. If the SRM limits are wider, the laboratory must use the acceptance limits provided as this table.
3 In-house QC Limits provided by APC Laboratories, Inc.

%R = Percent Recovery
NA = Not Applicable
ANR = Analyte Not Required

4.0 SAMPLING AND ANALYSIS PLAN

4.1 GENERAL APPROACH

The ABG Study Area as defined in this project consists of 2 AOCs: the Little Sulphur Creek and the Jeep Trail. The ABG Treatment Area also lies within the confines of the ABG Study Area, but is not considered an AOC since remediation of contaminated soils and ground water are already planned for the area. However, continued evaluation is being performed during this investigation to address the potential impact of surface soil runoff from the ABG Treatment Area into Little Sulphur Creek.

Sampling and analyses will be performed in one round during this field investigation for all media except surface water, which will be sampled in two rounds to address both low flow (base flow) and high flow (during / immediately after rainfall) conditions. The data will be used to determine the nature and extent of contamination in the sampled media, and will be further used to estimate the level of human health and ecological risks associated with the study area. Additional QAPPs or sampling rounds may be required in another stage of investigation after the sampling results are evaluated, in the event that the project objectives are not met. Should additional sampling rounds be required, concurrence from regulators for sampling locations, parameters, etc., will be obtained via meetings, conference calls, and correspondence, and will be documented for the administrative record. Additional modifications to the final QAPP will not be required. The staged sampling should assure decision makers of progress toward attaining project objectives, and should afford the earliest opportunity for declaring attainment of those objectives. Additional sampling stages that may be required beyond this initial stage are expected to involve limited sampling and analyses by taking advantage of knowledge gained during the previous sampling rounds.

The sampling to be performed as part of this field effort will include surface soil, subsurface soil, ground water, surface water, and sediment with a wide variety of analyses. The types of analyses to be performed on these samples is wide-ranging and commensurate with what is known and suspected about the types or quantities of chemicals that were present or may have been present at the study area. Analytes to be evaluated in each environmental medium are listed in Tables 1-8 and 1-9.

This chapter describes sampling locations and rationales for the sampling activities, and the equipment and procedures to be used for collecting, handling, preserving, and shipping the samples to the analytical laboratories. The text references SOPs (located in Appendix H) and the HASP, when applicable.

Prior to sampling, the TOM will ensure that all field personnel read and understand the QAPP and HASP, the FOL will ensure that all required field equipment for non-health-and-safety operations is available and operational, and the SSO will ensure that all health-and-safety-related equipment is available and operational.

4.2 SAMPLE IDENTIFICATION SYSTEM

All samples will be properly labeled with an adhesive-backed sample label affixed to, and a tag tied to, each sample container in accordance with SOP CTO126-01. The sample labels and tags will include the following information: project name, project location, sample tracking number, sampling date, sampling time, type of analysis required, matrix type, preservative, initials of sampler, and the name of the analytical laboratory to which the sample will be submitted.

Each sample collected will be assigned a unique sample tracking number. The sample tracking number for soil and sediment samples is a four-segment, alphanumeric code beginning with the site identification (03 represents the SWMU number), and followed by codes for the sample type, sample location, and sample depth. The sample tracking number for the other media is a five-segment, alphanumeric code identifying the site ID, sample type, sample location, sampling round, and filtering indicator. These numbering schemes are described in SOP CTO126-02. Any other pertinent information regarding sample identification will be recorded in the field logbooks and sample log sheets.

The sampling time recorded on the chain-of-custody form and labels for duplicate samples will be 0000 so that the duplicate samples are "blind" to the laboratory. Notes detailing the sample number, time, date, and type will be recorded on the sample log sheets and will document the location of the duplicate sample (sample log sheets are not provided to the laboratory).

Matrix spike and matrix spike duplicate (MS/MSD) samples will be designated on the field documentation forms and chain-of-custody form (see SOP CTO126-03).

4.3 UNEXPLODED ORDNANCE (UXO) CLEARANCE

The Jeep Trail was used for the demilitarization of large bombs and small ordnance items following the removal of the bulk explosives. Therefore, the potential for encountering buried UXO is low. However, borings located in and around the Burn Pit must first be cleared for the presence of UXO in accordance with the HASP. If during UXO clearance activities, potential ordnance is encountered, activities will stop

and the Crane Point of Contact will be notified. UXO clearance may be further conducted by Crane personnel, depending on materials found.

All measurements made with the field instruments (listed in Table 4-1) and visual observations concerning the subsurface materials encountered will be recorded on boring log sheets. Any encounters with metallic objects or discolored soil materials, and any above-background measurements of VOCs shall be immediately reported to the FOL and the SSO, and appropriate actions shall be taken as specified in the HASP.

4.4 SAMPLING LOCATIONS, ANALYSES, AND RATIONALES

This section presents sampling locations, QA samples to be collected, analyses to be performed, and rationale for the sampling and analytical program. Details regarding the equipment and procedures for collecting, preserving, packaging, and shipping the samples are included in Section 4.7. Sampling locations are shown on Figures 4-1, 4-2 and 4-3.

4.4.1 Surface and Subsurface Soils

Surface and subsurface soil samples will be collected in and around the Burn Pit and the Burn Area at the Jeep Trail Site. It is believed that all of the explosives-containing materials and residue have been removed from both the Burn Pit and Burn Area; however, this belief requires confirmation. As discussed previously, burning of materials occurred in a 10- to 12-foot-deep trench at the Burn Pit and on the ground surface at the Burn Area. The following surface and subsurface soil sampling activities are intended to determine whether any significant quantities of waste materials remain at the Jeep Trail, and if present, the extent of contamination in the surrounding soils and the possible health-risk impacts (both to humans and ecological receptors) to the surrounding environment.

A total of 33 soil borings will be drilled as part of the Jeep Trail investigation. Twenty-six (26) soil borings will be located within the area encompassed by the Burn Pit and Burn Area (SB01-SB26). Two soil borings (SB27 and SB28) will be drilled in a topographically-depressed area (resembling a man-made pond) located approximately 200 feet southeast of the Burn Pit, and five reference soil borings (SB29-SB33) will be drilled in areas expected to have been unaffected by site related activities as explained below.

A presumed extent of surface soil contamination above target action levels has been identified for both the Burn Pit and Burn Area. The soil sampling program extends in all directions within and beyond the perimeter of this presumed extent to provide an accurate representation of expected contamination.

The Jeep Trail unit consists of two subunits, the Burn Area and the Burn Pit. Both subunits are roughly 100 feet by 30 feet in dimension, and are separated by approximately 30 to 40 feet. Soil borings SB01 through SB16 are intended to address the Burn Area; soil borings SB17 and SB18 will address the area between the Burn Area and Burn Pit; and soil borings SB19 through SB26 will address the Burn Pit. The locations of these samples were selected in a judgmental sample design to determine the nature and extent (the boundaries of soil contamination are presumed to be within these locations) of contamination associated with the Burn Area and Burn Pit units with a minimum number of borings. The boring density is roughly the same for both units (one boring per 1,940 square feet for the Burn Area and one boring per 1,600 square feet for the Burn Pit). If it is determined that contamination above action levels is found at extreme locations, additional samples may be taken during subsequent rounds to delineate the boundaries of contamination.

The Burn Area consists of a flat area and an adjacent hillside on the opposite side of the Jeep Trail. Open burning did not take place at the hillside. However, this section could have been impacted by airborne deposition of particulates from open burning of the Burn Area because the bomb casings were oriented toward the hillside during treatment. Soil borings in the flat area (SB02, SB04-SB11, and SB13-16) will be sampled from three depth intervals. Soil borings on the hillside (SB01, SB03, and SB12) will be sampled at the surface only, since it is likely that the directed flashing of bomb casings toward the hillside at the Burn Area could have deposit materials only at the surface of the hill. The 16 borings located within the Burn Area and the two borings located between the Burn Area and Burn Pit cover an area of roughly 35,000 square feet (approximated by a circle of radius 106 feet). Sampling locations are up to 70 feet from the Burn Area in all directions, except the hillside where locations are up to 140 feet away due to the nature of discharge of materials caused by the flashing of munitions.

Sampling at the Burn Pit is designed to characterize the fill material used to backfill the pit in 1983 to establish whether it is clean and to determine whether there is residual contamination in the pit under the fill. The range of travel of ejected materials from the Burn Pit is believed to have been more limited than the dispersal range of the Burn Area. Open burning at the Burn Pit was conducted by burning materials in a wood pile. Therefore, the potential for airborne deposition of particulates would be the same as for a wood fire. In this case most airborne deposition of particulate would be expected to occur in the immediate vicinity of the Burn Pit. There will be 2 soil borings (SB19 and SB24) located in the Burn Pit,

and an additional eight borings (SB17, SB18, SB20-SB23, SB25, and SB26) surrounding the Burn Pit (including the two borings between the Burn pit and Burn Area). Each boring will be evaluated over three depth intervals, including one sample at 0 to 2 feet and a second at a depth representative of the bulk of the fill and surrounding materials. A third interval will be selected where the bottom of the pit is suspected to have been. These ten borings encompassing the Burn Pit are located within an area of approximately 16,000 square feet (roughly 148 feet by 108 feet). Sampling locations are all within 40 feet of the Burn Pit.

The two soil borings (SB27 and SB28) drilled in the topographically depressed area located approximately 200 feet southeast of the Burn Pit will be sampled at three depth intervals. Data from these borings will be used to address surface runoff of contaminants from the Burn Pit Area and redeposition in the ponded area. The five reference soil borings (SB29-SB33) will have one surface soil sample collected from each boring. Data from the reference soil borings will be used to establish baseline soil concentrations that are representative of non-site related chemical concentrations.

Each soil sample collected will represent a 2-foot interval, and will be taken at depths dependent upon the presumed waste treatment practice. The Burn Area practice consisted of burning waste on the ground surface. The waste is believed to have been removed, and a layer (probably less than one foot) of gravel and reworked natural materials may have been deposited on the area after operations ceased, and as part of ongoing maintenance of the Jeep Trail access road. Therefore, samples should be collected of the Burn Area at depths of 0 to 2, 2 to 6, and 6 to 10 feet bgs to evaluate the cover, waste, and underlying materials; respectively. At the Burn Pit, waste is reported to have been burned in a pit 10 to 12 feet bgs, and the waste has since been removed and the pit backfilled. Samples of the Burn Pit should be collected at 0 to 2, 2 to 12, and 12 to 15 feet bgs, to reflect the expected depth of the three profiles anticipated. Samples of the depressed area will be collected at 0 to 2, 2 to 6, and 6 to 10 feet bgs; and the reference samples will be collected at 0-2 feet bgs. However, the sampling intervals can be modified in the field based upon encountering waste or obvious contamination during drilling. Soil samples will be collected even if the boring advances into a saturated zone. Sampling will not be conducted beyond a depth of 10 and 15 feet bgs in any case at either the Burn Area or Burn Pit, respectively. If bedrock is shallower than the bottom of a depth interval, sampling will stop at the bedrock surface.

The analyses to be performed on each soil sample are listed in Table 4-2. The rationale for parameter selection is discussed in Section 1.4 and detailed on Table 1-8.

All soil samples will be analyzed for explosives, nitrocellulose, nitrate and nitrite. All of the soil samples except those along the hillside from borings SB01, SB03, and SB12 will also be analyzed for SVOCs. [SVOCs are not anticipated to be present along the hillside because the utility pole (potentially cresote-treated) used for securing burned materials was not located in this area.]

Five surface soil samples from borings located along the Burn Pit perimeter (SB17, SB20, SB23, SB25, and SB26) will also be analyzed for dioxins/furans to address the potential for these constituents to be present in undisturbed surface soils outside of the backfilled area. In addition, two subsurface soil samples located in the Burn Pit from borings SB19 and SB24 will also be analyzed for dioxins/furans, with the intention of targeting obvious waste material. If no waste material is found, then the deepest soil sample in the boring will be analyzed for dioxins/furans to represent contaminants that might have remained behind after closure.

All of the Burn Pit soil samples (from borings SB17-SB26) will also be analyzed for VOCs and perchlorate, due to the potential for these constituents to be present in the Burn Pit. The top 6 inches of surface soil will not be sampled when collecting samples for VOC analysis, because of the potential for VOCs having vaporized out of the soil.

Soil samples collected from the two soil borings located in the depressed area (SB27 and SB28) will be analyzed for VOCs, SVOCs, explosives, nitrocellulose, metals, nitrate, nitrite, and perchlorate to provide general information.

Five surface soil samples will be collected from borings SB29 – SB33 in areas unaffected by site related activities to provide reference concentration information. These samples will be analyzed for SVOCs, herbicides, pesticides, dioxins/furans, explosives, nitrocellulose, metals, nitrate and nitrite.

The soil background concentrations for organic contaminants are assumed to be zero for purposes of COPC selection. The background concentrations for metals in soils at NSWC Crane have been investigated and reported in the document, "Basewide Background Soil Investigation, Naval Surface Warfare Center Crane, Crane, Indiana" (TtNUS, 2000). The background soil metals concentrations will be compared to metal concentrations detected at the Jeep Trail to determine whether any above-background concentrations are present. Background soil sample results reflective of a depositional environment and soil type that is similar to the Jeep Trail samples will serve as a basis for the comparative evaluation.

The total number of soil samples to be analyzed for each analyte group is listed in Table 4-3. These numbers of analyses should be sufficient to determine whether any of the analytes are present in the Jeep Trail, at what depths the contaminants are most likely to occur, and the concentrations that might be present. Additional soil sampling and analysis may be necessary at a later date in order to better characterize the concentration distributions and the extent of contamination for each COC.

QA/QC samples will be collected at frequencies listed in Table 4-3. Duplicate samples and rinsate blanks will be collected at a rate of one for every 10 regular soil samples and analyzed for the same analytes as the corresponding soil samples. MS/MSD samples will be collected and analyzed in the fixed laboratory at a rate of one per every 20 soil samples. A trip blank will be placed in every cooler containing samples destined for VOC analyses. It is estimated that ten coolers will contain samples for VOC analyses. The total number of soil analyses for each analyte group is tabulated in Table 4-3.

Surface and subsurface soil sampling will be performed using direct push technology (DPT) soil sampling or hollow stem auger drilling with split spoon sampling. Split spoon sampling will be used only if DPT soil sampling does not give good recovery. All soil samples for VOC analyses will be collected immediately after the split spoon or DPT sampler is opened using an Encore™ sampler. Details regarding soil sampling equipment and procedures are included in Section 4.5.2 and SOP CTO126-04.

4.4.2 Ground Water

Continued investigation of the ground water at the Jeep Trail Site is planned for this field effort. A total of 17 monitoring wells have been installed at the Jeep Trail in 1981, 1982, and 1983. The wells have been periodically sampled since installation, including a comprehensive sampling round performed in September 1994. That data is included in Appendix B and are summarized in Tables 1-6 and 1-7. Construction details for all monitoring wells are summarized in Table 4-4. Some of these wells have not been sampled for several years; therefore, an attempt will be made to locate, repair (if necessary), redevelop, and sample each of these wells during the well-sampling program. At least one well, 19, was not found in 1994 and is presumed to be destroyed.

The existing monitoring wells have been installed into the shallow hydrogeologic zone beneath the site, which exists in either the unconsolidated material or the bedrock, depending on location. The shallow ground water beneath the site acts as an unconfined (water table) aquifer across the valley.

The objective of the ground water investigation at the Jeep Trail Site is to define the magnitude and downgradient extent of shallow ground water contamination migrating from the site, as well the vertical extent of ground water contamination. In order to meet this objective, all existing wells at the site will be resampled. In addition, the installation of nine shallow and four deep monitoring wells, as detailed in the remainder of this section may be necessary in future sampling rounds, depending on the results of this sampling of the existing wells. Data from the initial sampling round will be used to determine whether installation of some or all of these wells will be required. U.S. EPA Region 5 will be consulted for concurrence prior to any modifications to the existing moniotirng well network. The proposed sample locations are shown in Figure 4-1 and physical characteristics of the proposed monitoring wells (should they be necessary) are shown in Table 4-5. Figure 1-14 includes organic positive detections in ground water, which can support this discussion.

1. **Shallow Source Wells:** Shallow ground water concentrations in the center of the plume must be determined (plume magnitude). This is achieved by locating wells near the source and in the immediate downgradient direction, and collecting ground water samples for subsequent analyses. The analytical results should be reflective of the highest ground water contaminant concentrations at the site.

   In the case of the Jeep Trail Site, one of the wells located downgradient of the Burn Pit and Burn Area (07) detected notable chlorinated contamination, and several other wells, namely 15, 24, and 25 detected chlorinated constituents to a lesser extent. The sampling was performed in 1994, and it is likely that the observed plume has migrated since that time. Therefore, sampling of the existing wells is required to provide information on current ground water conditions. The analytical results of the existing well sampling activities will be reviewed and a decision will be made regarding the installation of additional wells. The additional monitoring well network that is described below is based on the premise that existing well sampling results will generally mimic the 1994 groundwater sampling round. The additional monitoring well network may require modification based on the groundwater analytical results. No monitoring wells exist in the immediate vicinity of the potential sources at the site (Burn Pit and Burn Area), and it is not known if ground water contamination exists in these areas at concentrations that are higher than has already been observed. It is also not known which source (Burn Pit or Burn Area, or both) contributed to the resultant ground water contamination. Shallow source monitoring well 03MWT01 and 03MWT02 may be installed to address ground water contamination at the Burn Area and Burn Pit, respectively depending on the result of the first round of sampling.

2. **Shallow Perimeter Wells**: Shallow ground water concentrations that are below the RBTL have to be determined (shallow downgradient extent). This is achieved by locating wells both side and downgradient in radial directions of the known plume. Ground water sampling and subsequent analytical results should be reflective of ground water contaminant concentrations that are below the RBTL. Because screening criteria are typically low, locating perimeter monitoring wells that yield non-detected ground water concentrations or concentrations near the detection limit are typically desired. At the Jeep Trail Site, all of the monitoring wells except 11, 18, and 20 detected organic contamination.

   Additional perimeter wells 03MWT03 through 03MWT09 may be installed further side and downgradient of the existing monitoring well network to define the extent of shallow ground water contamination should the extent of the contamination not be bounded by the first round of sampling. It is acknowledged that some redundancy may exist with the installation of shallow wells 03MWT08 and 03MWT09, which are located further downgradient of wells 18 and 20 (wells 18 and 20 detected no organic contamination in 1994). However, as previously stated, the existing ground water analytical results are more than five years old, and it is likely that the plume has migrated since that time. Should the extent of contamination to below RBTLs not be reached in this sampling effort, the proposed monitoring wells will be installed.

3. **Deep Vertical Extent Well:** Deeper ground water concentrations that are below a predetermined screening criteria for action have to be determined (vertical extent). This is typically achieved by installing deeper wells in those areas of the plume where the highest concentrations are anticipated (adjacent to shallow wells with high concentrations). Adequate vertical spacing between the monitored interval of deep wells versus shallow wells is needed to minimize overlap in ground water results between the two zones of investigation.

   As with shallow perimeter wells, subsequent analytical results should be reflective of ground water contaminant concentrations that are below the RBTL (at or below detection limits).

   At the Jeep Trail Site, three deep wells (03MWT11, 03MWT12, and 03MWT13) may be located in the ground water plume adjacent to shallow wells that yield ground water contamination (wells 12, 7, and 24, respectively) in the first round of sampling. It is hopeful that ground water contaminant concentrations from these deep wells will be below the RBTL for the site.

4. **Upgradient Wells:** Well(s) are required in upgradient areas, unaffected by site - related activities. Subsequent ground water sampling and laboratory analyses of the upgradient well(s) would then be compared to the site - related ground water sample set. Contaminants and the associated concentrations present in the downgradient ground water sample set that are not present in the upgradient well(s) would be indicative of site related contamination, whereas contaminants and concentrations detected in the upgradient sample set and not in the site-relate set would be reflective of unrelated upgradient sources. Upgradient wells should monitor the same hydrogeologic zone(s) as the site wells, to provide comparable reference information.

The Jeep Trail Site has one existing shallow upgradient well (16). Analytical results from this well indicated the presence of explosives contamination in 1994. Resampling of this upgradient well is proposed, and the installation and sampling of a deeper upgradient well (03MWT10) may be necessary, depending on the results of the first sampling round..

These shallow wells, should they prove necessary, will be installed into the first shallow hydrogeologic zone encountered during drilling beneath the site. This zone exists in thicker unconsolidated materials (Alluvium and Colluvium) that are present beneath the valley floor near Little Sulphur Creek, and extends laterally in the bedrock (base of the Beech Creek Limestone of the middle aquifer) along the hillsides where the unconsolidated materials are thin and unsaturated. This shallow hydrogeologic zone overlies the Elwren Shale.

The deep wells may be installed into the bedrock, in the first hydrogeologic zone encountered below the Elwren shale. It is anticipated that a sandstone unit exists at the base of the Elwren formation that will be suitable for installation of deep wells. However, bedrock coring will be required to evaluate the bedrock and to identify hydrogeologic zones suitable for the installation of monitoring wells.

The 17 existing monitoring wells were installed at the Jeep Trail with total depths ranging from 14.7 to 51.4 feet deep. Although the well depths vary considerably due to the varying topography at the site, the elevation of the monitored intervals remained somewhat consistent (see Table 4-4), with a 10 foot-long monitored interval for each well in the range of 530 to 550 feet NGVD, which monitors the shallow water-bearing zone beneath the site. Nine wells will be completed as shallow installations and 4 wells will be completed as deep installations.

The total depths and screen intervals anticipated for each new monitoring well are presented n Table 4-5. Based on observations and information gathered during the drilling of each hole, the total depth of the hole and the placement of the well screen may be adjusted at the discretion of the field geologist or the FOL. The decision concerning the monitored interval and well depth will be based on the following (and possibly other) information collected while the well bore is being drilled and logged.

- The specific depths where the initial (shallow) and deeper water yielding zones are encountered during drilling.

- The specific depths where above-average rates of ground water yield are observed during drilling.

- The specific depth interval where contaminants (i.e., VOCs), if any, are endountered during drilling.

All of this information will be recorded on the borehole log as the hole is drilled.

Table 4-6 lists the ground water samples and the analyses that will be performed on each sample. All samples will be analyzed for VOCs, SVOCs, explosives, nitrocellulose, total metals, nitrate, nitrite, and perchlorate, which is a compilation of constituents that could be detected in ground water at the Jeep Trail. During low-flow well sampling, the temperature, specific conductance, pH, dissolved oxygen, oxidation-reduction potential (ORP), and turbidity of the ground water will be measured and recorded for each well. If the turbidity of the well water samples cannot be reduced below 10 NTUs during low-flow sampling, then an aliquot of water will be filtered (see SOP CTO126-05) and analyzed for dissolved metals in addition to total metals.

The total number of ground water samples to be analyzed for each analyte group is listed in Table 4-7. The numbers of field QA/QC samples to be collected and analyzed are also listed in Table 4-7. One duplicate sample will be collected for every 10 ground water samples. Note: The duplicate samples will be preferentially collected for monitoring wells that appear to be contaminated (based on visual evidence, odor, or screening data). This will provide the greatest opportunity for computing a precision estimate with detectable analyte concentrations. One MS/MSD sample will be collected and analyzed for every 20 ground water samples analyzed.

One rinsate sample will be collected and analyzed each day of ground water sampling activities; this number is estimated to be four days. A trip blank will be included with each cooler containing samples for VOC analysis; it is estimated that four of these will be necessary. Two source water blanks (tap water and distilled water) will be analyzed to establish whether contaminants may be present in the water used for steam cleaning and decontamination of sampling equipment.

4.4.3 Surface Water

Little Sulphur Creek surface water will require evaluation for the presence of contamination as part of the field effort. Surface water flow is intermittent in Little Sulphur Creek. During base flow conditions, surface water flows past the ABG Treatment Unit, while leaking into the underlying ground water through the alluvium and fractured and cavernous bedrock. Ultimately, surface water flow disappears immediately downstream of the ABG Treatment Unit, and the creekbed continues to remain dry, until surface water flow reappears in the form of springs located downstream of the Jeep Trail. During high flow periods, (immediately after significant precipitation occurrences) surface water flows along the entire reaches of Little Sulphur Creek. Therefore, surface water sampling will be conducted in two sampling rounds to evaluate contaminant concentrations during these two types of flow conditions.

Up to 15 surface water samples will be collected from Little Sulphur Creek during each of two sample rounds to evaluate baseflow and high flow conditions at the locations shown on Figures 4-2 and 4-3. It is acknowledged that surface water may not be present at some of the sample locations, depending on flow conditions at the time of sampling. The surface water samples will be paired with most of the sediment sample locations planned for the field effort. Surface water and sediment samples will be collected using the methods described in Sections 4.5.10 and 4.5.11. (Additional sediment samples are being collected due to the inherent heterogeneity of sediment, when compared to surface water at a given time.) Of the 15 possible surface water samples, four samples (SW01-SW04) are being collected in the tributaries located upstream of the ABG Treatment Unit, to provide chemical concentrations in surface water prior to passing through the sites of interest. Two samples (SW06 and SW08), are being collected adjacent to, and downgradient of the ABG Treatment Unit. Three samples (SW09, SW11, and SW13) are being collected upstream, adjacent to, and downstream of the Jeep Trail Site. Three surface water sample pairs (SW14 and SW15, SW16 and SW17, SW18 and SW19; six total samples) are being collected upstream and downstream of the outlets of Springs C, A, and B, respectively. Whenever possible, the proposed samples have been located near historical sample locations to provide contaminant trend information over time.

Each surface water sample will be analyzed for the analyte groups listed in Table 4-8. Comparisons between upstream and downstream samples will be made to determine the potential contaminant contribution from the ABG Treatment Unit, Jeep Trail, and/or ground water discharge from springs.

In addition, two field duplicates, one trip blank, one matrix spike, and one matrix spike duplicate will be collected for QA/QC purposes (Table 4-9). No rinsate blanks will be collected because the sample bottles will be filled directly as discussed in Section 4.5.11. The field duplicate will be analyzed for all parameters and the trip blank will be analyzed only for VOCs. The MS and MSD will be analyzed for all parameters, except metals, which do not have TAL analyses performed. The total number of analyses, including QA samples, are tabulated in Table 4-9.

4.4.4 Sediment

Contaminants may have been eroded from the surface soils of the ABG Treatment Unit or the Jeep Trail, or contaminated ground water discharging to surface water may have sorbed onto sediments adjacent to the sites and downstream along the springs in Little Sulphur Creek. Therefore, one round of sediment samples will be collected from all of the previously discussed 15 surface water sample locations, as well as four additional sample locations, to provide adequate spatial coverage along Little Sulphur Creek. The sediment samples will be collected in two depth profiles at each location, to determine whether contaminant concentrations increase, decrease, or remain the same with depth. This information will be used to determine whether scouring of sediments during high surface water flow conditions could result in varying contaminant loading to downstream receptors.

Each of the sediment samples will be analyzed for the full suite of analytes listed in Table 4-10. One field duplicate, one trip blank, one rinsate blank, one matrix spike, and one matrix spike duplicate will be necessary for QA/QC purposes (Table 4-11). The field duplicate and rinsate blank will be analyzed for all parameters except TOC and geotechnical analyses. The trip blank will be analyzed only for VOCs. The MS and MSD will be analyzed for all parameters, except TOC and geotechnical analyses; and the MSD is not performed on metals analyses. The total number of laboratory analyses, including QA samples, are tabulated in Table 4-11.

4.5 INVESTIGATION EQUIPMENT AND PROCEDURES

4.5.1 UXO Clearance of Drilling Sites and VOC Screening

Because of the prior uses of the areas to be investigated, there is a possibility that unexploded ordnance (UXO) may be encountered during operations. All activities at the Burn Pit Area on the Jeep Trail will be conducted consistent with the UXO procedures discussed in the HASP with indicated variances. The UXO Specialist will conduct a surface sweep in all remaining areas of the site that are not used for regular vehicular or pedestrian traffic prior to the commencement of intrusive activities.

For any boreholes within or immediately adjacent to the Burn Pit, the borehole will be cleared down to a depth of two (2) feet and a magnetic gradiometer (down-hole instrument) or similar instrument will be lowered into the hole to clear the borehole. This clearance procedure will continue until the borehole has been cleared to a depth of ten (10) feet. Advancement may proceed within a two-foot radius of the clearance boring. All UXO procedures and borehole clearance will be documented in the site UXO log book.

Because VOCs may be present in the soil column, it will be necessary to screen the soils for contamination as they are brought to the surface. This information is also needed to assist in classifying the soils extracted from the holes, and help assess how they should be disposed.

4.5.2 DPT Sampling for Surface and Subsurface Soil

DPT (e.g., Geoprobe®) will be used to collect surface and subsurface soil samples from the unconsolidated overburden. The procedure for soil sampling using DPT is included in SOP CTO126-04. A new acetate liner will be used for each 2-foot section of soil core. Each soil core removed will be scanned for VOCs. The soil core will be visually inspected and logged by the field geologist, noting the soil texture, grain size (sand, silt or clay), color (and any unusual discoloration), moisture content, and USCS classification. The soil depositional environment will be identified by the field geologist.

After slicing the soil core liner open, the soils will be scanned to determine if significant VOC concentrations are present in the soils (see SOP CTO126-06). The measurements will be recorded on the boring log form (see SOP CTO126-07). A new form will be used for each boring.

For the first soil interval in each boring (i.e., 0 to 2 feet bgs), the PID will be used to scan the soil core for the presence of VOCs. The soil cores will be logged by a geologist (see SOP CTO126-07). A discrete

soil sample will be collected between the depths of 0.5 to 2.0 feet bgs in the soil core (not 0 to 0.5 feet bgs) for VOC analysis using an EnCore™ Sampler (see SOP CTO126-8). The VOC sample will be collected from the point along the soil core (0.5 to 2.0 feet bgs) that had the greatest PID reading. If no PID readings are greater than background, then the VOC sample will be collected from any discolored area of the soil or from the midpoint of the core. The Encore™ samples will be collected from each core immediately after PID readings are collected. Once the sample for VOC analysis has been collected, the 0- to 2-foot soil core interval will be placed in a decontaminated stainless steel mixing bowl; rocks, gravel, and other coarse debris will be removed; the sample will be mixed with a decontaminated stainless steel spoon; and appropriate jars will be filled and properly labeled. The bowl and spoon will be decontaminated between each sample. Details regarding the collection and labeling of soil samples are included in SOP CTO126-1.

When the soil cores for deeper samples have been brought to the surface, they will be scanned for VOCs in the same manner as the 0- to 2-foot interval. The soil cores will be logged by a geologist (see SOP CTO126-07). The VOC EnCore™ samples will be collected from the point in the soil cores that display the highest PID reading. If no PID reading is greater than background, then the VOC samples will be collected at the discretion of the field geologist based on visual observations for the presence of contamination during sample collection. The remainder of the two soil cores will be mixed together in a decontaminated stainless steel mixing bowl; rocks, gravel, and other coarse debris will be removed; and the soil will be thoroughly mixed with a decontaminated stainless steel spoon. The bowl and spoon will be decontaminated between each sample. Other sample jars will be filled as appropriate (Table 4-2) and properly labeled.

For each Geoprobe® boring, up to three soil samples will be collected. The appropriate containers to be used for each sample aliquot are listed in Table 4-12. Once the samples are properly containerized, labeled, tagged, and bagged (see SOP CTO126-04), they will be placed in a cooler containing ice until the samples can be properly packaged and prepared for shipment (Section 4.7).

For each cooler containing soil samples identified for VOC analysis (i.e., Encore™ samplers), a trip blank must also be stored in the cooler and continuously accompany the VOC samples until they have been analyzed. As samples are added to a cooler, the chain-of-custody form will be updated to include each new sample container (per SOP CTO126-03; see also Section 5.0).

One duplicate soil sample shall be collected for every 10 soil samples. Soil duplicates will be collected for those samples that have the greatest probability of containing contaminants (e.g., elevated levels of

VOCs as indicated by the PID reading). The duplicate samples should be placed in the same type of containers and handled in the same manner as the regular soil samples. The duplicate samples will be given unique QC sample IDs (see SOP CTO126-02). One rinsate blank will be collected for every 10 soil samples. The soil cores will be collected in new, clean, acetate liners. After samples are collected for VOC analyses, the cores will be mixed in a decontaminated stainless steel bowl with a decontaminated stainless steel spoon. The bowl and spoon will be decontaminated between each sample. For soil samples, the rinsate blank will consist of running distilled water over a decontaminated spoon into a decontaminated mixing bowl. This water will be used to fill sample bottles for the rinsate blank. This process will continue until all of the necessary bottles are filled for the rinsate sample (see Tables 4-3 and 4-13).

Soil borings will be backfilled with either the soil cuttings (if uncontaminated) or bentonite pellets (if contaminated) in accordance with Section 4.11.

When a boring has been sampled and backfilled, it will be identified by a tall wooden lath driven into the soil near the boring; a 2-by-2-inch inch wooden stake will be driven into the center of the backfilled boring. The stake and the lath will both have brightly-colored flagging attached to them to increase visibility, and both will be labeled by a waterproof marker with a unique soil boring number, corresponding to the boring log containing the survey data for the boring.

4.5.3 Inspection and Repair of Existing Monitoring Wells

Seventeen monitoring wells were installed between 1981 and 1983 at the Jeep Trail. One of the wells, 03-19 could not be found in recent field events and is presumed to be destroyed. These wells may have broken casings, bent casings, missing caps, no locks, broken locks, obstructions, and other problems. In addition, it is likely that some of the wells may contain enough sediment at the bottom such that the well screen may be partially or totally clogged. Therefore, at the beginning of field activities, the existing wells will be located, inspected, and repaired if possible. For example, broken or bent PVC viser pipes above the ground surface will be sawed off and new riser pipes will be added. Caps and locks will be replaced if necessary. The height of casing above ground surface and the depth to the bottom of the well will be measured and recorded. This information will be compared to the boring logs and well construction logs to confirm that the wells are open through the screen interval. These activities are addressed in SOP CTO126-09. Each of the existing wells will need to be redeveloped (see SOP CTO126-10) before any sampling can occur.

4.5.4 Well Drilling and Installation

A total of nine shallow and four deep wells may be installed at the Jeep Trail, depending on the results of the first round of sampling. The approximate depths of the proposed wells are listed in Table 4-5. It is anticipated that all of the deep well borings and possibly some of the shallow well borings (depending on location) will encounter bedrock that will require rotary drilling. Shallow well borings that do not encounter bedrock will be drilled using hollow stem auger drilling with DPT or split spoon soil sampling.

Two deep well borings [(03MWT10 and 03MWT12), see Figure 4-1] will be continuously sampled using hollow stem auger drilling with DPT or split-spoon soil sampling through the soil until bedrock is reached, and will be continued with rotary coring to the final depth (minimum 2 inch diameter samples). The soil samples and bedrock cores should provide an accurate characterization of stratigraphy, fracture distribution, and other features of the soil and rock units spanning the study area. Procedures for drilling and logging a boring in rock are included in SOP CTO126-11. After these two holes have been cored, they will be enlarged to a minimum diameter of 5 inches using an air rotary drill rig. The other two deep borings will be drilled using the air rotary drill rig. Geologic logging of these borings will be based on the rock chips brought up with the circulating air (SOP CTO126-11). In addition, the rates of water produced during drilling will be carefully observed in order to identify rock zones that might be fractured and have above-average permeability characteristics. Drilling standby may be required to monitor for ground water.

Either a temporary steel casing or hollow stem auger flights will be placed through the overburden and into the bedrock to minimize collapse, and to minimize downward vertical contaminant migration during drilling of the bedrock borings. The temporary casings or auger flights will be removed just after the installation of the permanent PVC riser pipe, sand pack, and bentonite pellet seal; and immediately before installation of the cement - bentonite grout.

At least three of the shallow well borings (to be identified by the field geologist) will be sampled continuously through the overburden, using either DPT or split spoon sampling, until the total depth is reached or bedrock drilling is conducted. The remaining six shallow well borings may be sampled at 5-foot intervals or as determined by the field geologist. Bedrock drilling, if required in the shallow well borings, can be conducted using a conventional rotary drilling with a roller bit and water wash.

A permanent monitoring well will be installed in each of the well borings. The wells will be constructed of 2-inch-diameter, schedule 40, flush joint, polyvinyl chloride (PVC) riser pipe and screen (see SOP CTO126-12). In each well, the screen will be 10 feet long and have a slot size of 0.02 inches (factory

slotted). All riser pipe and screen sections will be new and certified clean. Each well will consist of 10 feet of slotted screen and enough solid riser pipe above, so that the riser will extend about 2.5 feet above the ground surface.

If the boring contains viscous mud and rock fragments at the end of the drilling process, the driller shall remove this material with a wireline bailer.

A sand filter pack will be placed around the annulus of the well screen, from the bottom of the hole upward to 3 feet above the top of the well screen. Three feet of bentonite chips will be placed above the sandpack, and will be allowed to wet and expand for at least 3 hours before grout is added to the hole. After at least 3 hours has elapsed, the remainder of the well annulus will be filled up to the ground surface with a cement-bentonite grout mixture. A tremie pipe will be used to place grout in the well annulus to help ensure a good seal around the well annulus. An outer, black steel protective casing will be installed around the PVC casing. The outer casing will extend at least 2 feet below the ground surface and no more than 4 inches above the inner PVC well cap. The steel casing will have a hinged cap, or removable cap, and a padlock. A 6-inch thick, 3-by-3-feet concrete surface pad will be placed around the well at ground surface. In addition, three barrier posts will be installed around the concrete pad. Details regarding well construction sand pack and grout materials, the outer protective casing, the well pad, and the protective barrier posts are included in SOP CTO126-12.

4.5.5 Packer Testing of Uncased Borings

The two deep well borings (03MWT10 and 03MWT12) proposed for continuous sampling will also be packer tested. A double inflatable packer assembly attached to the drill string of the drilling rig will be used to hydraulically test specific sections of each new uncased boring. The procedures for conducting a packer test are presented in SOP CTO126-13. The packer assembly will be thoroughly decontaminated before being placed in a boring. The inflatable packers will be set 5 to 10 feet apart (i.e., the vertical section of rock tested in a single test is 5 to 10 feet). The packer assembly will be lowered down the boring so that the packers isolate a section of the hole that was identified during drilling as being fractured or yielded above-average rates of ground water during drilling. About two to three different zones will be tested for each hole. The number and depths of the zones to be tested will be determined by the FOL and lead field geologist based on their best judgement.

The packer tests will be the pump-out type, where ground water is pumped out of the hole from the isolated section of boring. A pump positioned between the two packers will pump water out of the

packed-off interval. Thus, no external water will be introduced to the holes during the packer tests. The flow rate of water discharging from the pump and the hydraulic pressure within the pack-off interval will be measured frequently during the test. The pumping rate shall be held nearly constant. Initially, the pumping rate will be at a low level (e.g., 1 gallon per minute or less). If this pumping rate can be sustained for 15 minutes and the water level stabilizes, then the rate will be increased to about 5 gallon per minute. This rate will be maintained and hydraulic head monitored for another 15 minutes. After 15 minutes, the pumping rate can be increased if the aquifer can sustain the increased rate and the FOL or lead geologist determines that a higher rate is necessary.

The data will be used to determine a hydraulic conductivity value for the rock material. It will also be used to help choose a suitable interval in the hole for the installation of the monitoring well screen. The screen for each well should be placed near its target depth (see Table 4-5), but in an interval that is permeable and likely to be connected to a fracture network.

4.5.6 Well Development

All existing and any new monitoring wells will be developed in accordance with SOP CTO126-10 to remove fine sediment from inside and around the well screens. The method to perform well development can be either vigorous on-and-off pumping, or surge block and pumping depending on which technique is most effective. Field measurements of pH, specific conductance, temperature, and turbidity will be performed at 5-10-minute intervals on the water retrieved from the well, in accordance with SOP CTO126-14. Well development will continue until three consecutive readings of pH, specific conductance, and temperature are within 10 percent of each other, and three consecutive turbidity readings are within 5 NTUs of each other. If these criteria cannot be met after five well volumes of water have been removed, then one additional well volume will be removed and well development will be considered complete.

All water removed from the well during the development process will be stored in a portable holding tank (already present at NSWC Crane) until ground water samples from the wells have been analyzed. The analytical reports will be submitted to the NSWC Crane water treatment plant for review. If acceptable, the development water will be discharged to the plant for treatment and disposal (see SOP CTO126-15).

4.5.7 Water Quality Field Measurements

Field measurements of water quality parameters, including pH, specific conductance, ORP, temperature, DO, and turbidity, will be performed on ground water in a flow-through cell attached to a pump discharge line. These measurements will be performed during well development (Section 4.5.7) and low-flow well

sampling (Section 4.5.9). These field measurements will be made using a YSI 6-Series Environmental Monitoring System or equivalent type of instrument. Turbidity measurements will be made using a LaMotte turbidity meter or equivalent. Calibration and measurements made with the field instruments will be in accordance with Section 6.1 and SOP CTO126-14.

Each calibration of an instrument will be recorded on an equipment calibration log sheet. Water quality measurements, along with date, time, instrument operator, and visual and other observations (e.g., weather conditions) will be recorded on well development logs, sample collection logs, or field notebooks, as appropriate.

4.5.8 Low-Flow Sampling of Monitoring Wells

Low-flow sampling procedures will be used to collect ground water samples from existing wells and new wells (see SOP CTO126-05 and -16). The depth to ground water in some of the wells is greater than 20 feet. Therefore, a compressed air bladder pump or submersible pump will be used to slowly pump ground water from the well at about 100 milliliters per minute (mL/minute). Low-flow pumping will proceed until readings of water temperature, pH, specific conductance, dissolved oxygen, Eh, and turbidity stabilize, but no more than 4 hours. Appropriate sample bottles shall be filled directly from the pump discharge tube (see Tables 4-6 and 4-13). The bottles will be properly labeled, tagged, bagged, and placed in an ice-filled cooler as quickly as possible (see SOPs CTO126-01 and -03). A ground water collection log sheet must be completed for each ground water sample collected (see SOP CTO126-05).

The wells will be sampled in order of least contaminated to most contaminated, starting with the upgradient wells, proceeding to the far downgradient wells, and finishing at the source wells. This approach will lessen the possibility of incurring cross contamination between wells. After each ground water sample is collected, the pump must be decontaminated (SOP CTO 126-17). For every 10 ground water samples that are collected, a rinsate blank sample must be collected to ensure that decontamination of the pumps is effectively accomplished. The rinsate blank will be collected by pumping distilled water through the pump and placing the pump discharge water directly into sample jars. The appropriate sample jars and preservatives for each analyte group are listed in Table 4-13.

For each cooler containing samples identified for VOC analysis, a trip blank must be included in the cooler. The trip blank will accompany the VOC samples until they have been analyzed for VOCs. As samples are added to a cooler, the chain-of-custody form should be updated to include each new sample container (see SOP CTO126-03).

4.5.9 Ground Water Level Measurements

Synoptic water-level measurements and total well depth soundings will be obtained at each of the existing monitoring wells before and after they are redeveloped. If new wells are installed and developed, water-level measurements will be performed on all wells and staff gages during relatively dry climatic conditions and a second round during a wet (immediately after a precipitation event) climatic condition. All water-level measurements will be taken within a 24-hour period. All water-level measurements will be taken using an electronic water-level meter (per SOP CTO126-18). Water-level elevations will be recorded to within a 0.01-foot accuracy from a marked reference point on the well riser pipe. Detailed procedures regarding water-level measurements are included in SOP CTO126-18.

Water levels will be recorded on a TtNUS water-level form. A blank water-level form is provided in SOP CTO126-18 for reference purposes.

The water-level meter will be decontaminated between each well; decontamination procedures are addressed in SOP CTO126-17.

4.5.10 Surface Water Sampling

Surface water samples will be collected as grab samples from Little Sulphur Creek, in accordance with SOP CTO126-19. It will be assumed that the water flowing at the sample locations is thoroughly mixed. Water sample bottles will be filled directly in the flowing water. If the depth of water is not sufficient to lower the bottles into the water without stirring up bottom sediment, then a decontaminated shovel will be used to dig a depression (i.e., a small pool) about 2 feet deep where the water can accumulate and pass through. After suspended sediment in the pool has settled out or is carried downstream, the water sample will be collected. A filtered water sample will be collected for dissolved metals analysis by drawing water into a plastic syringe and forcing it through a 0.45-µm filter cartridge directly into a sample container (see SOP CTO126-19). The bottles will be properly labeled (see SOP CTO126-01), tagged, bagged, and placed in an ice-filled cooler.

Field water quality measurements (see Section 4.5.8) will be made at each sampling location immediately after a sample has been collected. These data will be recorded on the sample collection log sheet.

4.5.11 Sediment Sampling

Sediment samples will be collected as grab samples from Little Sulphur Creek in accordance with SOP CTO126-20. At the sampling locations identified in Section 4.4.4 and on Figure 4-2, flow rates in Little Sulphur Creek are expected to be very small or nonexistent during sediment sampling, which will be conducted during the base flow sampling round. If no water is flowing at a sampling location, then the sample may be collected where fine sediment has accumulated. If water is flowing at the sampling location, then the sample should be collected at the edge of the flowing water along depositional areas, where fine sediment has accumulated. The appropriate sample jars will be filled directly from the sediment surface using disposable plastic spoons. Sample materials will be collected from two depths at each station location: 0 to 6 inches and 6 inches to one foot.

As samples are added to a cooler, the chain-of-custody form will be updated to include each new sample container (see SOP CTO126-03). A sample collection log sheet will be completed for each sediment sample collected. These logs will note the date, time, sampling personnel, weather conditions, and flow conditions at the sampling location, and include a complete description of the sampling location (see SOP CTO126-20). A 2-by-2-inch wooden stake with attached flagging material shall be driven into the sampling location, and the sample identification number shall be marked on the stake with a black waterproof marker. Alternatively, stakes may be driven into the Creek bank to mark the location of the sediment sample. This will be done so that the sampling location can be revisited at a later date, if necessary, for surveying or resampling purposes.

4.5.12 Staff Gage Installation and Estimation of Stream Flow

Up to 6 staff gages will be installed along the stretch of Little Sulphur Creek starting at a point along the ABG Treatment Area, and extending downstream to the facility boundary. The staff gages will be placed approximately equidistant along the stretch of the creek for adequate spacial distribution. Existing permanent structures such as culverts and bridge abutments where measurements to the water surface can be taken will be used as staff gages as much as possible. A mark will be placed on these permanent structures denoting the point where measurements will be taken and the staff gage number will be noted. If a permanent structure is not available, the staff gage will consist of a metal pipe that will be pounded into the sediment with a sledge hammer. The measurements will be taken with a weighted tape measure in reference to the established measuring point. All staff gages will be measured at the same time as water level measurements in monitoring wells. Staff gages and monitoring well water levels will be measured in 2 rounds.

The approximate flow of surface water at each staff gage location will be estimated during both rounds by measuring the cross section of the stream bed, and measuring the surface water flow, in accordance with SOP CTO 126 - 21. The information will be used to evaluate surface water flow in relation to the sites, and spring discharge along Little Sulphur Creek. This information will be used in conjunction with surface water flow data being collected by the University of Indiana, to estimate surface water flow in Little Sulphur Creek.

4.5.13 Aquifer Testing

Aquifer testing, in the form of slug tests, will be performed in up to six of the shallow wells at the Jeep Trail. Both rising- and falling-head tests will be performed in wells with submerged well screens, whereas only rising-head tests will be performed in wells that straddle the water table. The slug tests will be performed in accordance with SOP CTO 126 - 22.

4.6 QUALITY CONTROL SAMPLES

This section focuses on field QC samples that will be collected as part of this environmental investigation. Field QC samples include field duplicates, source water blanks, equipment rinsate blanks, and trip blanks. Tables 4-3, 4-7, 4-9, and 4-11 present the types and numbers of required field QC samples to be collected for soil, ground water, surface water, and sediment sampling activities, respectively; during the field investigation. Section 8.1 provides definitions and details for these and all other QC checks to be used during this investigation. Field QC sample requirements for field duplicates, source water blanks, equipment rinsate blanks, and trip blanks required for this project are described below.

Field Duplicates. Field duplicates are obtained during a single act of sampling and are used to assess the overall precision of the sampling and analysis program. Duplicate samples will be collected at a rate of one for every 10 environmental samples of each type of environmental medium. All duplicate samples will be analyzed for the same parameters in the laboratory as their environmental sample counterparts. Duplicate samples will be preferentially collected where field evidence (i.e., PID reading or odor) indicates that contamination is likely to be present in the environmental sample.

Equipment Rinsate Blanks. Equipment rinsate blanks will be obtained under representative field conditions by running analyte-free water through sample collection equipment after decontamination, and placing it in the appropriate sample containers for analysis. Equipment rinsate blanks will be collected for non-dedicated equipment for all sampling rounds. For surface and subsurface soil sampling activities, rinsate blanks will be collected by running analyte-free water over a decontaminated stainless steel bowl

and mixing spoon; these items are used to mix soil prior to being placed in sample jars. For ground water samples, analyte-free water will be pumped through a decontaminated pump and tubing that will be used for ground water sampling. Equipment rinsate blanks will not be required for surface water and sediment samples. Surface water samples will be collected directly from the surface water body, and only a new disposable spoon will be used to collect sediment samples.

Source Water Blanks. Source water blanks will be obtained by sampling each water source (e.g., potable water and distilled water) used for decontamination activities during the field investigation. Source water blanks will be used to determine if the water or the laboratory bottles are contributing to sample contamination. Source water blanks will be collected for each type of water used for decontamination and will be submitted at a frequency of one per sampling event. Source water blanks, as applicable, will be analyzed for the entire suite of parameters under investigation. It is anticipated that two source water blanks will be collected during the field investigation – one potable water sample and one sample of distilled water used for decontamination.

Trip Blanks. Trip blank samples are 40-mL glass vials that contain analyte-free water and are prepared by the analytical laboratory prior to the start of field activities. They should be stored in a sealed container until they are needed. During sampling activities, one trip blank, consisting of one vial, shall be placed in each cooler that contains environmental samples destined for VOC analysis. The trip blank shall be properly labeled, and added to the chain-of-custody form belonging to the cooler. Trip blanks are only analyzed for VOCs.

4.7 SAMPLE HANDLING, PACKAGING, AND SHIPPING

4.7.1 Sample Preservation

Preservation requirements for each of the chemicals of interest are provided in Tables 4-12 and 4-13. All soil and sediment samples require only to be cooled to 4 ± 2°C; no chemical preservatives are necessary. Sample bottles for aqueous samples will contain the proper amounts and types of preservatives prior to being shipped to NSWC Crane (Table 4-13). The preservatives placed in the sample bottles will be certified that they are free of analytes being tested in the samples. All samples will be promptly chilled with ice to 4 °C ± 2°C and packaged in an insulated cooler. Each cooler will include a temperature blank. Ice will be sealed in containers to prevent water leakage. Samples will not be frozen.

4.7.2 Sample Labeling

Before samples are packaged, the sample labels and tags will be checked to ensure that all information on the label and tag is complete and correct (see SOP CTO126-01). This information should be checked to ensure that it matches the information placed on the sample collection log sheets and the chain-of-custody form.

4.7.3 Sample Packaging

Each sample container will be placed in a zip-lock bag to prevent cross-contamination or leakage. The zip-lock bag will be placed in a bubble-wrap sleeve to protect from breakage and cross-contamination. Only shipping containers that meet all applicable state and federal standards for safe shipment will be used. Cube ice will be placed in plastic bags and placed around and between the samples in sufficient quantity to ensure that the samples remain chilled (4 °C ± 2 °C) during transport to the analytical laboratory.

The completed field chain-of-custody document will be signed, placed in a sealed plastic envelope, and taped to the top inside cover of the shipping container (see SOP CTO126-03).

SOP CTO126-01 provides a detailed description of sample handling, packaging, and shipping procedures required for this project. The FOL will be responsible for ensuring the completion of the following forms:

Sample Labels and Tags
Chain-of-custody Forms
Custody Seals for Coolers
Shipping Labels for Coolers
Express Mail Air Bills

4.7.4 Sample Shipping

Shipping containers (i.e., coolers) will be sealed with nylon strapping tape in at least two places, and custody seals will be signed, dated, and affixed in a manner that will allow the receiver to quickly identify any tampering that may have occurred during transport to the laboratory (see SOPs CTO126-01 and -03).

Shipment will be made by a public courier at the next scheduled pickup following completion of sample collection. Copies of the Express Mail Air Bills should be retained by the FOL for tracking purposes, if

needed, and for communications with the laboratory. Air Bills will be retained for the Permanent Record File.

4.7.5 Sample Custody

Custody of samples must be maintained and documented at all times as per SOP CTO126-03, beginning with the collection of samples in the field. Sample custody procedures are addressed in Section 5.0.

4.8 RECORD KEEPING

Standard forms, field notebooks, and a field log book will be used to record all sample collection activities, field measurements, observations concerning site conditions, and other project-related information. These records include sample log sheets, daily activity records, field logbooks, drilling and well completion log sheets, and field instrument calibration log sheets, among others. More details regarding record keeping are included in SOP CTO126-03.

4.8.1 Field Log Books

Bound, weatherproof field notebooks shall be maintained by sampling personnel. All information related to sampling and other field activities will be recorded in field notebooks. This information will include, but is not limited to, sampling time, weather conditions, unusual events, field measurements, and descriptions of photographs.

A bound, weatherproof logbook shall be maintained by the FOL. This book will contain a summary of each day's activities and will reference the field notebooks when applicable.

4.8.2 Drilling and Well Completion Logs

A drilling log will be completed for every boring that occurs during these field activities. A geologist will complete the boring log, which will include information regarding date, time, personnel, drilling and sampling equipment, geologic materials encountered, fracture locations and density in bedrock (where appropriate), color, texture, odors, and readings made with the screening instruments (see SOPs CTO126-07 and CTO126-11).

A well completion log will be completed for every monitoring well that is constructed. These logs will include information concerning the date, time of events, quantities of construction materials used, lengths

and diameters of riser pipe and well screen placed in the well, and other information, as described in SOP CTO126-12.

4.8.3 Well Development Log Sheets

During the development or redevelopment of each monitoring well, the date, time of events, development method and equipment, personnel present, amounts of water produced, measurements made by field water quality meters, and depths to water will be recorded on a well development log sheet, as described in SOP CTO126-10.

4.8.4 Equipment Calibration Logs

An equipment calibration log sheet will be used to record each time an instrument is calibrated or recalibrated, or calibration is checked against a standard or background. The procedures and standards to be used for instrument calibration are discussed in Section 6.1 and each instrument's SOP contained in Appendix H.

4.8.5 Sample Collection Logs

One sample collection log sheet will be completed for every environmental sample, every duplicate sample, and every field blank sample collected during the field activities. Only the MS and MSD samples do not require their own individual sample collection log sheet.

4.8.6 Chain-of-Custody Forms

A chain-of-custody form will be completed for every cooler that contains samples being shipped to an off-site laboratory for analyses. These forms are a record of the people having custody of the samples from the time the samples are collected to the time they are analyzed and disposed of (see SOP CTO126-03). The completed field chain-of-custody document will be signed, placed in a sealed plastic envelope, and taped to the top inside cover of the shipping container before it is shipped. A copy of the document will be retained by the FOL.

4.8.7 Shipping Forms/Air Bills

Copies of all forms and/or Air Bills related to the shipment of coolers will be retained by the FOL in order to trace the shipment, if necessary, and to communicate with the receiving laboratory.

4.8.8 Permanent Record File

At completion of the field activities, the FOL shall submit to the TOM all field records, data, field notebooks, logbooks, COC records, sample log sheets, daily activity logs, and other records concerning the project, including all of the forms and log sheets listed above. The FOL will check these records for legibility and completeness prior to submitting them to the TOM. These forms, data, and field notes will become part of the permanent project record.

4.9 SURVEYING

The location of every soil boring, surface water, and sediment sample will be marked with a wooden lath and flagging, and a hole number will be marked on the lath. In addition, a 2-by 2-inch wooden stake, 6 inches long, will be driven into the ground at the center of the backfilled boring. This stake will have a piece of brightly-colored flagging tacked onto its top, and the hole number indelibly marked on the side of the stake.

The horizontal and vertical locations of all monitoring wells, soil borings, surface water samples, sediment samples, and staff gages will be surveyed. The horizontal location will be surveyed for all locations to the Indiana State Plane Coordinates within the nearest foot and referenced to the 1983 North American Datum (NAD83). The vertical elevations of the ground surface and top-of-casing for wells, the top of the staff gage, and the ground surface for the borings and surface water and sediment samples will be measured to the nearest 0.01 foot.

4.10 EQUIPMENT DECONTAMINATION

All equipment used to collect soil and ground water samples will be decontaminated in accordance with SOP CTO126-17. All decontamination fluids will be placed in the wastewater storage tank until the wastewater can be analyzed. If accepted, the wastewater will be discharged to the NSWC Crane water treatment plant where it will be treated prior to disposal (see SOP CTO126-15).

4.11 MANAGEMENT OF INVESTIGATION-DERIVED WASTE

It is anticipated that this investigation will generate five types of potentially contaminated residues or investigation-derived waste (IDW):

- Personal protective equipment (PPE)

- Ground water sample tubing and DPT sample liners
- Well development and purge fluids
- Equipment decontamination fluids
- Waste cuttings from drilling activities

IDW will be handled as described below:

PPE, Tubing, and DPT Sample Liners - All PPE, tubing, and DPT sample liners will be decontaminated and double-bagged and placed in trash receptacles at the facility.

Well Development and Purge Fluids - All well development and purge fluids will be collected and stored on-site in a 300- or 500-gallon plastic holding tank. The development and purge fluids will be discharged to the NSWC Crane permitted sanitary sewer system. Discharge will occur at a manhole designated by NSWC Crane.

Drilling Equipment Decontamination Fluids - All drilling equipment decontamination fluids will be combined with well development and purge fluids and handled in the same manner as described for well development and purge fluids.

Equipment Decontamination Fluids - All sampling decontamination fluids will be combined with well development and purge fluids and handled in the same manner as described for well development and purge fluids.

Waste Cuttings and Rock Cores from Drilling Activities – For each boring, the cuttings obtained will be scanned for VOCs. If all readings from these screening instruments are at background levels, the soil cuttings from soil borings will be mixed with bentonite, placed back down the hole and tamped for compaction or spread on the ground adjacent to the borehole. Borings which contain contaminated cuttings will be backfilled with bentonite pellets or a cement-bentonite slurry.

Contaminated cuttings from borings will be placed in black plastic trash bags (or directly in drums if larger quantities), labeled, and then placed in 55-gallon sealable drums. The bags will be tagged and the drums will be clearly labeled regarding the dates, locations and depths from where the soils originated, and the personnel (including phone number) placing the cuttings in the drum. When analytical results are received back from the laboratory concerning contaminant concentrations in the soil samples, decisions will be made as to how to dispose of the soil materials (see SOP CTO126-15).

4.12 SAFETY

Health and safety issues and concerns are critically important during any field investigation involving drilling, UXO, and hazardous wastes. Sampling team members working at the site must be fully aware of the potential dangers involved with sampling activities, must be trained and prepared to deal with problems or health-related issues as they arise, and should minimize to the greatest possible extent the potential for exposure to harmful chemicals or accidents. To ensure that field activities are performed at a high level of safety, the following are included in the health and safety activities related to the sampling program.

4.12.1 Health and Safety Plan

A separate HASP has been prepared describing specific health and safety requirements, concerns, and information related to the site activities. This document must be read and understood by each person working at the site. Each worker or visitor to the site must sign an acknowledgment that he or she has read and understands the HASP.

4.12.2 Health and Safety Training

All workers involved with the site investigations shall have successfully completed the OSHA-mandated, 40-hour health and safety training, and follow-up annual 8-hour refresher courses when appropriate.

TtNUS and subcontractor personnel must supply OSHA documentation prior to beginning work. Personnel who do not comply with this requirement must receive verbal approval to work from TtNUS corporate health and safety personnel.

4.12.3 Personal Protective Clothing and Equipment

Workers at the site must be part of a medical monitoring program and be medically approved to perform their duties without physical limitations. Protective clothing and equipment, as specified in the HASP, will be worn while performing site activities.

4.12.4 Safety Meetings

Safety meetings will be held among on-site workers whenever the SSO feels it is appropriate. The SSO will discuss safety issues related to activities being performed, and will make site workers aware of any new conditions that could potentially affect health or safety.

4.13 ORGANIZATION AND LOGISTICS OF FIELD INVESTIGATIONS

4.13.1 Personnel

The duties, responsibilities, and line of command for each person working on the project are described in Section 2.0 and displayed on Figure 2-1. Persons working on the project should be intimately familiar with their roles and responsibilities. In addition, they should be familiar with the mechanisms and procedures for coordinating tasks, improving communications, and reporting incidences or irregularities. The FOL is responsible for coordinating all on-site personnel and activities (Section 2.3.1). The SSO is responsible for health and safety monitoring and ensures that the HASP is adhered to during all field activities (Section 2.3.3). The SSO has the authority to stop work if an imminent safety hazard is encountered (Section 2.3).

4.13.2 Subcontractors

Subcontractors will perform site activities involving drilling, packer testing, well installation, and surveying. The FOL will direct all subcontractor activities.

4.13.3 Mobilization and Demobilization

Following approval of the QAPP, TtNUS will begin mobilization activities. All field team members will review the QAPP (including the HASP) prior to mobilization. In addition, a field team orientation meeting will be held to familiarize personnel with the scope of the field activities. Items to be presented during that meeting include:

- Identification of the QAPP, including the HASP and applicable field SOPs (Appendix H),
- Site-specific safety concerns and requirements,
- Project objectives,

- Sampling designs and strategies for soil and ground water (including the relationship of soils data for this project to NSWC Crane background soil data),
- Site-specific particulars of field operations (e.g., locations of utilities, physical access to sampling location, communication mechanisms, lines of authority and responsibility, scheduling requirements, sample shipping concerns, etc.),
- Laboratory and other subcontractor coordination,
- Site access requirements, and
- Travel requirements.

The FOL will coordinate the mobilization activities for this project. The equipment required for the field activities will be mobilized from the TtNUS Pittsburgh office or a third party vendor. The ABG study area is in a fairly remote area of the base. As a result, electricity is not available on-site. Therefore, power for electric pumps and all other electric-powered equipment, if required, will be supplied from portable gas-powered generators. It is presently anticipated that no portable gas-powered equipment will be used during field operations, but if conditions arise that require such equipment, an application for their use will be made to the NSWC Crane Fire Department.

The FOL and crew will demobilize from the site upon completion of the field operations and transport field equipment back to the TtNUS Pittsburgh office, as necessary. All areas will be thoroughly checked; trash will be removed and disposed of. All drums containing IDW will be checked to ensure that lids are secured and proper labels have been attached to the drums.

4.13.4 Time Schedule

Roughly 60 working days have been scheduled to perform the field activities at the site (Figure 1-22). The activities will be performed in approximately the following order:

1. Repair and redevelop existing wells, install staff gages.
2. Collect first round of surface water samples and sediment samples
3. Perform UXO clearance, drill soil borings, collect soil samples.

4. Collect first round of water level measurements
5. Sample wells
4. Collect second round of surface water samples.
5. Collect second round of water level measurements
6. Perform aquifer tests and tracer study

Many of these activities will overlap each other.

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TABLE 4-1

FIELD SCREENING AND MEASUREMENTS
ABG STUDY
NSWC CRANE, CRANE, INDIANA

Parameter	Equipment	SOP	Calibration
Unexploded Ordnance (Surface)	GA-72CV Magnetic Locator	Per Manufacturer	Per Manufacturer
Unexploded Ordnance (Subsurface)	MG-220 Magnetic Grapiometer	Per Manufacturer	Per Manufacturer
Volatile Organics	Perkin-Elmer Photovac 2020 Photoionization Detector	SOP CTO126-6	Per Manufacturer
pH, Temperature, oxidation-reduction potential, specific conductance, dissolved oxygen (water quality parameters)(1)	YSI 6-Series Environmental Monitoring System	SOP CTO126-14	Per Manufacturer
Turbidity (water quality parameter)(1)	LaMotte Turbidity Meter	SOP CTO126-14	Per Manufacturer
NO_3, NO_2,	HACH DR-800 Colorimeter (or equivalent)	Test Kit Instructions	Per Manufacturer
Water-Level Measurements	Heron Dipper-T (or equivalent)(2)	SOP CTO126-18	Per Manufacturer

1 Field measurements used to establish well stabilization prior to collecting ground water samples. Field measurements will also be collected at each surface water sample location.
2 Any electronic water-level indicator may be used with the capability of measuring to depths of 100 feet.

TABLE 4-2

SOIL SAMPLES AND LABORATORY ANALYSES
ABG STUDY AREA
NSWC CRANE, CRANE, INDIANA
PAGE 1 OF 4

Sample No.	VOC[5]	SVOC[5,6]	Herbicides [5]	Pesticides [6]	Dioxins / Furans	Explosives	Nitrocellulose	Metals[7]	Nitrate	Nitrite	Perchlorate
03-SS-01-0002[1]	-	-	-	-	-	X	X	-	X	X	-
03-SS-02-0002[1]	-	X	-	-	-	X	X	-	X	X	-
03-SB-02-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SB-02-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SS-03-0002[1]	-	-	-	-	-	X	X	-	X	X	-
03-SS-04-0002[1]	-	X	-	-	-	X	X	-	X	X	-
03-SB-04-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SB-04-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SS-05-0002[1]	-	X	-	-	-	X	X	-	X	X	-
03-SB-05-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SB-05-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SS-06-0002[1]	-	X	-	-	-	X	X	-	X	X	-
03-SB-06-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SB-06-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SS-07-0002[1]	-	X	-	-	-	X	X	-	X	X	-
03-SB-07-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SB-07-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SS-08-0002[1]	-	X	-	-	-	X	X	-	X	X	-
03-SB-08-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SB-08-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SS-09-0002[1]	-	X	-	-	-	X	X	-	X	X	-
03-SB-09-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SB-09-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SS-10-0002[1]	-	X	-	-	-	X	X	-	X	X	-

TABLE 4-2

SOIL SAMPLES AND LABORATORY ANALYSES
ABG STUDY AREA
NSWC CRANE, CRANE, INDIANA
PAGE 2 OF 4

Sample No.	VOC[5]	SVOC[5,6]	Herbicides [5]	Pesticides [6]	Dioxins / Furans	Explosives	Nitrocellulose	Metals[7]	Nitrate	Nitrite	Perchlorate
03-SB-10-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SB-10-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SS-11-0002[1]	-	X	-	-	-	X	X	-	X	X	-
03-SB-11-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SB-11-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SS-12-0002[1]	-	-	-	-	-	X	X	-	X	X	-
03-SS-13-0002[1]	-	X	-	-	-	X	X	-	X	X	-
03-SB-13-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SB-13-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SS-14-0002[1]	-	X	-	-	-	X	X	-	X	X	-
03-SB-14-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SB-14-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SS-15-0002[1]	-	X	-	-	-	X	X	-	X	X	-
03-SB-15-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SB-15-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SS-16-0002[1]	-	X	-	-	-	X	X	-	X	X	-
03-SB-16-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SB-16-????[1][8]	-	X	-	-	-	X	X	-	X	X	-
03-SS-17-0002[2]	X	X	-	-	X	X	X	X	X	X	X
03-SB-17-????[2][8]	X	X	-	-	-	X	X	X	X	X	X
03-SB-17-????[2][8]	X	X	-	-	-	X	X	X	X	X	X
03-SS-18-0002[2]	X	X	-	-	-	X	X	X	X	X	X
03-SB-18-????[2][8]	X	X	-	-	-	X	X	X	X	X	X
03-SB-18-????[2][8]	X	X	-	-	-	X	X	X	X	X	X

TABLE 4-2

SOIL SAMPLES AND LABORATORY ANALYSES
ABG STUDY AREA
NSWC CRANE, CRANE, INDIANA
PAGE 3 OF 4

Sample No.	VOC[5]	SVOC[5,6]	Herbicides [5]	Pesticides [6]	Dioxins / Furans	Explosives	Nitrocellulose	Metals[7]	Nitrate	Nitrite	Perchlorate
03-SS-19-0002[2]	X	X	-	-	-	X	X	X	X	X	X
03-SB-19-????[2][8]	X	X	-	-	-	X	X	X	X	X	X
03-SB-19-????[2][8]	X	X	-	-	X	X	X	X	X	X	X
03-SS-20-0002[2]	X	X	-	-	X	X	X	X	X	X	X
03-SB-20-????[2][8]	X	X	-	-	-	X	X	X	X	X	X
03-SB-20-????[2][8]	X	X	-	-	-	X	X	X	X	X	X
03-SS-21-0002[2]	X	X	-	-	-	X	X	X	X	X	X
03-SB-21-????[2][8]	X	X	-	-	-	X	X	X	X	X	X
03-SB-21-????[2][8]	X	X	-	-	-	X	X	X	X	X	X
03-SS-22-0002[2]	X	X	-	-	-	X	X	X	X	X	X
03-SB-22-????[2][8]	X	X	-	-	-	X	X	X	X	X	X
03-SB-22-????[2][8]	X	X	-	-	-	X	X	X	X	X	X
03-SS-23-0002[2]	X	X	-	-	X	X	X	X	X	X	X
03-SB-23-????[2][8]	X	X	-	-	-	X	X	X	X	X	X
03-SB-23-????[2][8]	X	X	-	-	-	X	X	X	X	X	X
03-SS-24-0002[2]	X	X	-	-	-	X	X	X	X	X	X
03-SB-24-????[2][8]	X	X	-	-	-	X	X	X	X	X	X
03-SB-24-????[2][8]	X	X	-	-	X	X	X	X	X	X	X
03-SS-25-0002[2]	X	X	-	-	X	X	X	X	X	X	X
03-SB-25-????[2][8]	X	X	-	-	-	X	X	X	X	X	X
03-SB-25-????[2][8]	X	X	-	-	-	X	X	X	X	X	X
03-SS-26-0002[2]	X	X	-	-	X	X	X	X	X	X	X
03-SB-26-????[2][8]	X	X	-	-	-	X	X	X	X	X	X
03-SB-26-????[2][8]	X	X	-	-	-	X	X	X	X	X	X

TABLE 4-2

SOIL SAMPLES AND LABORATORY ANALYSES
ABG STUDY AREA
NSWC CRANE, CRANE, INDIANA
PAGE 4 OF 4

Sample No.	VOC[5]	SVOC[5,6]	Herbicides [5]	Pesticides [6]	Dioxins / Furans	Explosives	Nitrocellulose	Metals[7]	Nitrate	Nitrite	Perchlorate
03-SS-27-0002[3]	X	X	-	-	-	X	X	X	X	X	X
03-SB-27-????[3][8]	X	X	-	-	-	X	X	X	X	X	X
03-SB-27-????[3][8]	X	X	-	-	-	X	X	X	X	X	X
03-SS-28-0002[3]	X	X	-	-	-	X	X	X	X	X	X
03-SB-28-????[3][8]	X	X	-	-	-	X	X	X	X	X	X
03-SB-28-????[3][8]	X	X	-	-	-	X	X	X	X	X	X
03-SS-29-0002[4]	-	X	X	X	X	X	X	X	X	X	-
03-SS-30-0002[4]	-	X	X	X	X	X	X	X	X	X	-
03-SS-31-0002[4]	-	X	X	X	X	X	X	X	X	X	-
03-SS-32-0002[4]	-	X	X	X	X	X	X	X	X	X	-
03-SS-33-0002[4]	-	X	X	X	X	X	X	X	X	X	-
Totals	36	80	5	5	12	83	83	41	83	83	36

1 Burn Area
2 Burn Pit
3 Deposition
4 Reference
5 Appendix IX.
6 Excluding organophosphorus pesticides.
7 TAL metals plus Sn (total).
8 Sample depth to be determined during drilling.

TABLE 4-3

SUMMARY OF SOIL ANALYSES AND QUALITY CONTROL SAMPLES
ABG STUDY AREA
NSWC CRANE, CRANE, INDIANA

Parameter[1]	Samples	Field Duplicates[2]	Trip Blanks[3]	Rinsate Blanks[4]	Matrix Spike/ Matrix Spike Duplicates[5]	Total
Appendix IX VOCs	36	4	10	7	2/2	61
Appendix IX SVOCs (excluding organophosphorus pesticides)	80	8	NA	15	4/4	111
Appendix IX Herbicides	5	1	NA	2	1/1	10
Appendix IX Pesticides	5	1	NA	2	1/1	10
Dioxins / Furans	12	2	NA	3	1/1	19
Explosives	83	9	NA	15	3/3	113
Nitrocellulose	83	9	NA	15	3/3	113
TAL Metals plus Sn (total)	41	5	NA	7	2/0	55
Nitrates	83	9	NA	15	4/0	111
Nitrites	83	9	NA	15	4/0	111
Perchlorate	36	4	NA	7	2/2	51

NA Not Applicable

1 See Table 1-9 of this QAPP for specific analysis requirements and analyte lists.
2 Field duplicates will be collected at a frequency of one per every 10 samples.
3 Trip blanks will be submitted for analysis at a frequency of one per cooler containing samples for volatile organics analysis. Because the number of sample coolers shipped may vary, the number of trip blanks are estimated to be ten.
4 Rinsate blanks will be collected at a frequency of one per every 10 samples, with a minimum of one per day of sampling, per sampling device/instrument. These amounts are estimates and may vary.
5 Matrix spike (MS) and matrix spike duplicate (MSD) samples will be collected at a frequency of one per every 20 samples. MS/MSDs are not applicable (NA) for field analyses.

TABLE 4-4

SUMMARY OF MONITORING WELL CONSTRUCTION DETAILS AT THE JEEP TRAIL (1)
NSWC CRANE, CRANE, INDIANA

Monitoring Well Number	Date Installed	Horizontal Location		Ground Surface Elevation (feet-NGVD)	Top of Casing Elevation (feet-NGVD)	Well Screen Interval		Well Screen Interval		Ground water Depth & Elevation		
		North Coord Feet	East Coord Feet			Depth to Top (feet-TOC)	Depth to Bottom (feet-TOC)	Elevation of Top (feet)	Elevation of Bottom (feet)	Date Measured	Depth to Water (feet - TOC)	Ground water Elevation (feet)
03-07	10/8/81	487,838	596,316	553.46	556.46	12.4	21.7	544.06	534.76	Sep-94	13.36	543.10
03-10	11/3/82	487,821	596,516	554.94	557.94	12.2	21.5	545.74	536.44	Sep-94	17.00	540.94
03-11	11/4/82	487,709	596,435	550.05	553.05	5.7	15.1	547.35	537.95	Sep-94	11.80	541.25
03-12	11/4/82	487,765	596,232	554.99	557.99	12.2	21.6	545.79	536.39	Sep-94	17.45	540.54
03-13	11/5/82	487,634	596,377	549.24	552.24	12.0	21.4	540.24	530.84	Sep-94	13.46	538.78
03-14	11/6/82	487,673	596,420	549.37	552.37	5.2	14.7	547.17	537.67	Sep-94	12.42	539.95
03-15	11/22/82	487,899	596,369	556.09	559.09	15.7	25.1	543.39	533.99	Sep-94	18.46	540.63
03-16	11/23/82	488,568	595,788	568.61	571.61	23.2	32.6	548.41	539.01	Sep-94	29.67	541.94
03-17	11/24/82	487,650	596,265	550.44	553.44	12.3	21.7	541.14	531.74	Sep-94	16.45	536.99
03-18	1/14/83	487,508	596,288	549.80	552.80	14.6	23.9	538.20	528.90	Sep-94	17.98	534.82
03-19	1/15/83	NF	NF	556.37(2)	559.37	20.1	29.5	539.27	529.87	NF	NF	NF
03-20	1/17/83	487,674	596,120	551.83	554.83	14.4	23.7	540.43	531.13	Sep-94	19.20	535.63
03-21	1/27/83	488,044	596,243	557.12	560.12	12.8	22.1	547.32	538.02	Sep-94	19.08	541.04
03-22	1/27/83	487,820	596,405	555.72	558.72	14.5	23.9	544.22	534.82	Sep-94	17.61	541.11
03-23	1/28/83	487,933	596,069	559.34	562.34	14.9	23.3	547.44	539.04	Sep-94	18.30	544.04
03-24	2/6/83	488,012	596,462	586.04	589.04	42.0	51.4	547.04	537.64	Sep-94	49.32	539.72
03-25	2/7/83	487,902	596,498	570.64	573.64	24.2	33.5	549.44	540.14	Sep-94	33.06	540.58

1 All data was obtained from "Letter Report: Preliminary assessment of Geology, Groundwater Hydrology, and Groundwater Contaminant Distribution of Jeep Trail 25 Area, Ammunition Burning Ground, Naval Surface Warfare Center, Crane, Indiana
2 Data obtained from the original well log
NF - Not Found, presumed to be destroyed
NGVD - National Geodetic Vertical Datum

TABLE 4-5

PHYSICAL CHARACTERISTICS OF POTENTIAL MONITORING WELLS
ABG STUDY AREA
NSWC CRANE, CRANE, INDIANA

Monitoring Well Number	Approximate Ground Surface Elevation (feet NGVD)	Approximate Total Depth (feet bgs)	Screen Length (feet)	Approximate Desired Well Screen Elevation[1]	
				Top (feet NGVD)	Bottom (feet NGVD)
SHALLOW ZONE WELLS					
03MWT01	560	25	10	545	535
03MWT02	560	25	10	545	535
03MWT03	560	25	10	545	535
03MWT04	585	50	10	545	535
03MWT05	590	55	10	545	535
03MWT06	550	15	10	545	535
03MWT07	550	15	10	545	535
03MWT08	550	15	10	545	535
03MWT09	560	25	10	545	535
DEEP ZONE WELLS					
03MWT10	570	75	10	505	495
03MWT11	555	60	10	505	495
03MWT12	555	60	10	505	495
03MWT13	585	60	10	505	495

NGVD - National Geodetic Vertical Datum
Bgs - below ground surface

1 Elevations will vary depending on the soil and rock types and fracture distributions encountered in each boring, with the intent of monitoring similar hydrogeologic zones.

TABLE 4-6

GROUND WATER SAMPLES AND LABORATORY ANALYSES
ABG STUDY AREA
NSWC CRANE, CRANE, INDIANA

Location	VOC (1)	SVOC (1,2)	Explosives	Nitrocellulose	Metals (3)	Nitrate	Nitrite	Perchlorate
EXISTING WELLS								
03-GW-07-01	X	X	X	X	X	X	X	X
03-GW-10-01	X	X	X	X	X	X	X	X
03-GW-11-01	X	X	X	X	X	X	X	X
03-GW-12-01	X	X	X	X	X	X	X	X
03-GW-13-01	X	X	X	X	X	X	X	X
03-GW-14-01	X	X	X	X	X	X	X	X
03-GW-15-01	X	X	X	X	X	X	X	X
03-GW-16-01	X	X	X	X	X	X	X	X
03-GW-17-01	X	X	X	X	X	X	X	X
03-GW-18-01	X	X	X	X	X	X	X	X
03-GW-20-01	X	X	X	X	X	X	X	X
03-GW-21-01	X	X	X	X	X	X	X	X
03-GW-22-01	X	X	X	X	X	X	X	X
03-GW-23-01	X	X	X	X	X	X	X	X
03-GW-24-01	X	X	X	X	X	X	X	X
03-GW-25-01	X	X	X	X	X	X	X	X
NEWLY INSTALLED								
03-GW-T01-01	X	X	X	X	X	X	X	X
03-GW-T02-01	X	X	X	X	X	X	X	X
03-GW-T03-01	X	X	X	X	X	X	X	X
03-GW-T04-01	X	X	X	X	X	X	X	X
03-GW-T05-01	X	X	X	X	X	X	X	X
03-GW-T06-01	X	X	X	X	X	X	X	X
03-GW-T07-01	X	X	X	X	X	X	X	X
03-GW-T08-01	X	X	X	X	X	X	X	X
03-GW-T09-01	X	X	X	X	X	X	X	X
03-GW-T10-01	X	X	X	X	X	X	X	X
03-GW-T11-01	X	X	X	X	X	X	X	X
03-GW-T12-01	X	X	X	X	X	X	X	X
03-GW-T13-01	X	X	X	X	X	X	X	X
Totals	16-29	16-29	16-29	16-29	16-29	16-29	16-29	16-29

1 Appendix IX.
2 Excluding organophosphorus pesticides.
3 Target Analyte List metals plus Sn. Unfiltered sample will be analyzed for total metals. If turbidity of water is greater than 10 NTUs, a filtered sample will also be collected and analyzed for dissolved metals.

TABLE 4-7

SUMMARY OF GROUND WATER ANALYSES AND QUALITY CONTROL SAMPLES, ABG STUDY AREA NSWC CRANE, CRANE, INDIANA

Parameter[1]	Samples	Field Duplicates[2]	Trip Blanks[3]	Rinsate Blanks[4]	Source Water Blanks[5]	Matrix Spike/ Matrix Spike Duplicates[6]	Total[7]
Appendix IX VOCs	16-29	2-3	2-4	3-4	1-2	1/1-2/2	26-46
Appendix IX SVOCs[8]	16-29	2-3	NA	3-4	1-2	1/1-2/2	24-42
Explosives	16-29	2-3	NA	3-4	1-2	1/1-2/2	24-42
Nitrocellulose	16-29	2-3	NA	3-4	1-2	1/1-2/2	24-42
TAL Metals plus Sn (total)[9]	16-29	2-3	NA	3-4	1-2	1/1-2/0	24-40
Nitrate	16-29	2-3	NA	3-4	1-2	1/1-2/2	24-42
Nitrite	16-29	2-3	NA	3-4	1-2	1/1-2/2	24-42
Perchlorate	16-29	2-3	NA	3-4	1-2	1/1-2/2	24-42

NA Not Applicable
1 See Table 1- 9 of this QAPP for specific analytical requirements and analyte lists.
2 Field duplicates will be collected at a frequency of one per every 10 samples.
3 Trip blanks will be submitted for analysis at a frequency of one per cooler containing samples for VOC analysis. These amounts are estimates and may vary with actual final conditions.
4 Rinsate blanks will be collected at a frequency of one per every 10 samples, with a minimum of one per day of sampling, per sampling device/instrument. These amounts are estimates and may vary.
5 Source water blanks consist of analyte-free water and potable water used for decontamination.
6 Matrix spike (MS) and matrix spike duplicate (MSD) samples will be collected at a frequency of one per every 20 samples.
7 Totals may vary due to estimates made for trip blanks and rinsate blanks.
8 Excluding organophosphorus pesticides.
9 TAL metals plus Sn. Unfiltered sample will be analyzed for total metals. If turbidity of water is greater than 5 NTUs, a filtered sample will also be collected and analyzed for dissolved metals.

Note: No QA/QC samples will be required for bromide analyses in support of the tracer study.

TABLE 4-8

SURFACE WATER LABORATORY ANALYSES
ABG STUDY AREA
NSWC CRANE, CRANE, INDIANA

Location	VOC (1)	SVOC (1,2)	Herbicides (1)	Pesticides (1)	Explosives	Nitrocellulose	Nitrate	Nitrite	Metals(3)		TSS	Perchlorate
									Total	Dissolved		
03-SW-01-01	X	X	X	X	X	X	X	X	X	X	X	X
03-SW-02-01	X	X	X	X	X	X	X	X	X	X	X	X
03-SW-03-01	X	X	X	X	X	X	X	X	X	X	X	X
03-SW-04-01	X	X	X	X	X	X	X	X	X	X	X	X
03-SW-06-01	X	X	X	X	X	X	X	X	X	X	X	X
03-SW-08-01	X	X	X	X	X	X	X	X	X	X	X	X
03-SW-09-01	X	X	X	X	X	X	X	X	X	X	X	X
03-SW-11-01	X	X	X	X	X	X	X	X	X	X	X	X
03-SW-13-01	X	X	X	X	X	X	X	X	X	X	X	X
03-SW-14-01	X	X	X	X	X	X	X	X	X	X	X	X
03-SW-15-01	X	X	X	X	X	X	X	X	X	X	X	X
03-SW-16-01	X	X	X	X	X	X	X	X	X	X	X	X
03-SW-17-01	X	X	X	X	X	X	X	X	X	X	X	X
03-SW-18-01	X	X	X	X	X	X	X	X	X	X	X	X
03-SW-19-01	X	X	X	X	X	X	X	X	X	X	X	X
Totals	15	15	15	15	15	15	15	15	15	15	15	15

1 Appendix IX.
2 Excluding organophosphorus pesticides.
3 TAL metals plus Sn.

Note: Two rounds of Surface Water Samples will be collected, one during low flow periods and one during high flow periods. Round 1 samples are listed above. Round 2 samples have "02" replacing "01" in the last segment of the location identifier.

TABLE 4-9

SUMMARY OF SURFACE WATER ANALYSES AND QUALITY CONTROL SAMPLES ABG STUDY AREA NSWC CRANE, CRANE, INDIANA

Parameter[1]	Samples	Field Duplicates[2]	Trip Blanks[3]	Matrix Spike/ Matrix Spike Duplicates[4]	Total
Appendix IX Volatile Organic Compounds	15	2	1	1/1	20
Appendix IX Semivolatile Organic Compounds[5]	15	2	NA	1/1	19
Appendix IX Herbicides	15	2	NA	1/1	19
Appendix IX Pesticides	15	2	NA	1/1	19
Explosives	15	2	NA	1/1	19
Nitrocellulose	15	2	NA	1/1	19
Nitrate	15	2	NA	1/1	19
Nitrite	15	2	NA	1/1	19
TAL Metals plus Sn (total)[6]	15	2	NA	1/0	18
TAL Metals plus Sn (dissolved)[6]	15	2	NA	1/0	18
Total Suspended Solids	15	2	NA	NA	17
Perchlorate	15	2	NA	1/1	19

NA Not Applicable

1 See Table 1-9 of this QAPP for specific analytical requirements and analytes lists.
2 Field duplicates will be collected at a frequency of one per every 10 samples.
3 Trip blanks will be submitted for analysis at a frequency of one per cooler containing samples for VOC analysis.
4 Matrix spike (MS) and matrix spike duplicate (MSD) samples will be collected at a frequency of one per every 20 samples.
5 Excluding organophosphorus pesticides.
6 TAL metals plus Sn.

Note: Two rounds of surface water samples will be collected, one during low flow periods and one during high flow periods.

Note: No QA/QC samples will be required for bromide analyses in support of the tracer study.

TABLE 4-10

SUMMARY OF SEDIMENT SAMPLES AND LABORATORY ANALYSES
ABG STUDY AREA
NSWC CRANE, CRANE, INDIANA
PAGE 1 OF 2

Location	VOC (1)	SVOC (1,2)	Herbicides (1)	Pesticides (1)	Explosives	Nitrocellulose	Metals (3)	Nitrate	Nitrite	TOC	pH	Geotech (4)	Perchlorate
03-SD-01-0006	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-01-0612	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-02-0006	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-02-0612	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-03-0006	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-03-0612	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-04-0006	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-04-0612	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-05-0006	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-05-0612	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-06-0006	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-06-0612	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-07-0006	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-07-0612	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-08-0006	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-08-0612	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-09-0006	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-09-0612	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-10-0006	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-10-0612	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-11-0006	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-11-0612	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-12-0006	X	X	X	X	X	X	X	X	X	X	X	X	X

TABLE 4-10

SUMMARY OF SEDIMENT SAMPLES AND LABORATORY ANALYSES
ABG STUDY AREA
NSWC CRANE, CRANE, INDIANA
PAGE 2 OF 2

Location	VOC (1)	SVOC (1,2)	Herbicides (1)	Pesticides (1)	Explosives	Nitrocellulose	Metals (3)	Nitrate	Nitrite	TOC	pH	Geotech (4)	Perchlorate
03-SD-12-0612	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-13-0006	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-13-0612	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-14-0006	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-14-0612	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-15-0006	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-15-0612	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-16-0006	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-16-0612	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-17-0006	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-17-0612	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-18-0006	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-18-0612	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-19-0006	X	X	X	X	X	X	X	X	X	X	X	X	X
03-SD-19-0612	X	X	X	X	X	X	X	X	X	X	X	X	X
Totals	38	38	38	38	38	38	38	38	38	38	38	38	38

1 Appendix IX
2 Excluding organophophorus pesticides
3 Target Analyte List Metals plus Sn
4 Geotech = Geotechnical Parameters including Unified Soil Classification, Grain Size, and Bulk Density

TABLE 4-11

SUMMARY OF SEDIMENT ANALYSES AND QUALITY CONTROL SAMPLES
ABG STUDY AREA
NSWC CRANE, CRANE, INDIANA

Parameter[1]	Samples	Field Duplicates[2]	Trip Blanks[3]	Rinsate Blanks[4]	Matrix Spikes/ Matrix Spike Duplicates[5]	Total
Appendix IX VOCs	38	4	1	4	2/2	51
Appendix IX SVOCs (excluding organophosphorus pesticides)	38	4	NA	4	2/2	50
Appendix IX Herbicides	38	4	NA	4	2/2	50
Appendix IX Pesticides	38	4	NA	4	2/2	50
Explosives	38	4	NA	4	2/2	50
Nitrocellulose	38	4	NA	4	2/2	50
TAL Metals plus Sn (total)	38	4	NA	4	2/0	48
Nitrate	38	4	NA	4	2/2	50
Nitrite	38	4	NA	4	2/2	50
Total Organic Carbon (TOC)	38	0	NA	0	0/0	38
Geotech [6]	38	0	NA	0	0/0	38
Perchlorate	38	4	NA	4	2/2	50

1 See Table 1-9 of this QAPP for specific analysis requirements and analytes lists.
2 Field duplicates will be collected at a frequency of one per every 10 samples.
3 Trip blanks will be submitted for analysis at a frequency of one per cooler containing samples for volatile organics analysis.
4 Rinsate blanks will be collected at a frequency of one per every 10 samples, with a minimum of one per day per sampling device/instrument.
5 Matrix spike (MS) and matrix spike duplicate (MSD) samples will be collected at a frequency of one per every 20 samples.
6 Geotech = Geotechnical parameters including Unified Soil Classification, grain size, and bulk density.

NA Not Applicable

TABLE 4-12

SUMMARY OF SAMPLE ANALYSES, CONTAINER TYPES AND VOLUMES, PRESERVATION REQUIREMENTS, HOLDING TIMES AND ANALYTICAL LABORATORY FOR SOILS AND SEDIMENTS ABG STUDY AREA NSWC CRANE, CRANE, INDIANA

Parameter	Sample Container	Container Volume	Preservation	Maximum Holding Time[1]	Analytical Laboratory
Appendix IX Volatile Organic Compounds	4 Encore™ samplers	Four 5-gram containers	Cool to 4 °C	48 hours to preservation; 14 days to analysis	Laucks
Appendix IX Semivolatile Organic Compounds (excluding organophosphorus pesticides)	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	Extraction 14 days; analysis within 40 days of extraction	Laucks
Appendix IX Herbicides	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	Extraction 14 days; analysis within 40 days of extraction	Laucks
Appendix IX Pesticides	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	Extraction 14 days; analysis within 40 days of extraction	Laucks
Explosives and nitrocellulose	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	Extraction 14 days; analysis within 40 days of extraction	Laucks
Target Analyte List Metals plus tin (total)	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	Within 180 days; mercury within 28 days	Laucks
Dioxins	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	Extraction within 30 days; analysis within 40 days of extraction.	Triangle
Nitrate	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	48 hour to analysis	Laucks
Nitrite	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	48 hours to analysis	Laucks
Perchlorate	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	28 days to analysis	To Be Determined
Total Organic Carbon (TOC)	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	28 days	Laucks
PH	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	As soon as possible	Laucks
Geotechnical[2]	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	None	Indefinite	To be Determined

1 All holding times are from date of collection.
2 Includes Unified Soil Classification, grain size, and bulk density

TABLE 4-13

SUMMARY OF SAMPLE ANALYSES, CONTAINER TYPES AND VOLUMES, PRESERVATION REQUIREMENTS, HOLDING TIMES, AND ANALYTICAL LABORATORY FOR AQUEOUS SAMPLES
ABG STUDY AREA
NSWC CRANE, CRANE, INDIANA
PAGE 1 OF 2

Parameter	Sample Container	Container Volume	Preservation[1]	Maximum Holding Time[2]	Analytical Laboratory[3]
Appendix IX Volatile Organic Compounds	Glass, black phenolic plastic screw cap, Teflon-lined septum	(6) 40 mL	Cool to 4 °C, dark, zero headspace, HCl to pH <2	14 days to analysis	Laucks
Appendix IX Semivolatile Organic Compounds (excluding organophosphorus pesticides)	Amber glass, Teflon-lined cap	(2) 1000 mL	Cool to 4 °C, dark	Extraction 7 days; analysis within 40 days of extraction	Laucks
Appendix IX Herbicides	Amber glass, Teflon-lined cap	(2) 1000 mL	Cool to 4 °C, dark	Extraction 7 days; analysis within 40 days of extraction	Laucks
Appendix IX Organochlorine Pesticides	Amber glass, Teflon-lined cap	(2) 1000 mL	Cool to 4 °C, dark	Extraction 7 days; analysis within 40 days of extraction	Laucks
Explosives	Amber glass, Teflon-lined cap	(2) 1000 mL	Cool to 4 °C, dark	Extraction 7 days; analysis within 40 days of extraction	Laucks
Nitrocellulose	Amber glass, Teflon-lined cap	(2) 500 mL	Cool to 4 °C, dark	Filtration 7 days; analysis within 40 days of filtration	Laucks
Target Analyte List Metals plus tin (total)	Polyethylene, plastic cap w/ plastic liner	1000 mL	Cool to 4 °C, HNO_3 to pH <2	Within 180 days; mercury within 28 days	Laucks
Target Analyte List Metals plus tin (dissolved)	Polyethylene, plastic cap w/ plastic liner	1000 mL	Cool to 4 °C, HNO_3 to pH <2	Within 180 days; mercury within 28 days	Laucks
Nitrate	Polyethylene, plastic cap w/ plastic liner	1000 mL	Cool to 4 °C, dark	analysis within 48 hours/48 hours	Laucks
Nitrite	Polyethylene, plastic cap w/ plastic liner	1000 mL	Cool to 4 °C, dark	analysis within 48 hours/48 hours	Laucks
Perchlorate	Polyethylene, plastic cap w/ plastic liner	500 mL	Cool to 4 °C, dark	analysis within 28 days	To Be Determined
Total Suspended Solids (TSS)	Polyethylene, plastic cap w/ plastic liner	500 mL	Cool to 4 °C	7 days to analysis	Laucks

TABLE 4-13

SUMMARY OF SAMPLE ANALYSES, CONTAINER TYPES AND VOLUMES, PRESERVATION REQUIREMENTS, HOLDING TIMES, AND ANALYTICAL LABORATORY FOR AQUEOUS SAMPLES
ABG STUDY AREA
NSWC CRANE, CRANE, INDIANA
PAGE 2 OF 2

Parameter	Sample Container	Container Volume	Preservation[1]	Maximum Holding Time[2]	Analytical Laboratory[3]
Bromide	Polyethylene, plastic cap w/ plastic liner	1000 mL	Cool to 4°C, dark	28 days	Laucks

Note: Aqueous samples include ground water, surface water, and seeps.

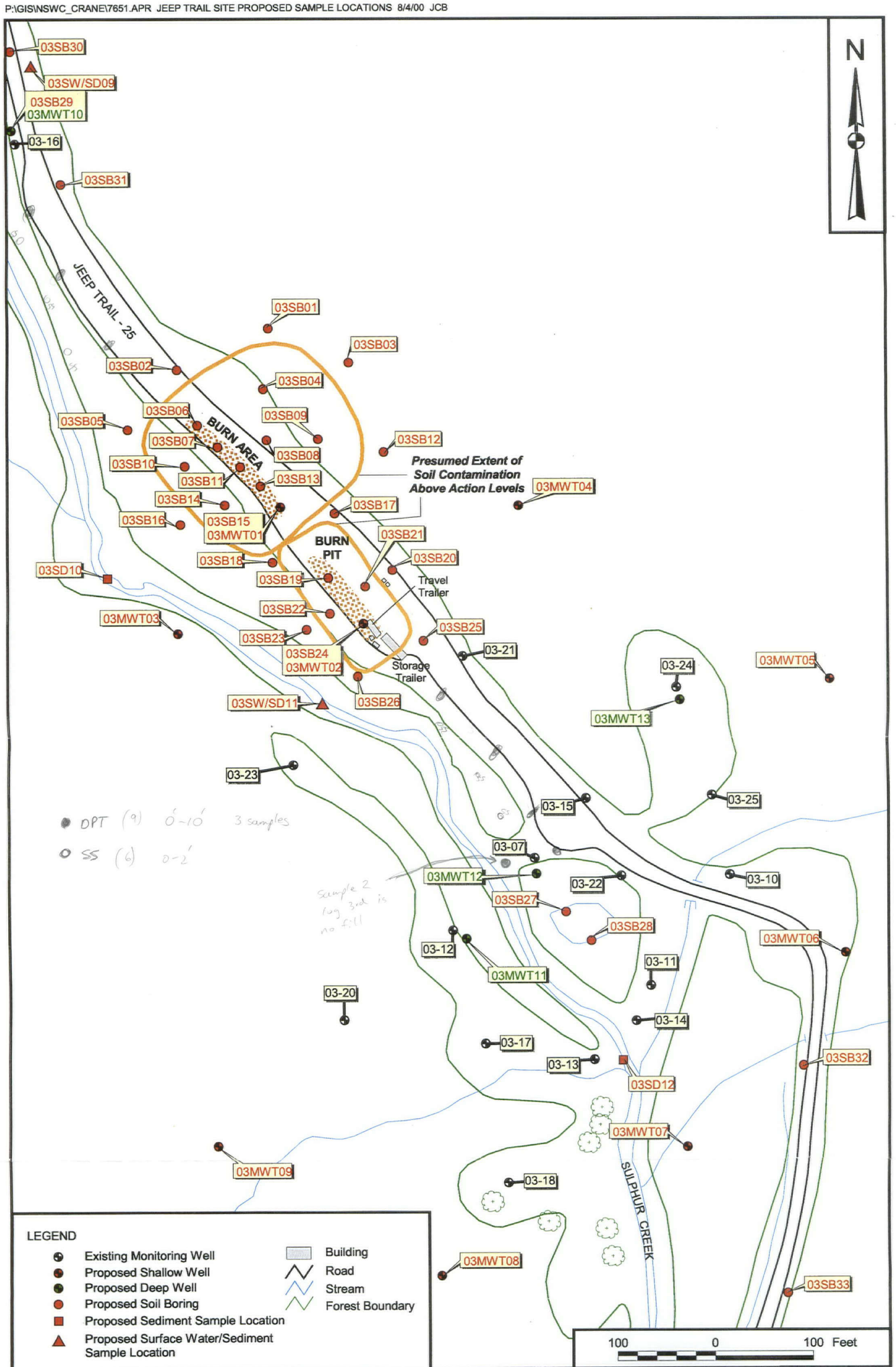
1 HCl = Hydrochloric acid, H_2SO_4 = Sulfuric Acid, HNO_3 = Nitric Acid

2 All holding times are from date of collection.

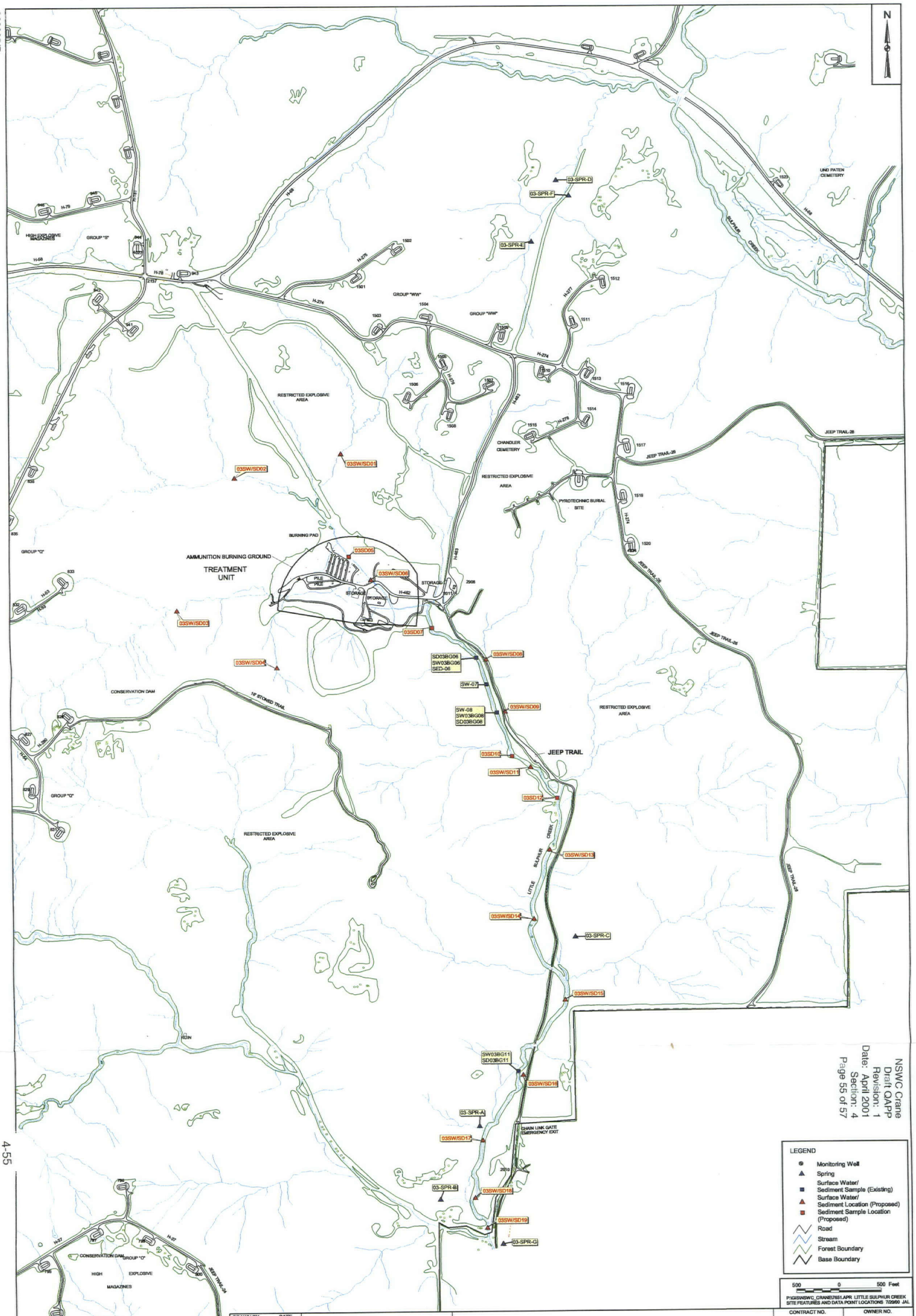
3 Laucks = Laucks Testing Laboratories, Inc.

mL = milliliters

P:\GIS\NSWC_CRANE\7651.APR JEEP TRAIL SITE PROPOSED SAMPLE LOCATIONS 8/4/00 JCB



DRAWN BY J. LAMEY	DATE 7/12/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0514	OWNER NUMBER CTO 126
CHECKED BY —	DATE —	JEEP TRAIL PROPOSED SAMPLE LOCATIONS NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY —	DATE —
COST/SCHEDULE-AREA			APPROVED BY —	DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 4-1	REV 0



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Section: 4
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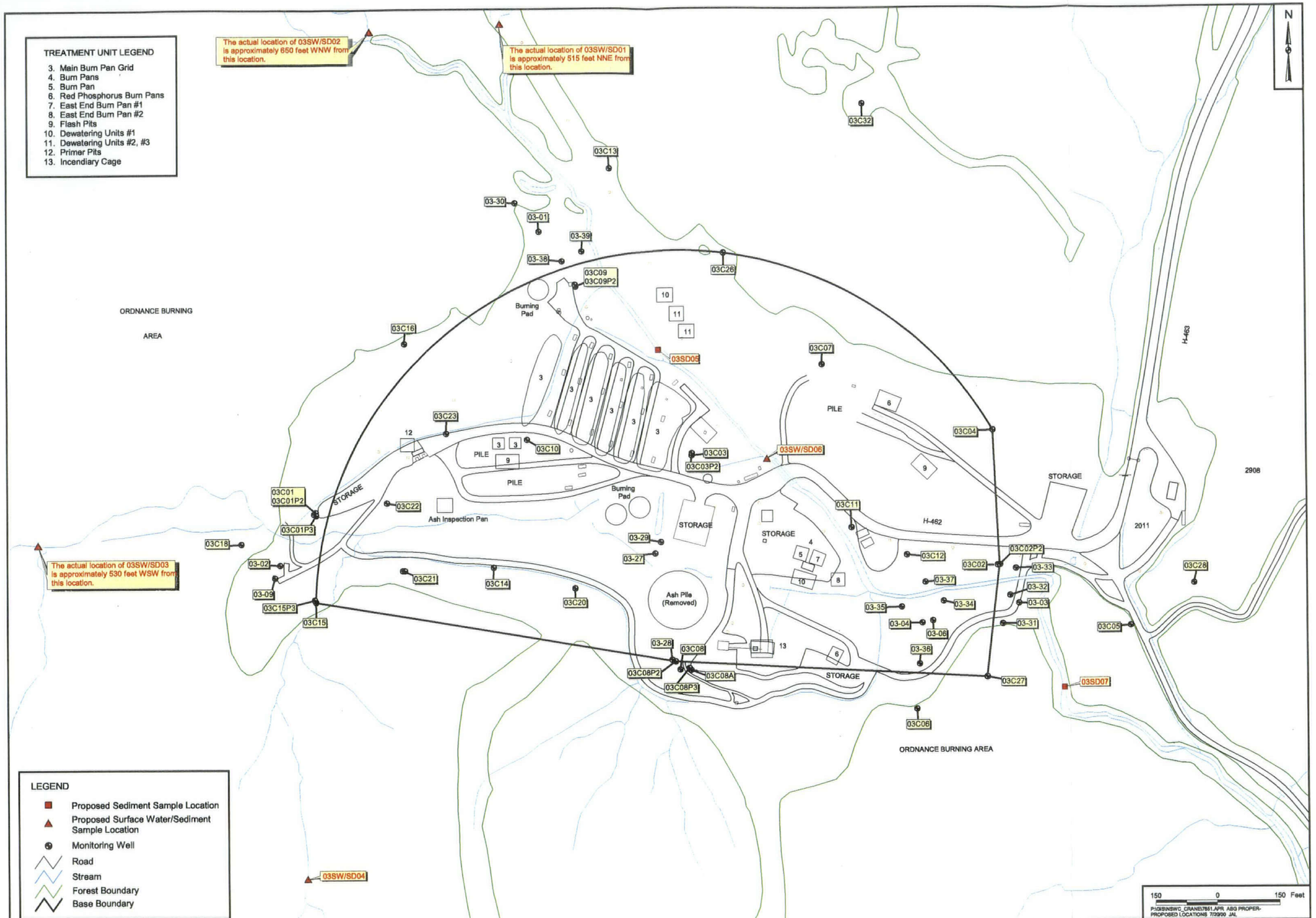
DRAWN BY	DATE
J. LAMEY	6/1/00
CHECKED BY	DATE
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

Tetra Tech NUS, Inc.

LITTLE SULPHUR CREEK PROPOSED SAMPLE LOCATIONS
NAVAL SURFACE WARFACE CENTER
CRANE, INDIANA

CONTRACT NO.	OWNER NO.
0514	CTO 126
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING NO.	REV.
FIGURE 4-2	0



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	NO.	RELEASED FOR	BY	DATE

DRAWN BY J. LAMEY DATE 7/12/00
CHECKED BY DATE
COST/SCHEDULE-AREA
SCALE AS NOTED

Tetra Tech NUS, Inc.

AMMUNITION BURNING GROUND
PROPOSED SAMPLE LOCATIONS
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

CONTRACT NO. 0514
OWNER NO. CTO 126
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 4-3
REV. 0

5.0 CUSTODY PROCEDURES

Documented sample custody is one of several factors necessary for the admissibility of environmental data as evidence in a court of law. Custody procedures help to satisfy the two major requirements for admissibility: relevance and authenticity. Sample custody is addressed in three parts: field sample collection, laboratory analysis, and final evidence files. Final evidence files, including all original laboratory reports and purge files, are maintained under document control in a secure area. A sample or evidence file is under custody when any one of the following conditions is satisfied:

- The item is in the actual physical possession of an authorized person
- The item is in view of the person after being in his or her possession
- The item was placed in a secure area to prevent tampering
- The item is in a designated and identified secure area with access restricted to authorized personnel only

The Chain of Custody (COC) form is a multi-part, standardized form used to summarize and document pertinent sample information such as sample identification and type, sample matrix, date and time of collection, preservation, and requested analyses. Furthermore, through the sequential signatures of various sample custodians (e.g., sampler, airbill number, laboratory sample custodian), the COC form documents sample custody and tracking. Laboratory custody procedures will ensure that sample integrity is not compromised from the time of receipt at the laboratory until final data are reported to TtNUS. This requires that the laboratory control all sample handling and storage conditions and circumstances. Custody procedures apply to all environmental and associated field QC samples obtained as part of the data collection system.

5.1 FIELD CUSTODY PROCEDURES

The FOL (or designee) is responsible for the care and custody of the samples collected until they are relinquished to the laboratory or entrusted to a commercial courier. Together, field logbooks and sample documentation including COC forms provide a record that should allow a technically qualified individual to reconstruct significant field activities without resorting to memory. COC forms are completed to the fullest extent possible for each sample cooler used for shipment. The forms are legibly completed with waterproof ink, and are signed (and dated) by the sampler. COC forms will include the following information: project name, sample number, time collected, matrix, designated analyses, type of sample, preservative, and name of sampler. Pertinent notes or comments, such as positive results during sample

screening, are also indicated on the COC form. An example COC form is included in SOP CTO 126-3 (Appendix H).

Information similar to that contained on the COC form is provided on the sample label, which is securely attached to the sample bottle. In addition, sample tags will be affixed to the sample bottles and returned by the analytical laboratory for inclusion in the final evidence file. Sample labels and tags will include, at a minimum, the following information: sample number, date and time of collection, analysis required for the sample aliquot in the associated sample container, and a space for the laboratory sample number. The procedures for sample numbering by TtNUS are described in SOP CTO 126-2 (Appendix H), and the procedures for sample numbering by Laucks Testing Laboratories, Inc., Triangle Laboratories Inc., and APC Laboratories, Inc., are described in SOPs LTL-4002, Triangle-5.01, and APCL-C-19 (Appendix I).

Site conditions during sampling and the care with which samples are handled may factor into the degree to which samples represent the media from which they are collected. This, in turn, could affect the ability of decision makers to make accurate and timely decisions concerning the contamination status of the site. As appropriate, logbooks are assigned to, and maintained by, key field team personnel. The logbooks are used to record daily conditions/activities such as weather conditions, dates/times of significant events, level of PPE used, boring activities, actual sample collection locations, photographs taken, problems encountered during field activities, chemical screening results, and corrective actions taken to overcome problems. In addition, the names of site visitors and the purposes of their visits shall be recorded. Field logbook assignments shall be recorded in the Site Logbook or other central file whose location is known by the FOL and the TOM. All field logbook assignments, use, control, and archiving are governed by SOP CTO 126-3 (Appendix H). Examples of all forms to be used during sampling activities are also provided in SOP CTO 126-3 (Appendix B). The FOL is responsible for the maintenance and security of all field records at the end of each workday during field activities. At the completion of field activities, the FOL will forward all field records to the TtNUS TOM. All sample records are eventually docketed into the final evidence file.

SOPs CTO 126-5, CTO 126-6, CTO 126-8, CTO 126-19 and CTO 126-20 (Appendix H) describe procedures for sample screening, packaging, and shipment. A temperature blank shall be included in each cooler containing samples for use by the laboratory upon receipt. Each cooler that contains samples to be analyzed for volatile organic compounds shall also include a trip blank. Each cooler shall be taped shut with strapping tape in at least two places to prevent tampering. Custody seals shall be attached as described in SOP CTO 126-3 so that the seals must be broken to open the cooler. Shipment will be made by a public courier at the next scheduled pickup following completion of sample collection.

The following procedures will be used when transferring custody of samples. As previously noted, individual custody records will accompany each sample cooler. The methods of shipment, courier name, and other pertinent information will be entered in the remarks section of the custody record. When transferring samples, the individuals relinquishing and receiving the samples will sign, date, and note the time on the COC form. The original record (top copy of the multi-part form) will accompany the shipment and the field sampler will retain a copy. This record documents the sample custody transfer from the sampler to the laboratory, often through another person or agency (common courier). After COC forms have been placed within sealed shipping coolers, the signed courier airbills will serve to document COC. Upon arrival at the laboratory, internal laboratory sample custody procedures will be followed (see Section 5.2).

5.2 LABORATORY CUSTODY PROCEDURES

When Laucks Testing Laboratories, Inc., Triangle Laboratories, Inc., and APC Laboratories, Inc. receive a shipment of samples, each laboratory's sample custodian will verify that the correct number of coolers has been received. The custodian will examine each cooler's custody seals to verify that they are intact and that the integrity of the environmental samples has been maintained. The custodian will then open each cooler and measure its internal temperature by measuring the temperature of the temperature blank. The temperature reading will be documented in the comments column of the COC form. In addition, Laucks Testing Laboratories, Inc. will record the temperature reading on the Supplemental Sample Receipt Log, Appendix I, SOP LTL-4002. The sample custodian will then sign the COC form and examine the contents of the cooler. Identification of broken sample containers or discrepancies between the COC form and sample labels will be recorded. The laboratory will retain the original field COC forms, providing copies of the forms with the final data package deliverable. All problems or discrepancies noted during this process will be promptly reported to the TtNUS TOM. Samples will be logged into the laboratory information management system. Other pertinent issues relating to laboratory sample custody and tracking are presented in the following laboratory SOPs (Appendix I):

SOP LTL-1002	Document Tracking and Control
SOP LTL-1003	Chain-of-Custody and Documentation Procedures
SOP LTL-1007	Use of Instrument Records and Logbooks
SOP LTL-1013	Preparation, Storage, Shelf Life and Traceability Documentation of Standards and Reference Materials
SOP LTL-1019	Controlling, Maintaining, and Monitoring Laboratory Logbooks
SOP LTL-4002	Electronic Sample Entry and Log-In
Triangle 5.01	Sample Receipt, Identification, Handling and Storage

APCL-C-11	Sample Receipt
APCL-C-12	Sample Lims Login
APCL-C-14	Sample Storage and Sample Tracking

5.3 FINAL EVIDENCE FILES

The Administrative Record at NSWC Crane will be the repository for all documents that constitute evidence relevant to sampling and analysis activities as described in this QAPP. NSWC Crane will be the custodian of the evidence file and will maintain the contents of these files, including all relevant records, reports, logs, field notebooks, pictures, subcontractor reports, and data reviews in a secure, limited-access location and under custody of the NSWC Crane Site Manager. The control file will include at a minimum:

- Field logbooks
- Field data and data deliverables
- Photographs and negatives
- Drawings
- Soil boring logs
- Laboratory data deliverables (including raw data and calibrations)
- Data validation reports
- Data assessment reports
- Progress reports, QA reports, interim project reports, etc.
- All custody documentation (tags, forms, airbills, etc.)

Upon completion of the contract, all files associated with this investigation will be maintained in the Administrative Record at NSWC Crane and will be available for inspection by the regulatory agencies for at least six years. Prior to disposal of all administrative records, the records will be offered to the U.S. EPA.

6.0 CALIBRATION PROCEDURES AND FREQUENCY

All instrumentation used to perform chemical measurements must be properly calibrated prior to use in order to obtain valid and usable results. Instruments used in the field and in the laboratory will be calibrated in accordance with the procedures governing the use of the instruments. Field SOPs are included in Appendix H, and laboratory SOPs are included in Appendix I. For this investigation, field instrument calibration is described in Section 6.1, and laboratory instrument calibration is outlined in Section 6.2.

6.1 FIELD INSTRUMENT CALIBRATION

Various instruments will be required for field measurements during this investigation and include the following:

- Multi-parameter water quality meter
- LaMotte turbidity meter
- Electronic water level meter
- Photoionization detector
- HACH DR-800 colorimeter (or equivalent)

Instruments used in the field will be calibrated in accordance with the procedures outlined in specific SOPs (water quality meter and PID) and the manufacturer's calibration procedures. Calibration of each instrument will be documented on a separate Equipment Calibration Log Form (in SOPs CTO) 126-06 and -14 Appendix H). During calibration, an appropriate maintenance check will be performed on each piece of equipment. If damaged or defective parts are identified during the maintenance check and it is determined that the damage could have an impact on the instrument's performance, the instrument will be removed from service until the defective parts are repaired or replaced. If the instrument cannot be repaired, a replacement will be procured from the supplier.

Calibration of the HACH DR-800 colorimeter (or equivalent) will be accomplished through accuracy checks performed for each required parameter. Accuracy checks include one or more of standard additions, standard solutions, and reagent blank measurements. The purpose of accuracy checks is to check the performance of the reagents, the colorimeter, and the analytical procedure. Information on the type of accuracy check, its associated parameter, and the QC associated with the accuracy check is

included in the test kit used to perform the analysis. Test kits do not require calibration by field personnel. To ensure proper operation, they must be used within the specified holding times.

The electronic water-level meters will be calibrated prior to field use and periodically at the discretion of the FOL. They will be calibrated by comparison of meter markings with a steel tape measure.

6.2 LABORATORY INSTRUMENT CALIBRATION

Calibration procedures for metals analyses by ICP/AES begin with a periodic establishment of the useful linear response range, followed by routine daily calibrations. The daily calibrations consist of at least one blank and one calibration standard, an initial calibration verification, and continuing calibration verification standards/blanks, with each batch of samples analyzed. In all cases, an independently prepared standard (i.e., from a second source or a different lot number from the primary source) will be used as a calibration verification solution or as the MS spiking mix.

Organic chemical analyses begin with an initial calibration of the gas chromatograph (GC), high performance liquid chromatograph (HPLC), or gas chromatograph/mass spectrometer (GC/MS) system with an initial calibration curve that establishes the instrument responses as functions of analyte concentration. The initial calibration curves incorporate a calibration blank and a series of calibration standards for the target analytes and any applicable internal standards or surrogate compounds. On a routine basis, a continuing calibration is performed in which the validity of the calibration curve is checked with a known chemical standard from a source independent of the initial calibration standards. This continuing calibration standard contains the target analytes of interest and any applicable internal standards and surrogate compounds. The internal standards compensate for variations in analytical response that may occur in individual chromatographic analyses. The surrogate compounds provide a means to assess the efficiency of analyte extraction and analysis for each sample.

The miscellaneous parameter analyses (bromide, nitrate, nitrite, and perchlorate) begin with a daily calibration via a number of calibration standards at varying concentrations for each analyte. Once an acceptable calibration linearity is established, an initial calibration verfication will be performed. A continuing calibration verification will be performed at a routine frequency to ensure validity of the calibration curve.

All standards used to calibrate analytical instruments must be obtained from the National Institute of Standards and Technology (NIST) or through a reliable commercial supplier with a proven record for quality standards. All commercially supplied standards will be traceable to NIST reference standards,

where possible, and appropriate pedigree documentation will be obtained from the supplier. In cases where documentation is not available, the laboratory will analyze the standard and compare the results to a U.S. EPA-known or previous NIST-traceable standard.

Calibrations and associated documentation are required for all laboratory instruments. The documentation for calibrations performed in-house shall identify the person performing the calibration, the instrument being calibrated, the standards used for calibration and their concentration values or other pertinent calibration values, the source of the calibration standards, and the date of calibration. Certain instruments (e.g., balances) may be calibrated by a third party. In those cases, the details of calibration as described above and a certification of acceptable performance shall be obtained from the third party. The period during which the calibration is valid may appear in the calibration record or may be governed by the SOP.

Calibration procedures, frequency requirements, acceptance criteria, and conditions that require recalibration are described for each analytical procedure in the applicable laboratory SOPs included in Appendix I.

7.0 ANALYTICAL AND MEASUREMENT PROCEDURES

Field measurements and laboratory analytical procedures are presented in this section.

7.1 FIELD MEASUREMENT PROCEDURES

Chemical/physical parameters to be measured using field instrumentation include pH, specific conductance, temperature, turbidity, nitrate, nitrite, dissolved oxygen, groundwater flow rate, oxidation – reduction potential (ORP), grain size, depositional environment, sample depth, sample location, and water-level elevation. The field target parameters and the rationales for including them in the analysis scheme are presented in Table 1-8 and Table 1-9. Measurement of field parameters is described in detail in Section 4. Calibration of field instruments is discussed in Section 6 and in individual field measurement SOPs (Appendix H).

7.2 LABORATORY ANALYTICAL AND MEASUREMENT PROCEDURES

The laboratory analytical procedures (with the exception of the dioxins/furans and perchlorate) will be performed by Laucks Testing Laboratories, Inc., 940 South Harney Street, Seattle, Washington 98108; (206) 767-5060; FAX (206) 767-5063. Analysis for dioxins/furans will be subcontracted by Laucks to Triangle Laboratories, Inc., 801 Capitola Drive, Durham, NC 27713; (919) 544-5729; FAX (919) 544-5491. The analysis for perchlorate will be performed at Applied P & Ch Laboratory (APC Laboratory), 13760 Magnolia Ave, Chino, CA 91760; (909)-590-1828; FAX (909)-902-1661. All three laboratories have successfully completed the laboratory evaluation process required as part of the NFESC QA Program and described in the Navy Installation Restoration Laboratory Quality Assurance Guide (NFESC, February 1996). Table 7-1 provides a summary of the laboratory analytical methods and associated laboratory SOPs to be used during this investigation. Laboratory SOPs are included in Appendix I of this QAPP.

7.2.1 List of Project Target Compounds and Detection Limits

A list of the laboratory target analytes; project-specific risk-based target levels; and laboratory-specific MDLs (organic compounds and miscellaneous parameters), IDLs (metals), and RLs is provided in Table 1-11. The MDLs shown have been experimentally determined using the procedures described in Section 6.3 of Laucks Testing Laboratories, Inc., SOP LTL-1011 which is included in Appendix I of this QAPP. These procedures are based on the method provided in 40 CFR Part 136 Appendix B (FR, 1984). The IDLs provided for metals have been experimentally determined as described in Section 6.2.6 of Laucks

Testing Laboratories, Inc., SOP LTL-1011. This procedure is based on the procedure for IDL determination as specified in the U.S. EPA Contract Laboratory Program (CLP) (U.S. EPA, 1995). All environmental data will be reported to the analyte's laboratory-specific and matrix specific RL, or MDL or IDL. An analyte's RL is based on the associated MDL/IDL with adjustments made to ensure that the precision and accuracy requirements of the method are attainable. RLs will be adjusted on a sample-by-sample basis, as necessary, based on dilutions, sample volume and, for soil samples, percent moisture.

7.2.2 List of Associated Quality Control Samples

Field and laboratory QC samples to be analyzed in support of this project are identified in Section 8.0. The analytical SOPs included in Appendix I of this QAPP address minimum QC requirements for each associated analytical method. The SOPs include calibration QC requirements. Details on QC sample usage are provided in Section 8.0.

TABLE 7-1

**SUMMARY OF ORGANIC, INORGANIC, AND MISCELLANEOUS ANALYTICAL PROCEDURES
SOLID AND AQUEOUS SAMPLES
NSWC CRANE, CRANE, INDIANA
PAGE 1 OF 3**

Analytical Parameter	Preparation Method	Analytical Method	Preparation/Analytical SOP(s) [1]
Explosive compounds[2]	SW-846[3] 8330	SW-846 8330	Aqueous LTL-3077 / LTL-8330 Solid LTL-3161 / LTL-8330
Nitrocellulose	Modified U.S. Army Corps Method[4]	Modified U.S. Army Corps Method	LTL-9132 / LTL 9125
Metals (As, Ba, Be, Cd, Cr [total], Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn)	Aqueous SW-846 Methods 3010A (**no** HCl) or 3015 (**no** HCl) Solid SW-846 Method 3050B (**no** HCl)	SW-846 Method 6020	Aqueous LTL-7009 or LTL-7010/ LTL-7202 Solid LTL-7012 or LTL-7015/ LTL-7202
Sb and Sn	Aqueous SW-846 Methods 3010A or 3015 (**no** H_2O_2) Solid SW-846 Method 3050B (**no** H_2O_2)	SW-846 Method 6020	Aqueous LTL-7009 or LTL-7010/ LTL-7202 Solid LTL-7012 or LTL-7015/ LTL-7202
Metals (Al, Ca, Fe, Mg, Mn, K, Na)	Aqueous SW-846 Methods 3010A or 3015 Solid SW-846 Method 3050B	SW-846 Method 6010B	Aqueous LTL-7009 or LTL-7010/ LTL-7105 Solid LTL-7012 or LTL-7015/ LTL-7105
Mercury	Aqueous SW-846 Method 7470A Solid SW-846 Method 78471A	Aqueous SW-846 Method 7470A Solid SW-846 Method 7471A	Aqueous LTL-7501 Solid LTL-7501
Appendix IX volatile organic compounds[5] (excluding Acetonitrile, 1,4-Dioxane, Isobutyl alcohol, Propionitrile)	Aqueous SW-846 Method 8260B (25 mL purge) Solid SW-846 Method 8260B (5 g purge)	Aqueous SW-846 Method 8260B (25 mL purge) Solid SW-846 Method 8260B (5 g purge)	Aqueous LTL-8265 (low level) Solid LTL-8265

TABLE 7-1

**SUMMARY OF ORGANIC, INORGANIC, AND MISCELLANEOUS ANALYTICAL PROCEDURES
SOLID AND AQUEOUS SAMPLES
NSWC CRANE, CRANE, INDIANA
PAGE 2 OF 3**

Analytical Parameter	Preparation Method	Analytical Method	Preparation/Analytical SOP(s) [1]
Selected Appendix IX Volatile Organic Compounds - Acetonitrile, 1,4-Dioxane, Isobutyl alcohol, Propionitrile	SW-846 Method 8015B	SW-846 Method 8015B	LTL-8019
Appendix IX Semivolatile Organic Compounds[6] (excluding 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,I)perylene, Benzo(k)fluoranthene, Chrysene, Dibenzo(a,h)anthracene, Fluoranthene, Fluoranthene, Fluorene, Indeno(1,2,3-cd)pyrene, Naphthalene, Phenanthrene, Pyrene)	SW-846 Method 8270C	SW-846 Method 8270C	Aqueous LTL-3000 / LTL-8276 Solid LTL-3100 / LTL-8276
2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,I)perylene, Benzo(k)fluoranthene, Chrysene, Dibenzo(a,h)anthracene, Fluoranthene, Fluoranthene, Fluorene, Indeno(1,2,3-cd)pyrene, Naphthalene, Phenanthrene, Pyrene	SW-846 Methods 8270C-SIM	SW-846 Methods 8270C-SIM	Aqueous LTL-3000 / LTL-8277 Solid LTL-3100 / LTL-8277
Appendix IX Organochlorine Pesticides[7]	SW-846 Method 8081A	SW-846 Method 8081A	Aqueous LTL-3202 / LTL-8084 Solid LTL-3302 / LTL-8084
Appendix IX PCBs[7]	SW-846 Method 8082	SW-846 Method 8082	Aqueous LTL-3202 / LTL-8084 Solid LTL-3302 / LTL-8084

TABLE 7-1

SUMMARY OF ORGANIC, INORGANIC, AND MISCELLANEOUS ANALYTICAL PROCEDURES SOLID AND AQUEOUS SAMPLES NSWC CRANE, CRANE, INDIANA PAGE 3 OF 3

Analytical Parameter	Preparation Method	Analytical Method	Preparation/Analytical SOP(s) [1]
Appendix IX Herbicides[8]	SW-846 Method 8151A	SW-846 Method 8151A	Aqueous LTL-3510 / LTL-8151 Solid LTL-3011 / LTL-8151
Polychlorinated dibenzodioxins and dibenzofurans[9]	SW-846 Method 8290	SW-846 Method 8290	Solid DSP-105/DHR-182
Total Organic Carbon	Aqueous SW-846 9060 Solid Lloyd Kahn	Aqueous SW-846 9060 Solid Lloyd Kahn	Aqueous LTL-9115 Solid LTL-9116
Perchlorate	EPA Method[10] 314.0	EPA Method 314.0	Aqueous G-38
Bromide	SW-846 Method 9056	SW-846 Method 9056	Aqueous LTL-9110
Nitrate	SW-846 Method 9056	SW-846 Method 9056	Aqueous and Solid LTL-9110
Nitrite	SW-846 Method 9056	SW-846 Method 9056	Aqueous and Solid LTL-9110

1 Laboratory SOPs are included in Appendix C of this QAPP.
2 Reference Table 1-11 of Section 1 for the specific of explosive compounds.
3 U.S. EPA, 1986a. Test methods for Evaluating Solid Wastes, Physical/Chemical Methods. SW-846, 3rd Ed. and subsequent updates.
4 Indiana Army Ammunition Plant Contamination Survey. "Nitrocellulose in Water". Aqualab, Inc., 1983.
5 Reference Table 1-11 of Section 1 for the specific volatile organic compounds.
6 Reference Table 1-11 of Section 1 for the specific semivolatile organic compounds.
7 Reference Table 1-11 of Section 1 for the specific pesticides and PCBs compounds.
8 Reference Table 1-11 of Section 1 for the specific herbicide compounds.
9 Reference Table 1-11 of Section 1 for the specific polychlorinated dibenzodioxin and dibenzofuran compounds.
10 U.S. EPA Chemical Analyses of Water and Wastewater

8.0 INTERNAL QUALITY CONTROL CHECKS

Field and laboratory QC samples will be analyzed routinely to evaluate overall data quality. This section provides information regarding those internal QC checks. Laboratory QC samples are addressed in Sections 3.2, 6.0, and 8.2, and Table 3-1 of this QAPP. Section 3.2 addresses field and laboratory QC sample types and level of effort; Section 6.0 addresses instrument calibrations; Section 8.2 addresses non-calibration analytical QC of the laboratories. Table 3-1 summarizes analysis frequencies and associated corrective actions for the routine field and laboratory non-calibration QC samples. Tables 4-3, 4-7, 4-9 and 4-11 of Section 4.0 present the numbers of QC samples that are anticipated to be collected in the field.

8.1 FIELD QUALITY CONTROL CHECKS

TtNUS has established a QC program designed to monitor and assess the quality of field work performed during environmental investigations. That program includes the use of various types of QC samples as indicated in Table 3-1. Some of the samples are identified in Table 3-1 as requiring additional sample material to be collected in the field even though the actual field QC check is performed in the laboratory.

The field QC samples consist of field duplicates, trip blanks, equipment rinsate blanks, source water blanks, temperature blanks, and, at the discretion of the FOL, ambient condition blanks. Temperature blanks will be included in each cooler submitted to the laboratory to monitor sample storage conditions prior to arrival at the laboratory. With the exception of temperature blanks, each type of field QC sample undergoes the same preservation, analysis, and reporting procedures as the related environmental samples. The types of field QC samples to be used for this project are described in detail in Sections 8.1.1 through 8.1.6. Target precision and accuracy values, as applicable, for field QC samples are presented in Table 3-1.

8.1.1 Source Water Blanks

Source water blanks are obtained by sampling the analyte-free water and potable water sources used for decontaminating sampling equipment. Source water blanks are used to determine whether the analyte-free water (used for sampling equipment decontamination procedures) or the potable water (used for steam cleaning) may be contributing to sample contamination.

8.1.2 Field Duplicates

Field duplicates will be collected and analyzed for chemical constituents to measure the cumulative uncertainty (i.e., precision) of the sample collection, splitting, handling, storage, preparation, and analysis operations, as well as natural sample heterogeneity that is not eliminated through simple mixing in the field. Field duplicates are two samples prepared by mixing a volume of sample and splitting it into two separate sample containers that are labeled as individual field samples. Solid field duplicates collected for VOC analysis are not mixed in the field. Two samples are taken in rapid succession from separate, but closely located positions. For ground water and surface water sampling, field duplicates may be generated by collecting individual water samples from the same well or water source in rapid succession rather than splitting a given volume of water. Field duplicates are labeled as individual environmental samples and are not identified to the laboratory as duplicate samples.

8.1.3 Rinsate Blanks

Equipment rinsate blanks or rinsate blanks are obtained under representative field conditions by collecting the rinse water generated by running analyte-free water through sample collection equipment after sampling and decontamination and prior to use. These blanks will be collected to indicate the potential for sample cross-contamination through the use of improperly cleaned sampling equipment.

8.1.4 Trip Blanks

Trip blanks are samples of deionized water that are analyzed for VOCs. These blanks are used to indicate the potential for cross contamination of the samples by VOCs during sample shipment.

8.1.5 Ambient Condition Blanks

Ambient condition blanks are samples of deionized water poured from one container to another in the field to detect the infiltration of airborne contaminants into field samples. These samples will be used at the discretion of the FOL if the FOL believes that such infiltration is a possibility based on site conditions.

8.1.6 Temperature Blanks

Temperature blanks are vials of water inserted into each sample cooler prior to shipment from the field. The temperature of the temperature blank is measured prior to shipment and upon receipt at the laboratory to assess whether samples were properly cooled during transit.

8.2 LABORATORY QUALITY CONTROL CHECKS

Laucks Testing Laboratories Inc., Triangle Laboratories Inc., and APC Laboratory operate QC programs that ensure the reliability and validity of the analyses performed at the laboratory. Each laboratory's QA plan describes the policies, organization, objectives, QC activities, and specific QA functions used by that laboratory. All analytical procedures are documented as SOPs. Each analytical SOP specifies minimum QC requirements for the procedure. As previously noted, SOPs for all analyses to be performed during this investigation are included in Appendix I of this QAPP. Table 7-1 lists the SOPs associated with each analytical procedure. In addition, the laboratories maintain SOPs regarding general laboratory QA operations. Several of these SOPs, as applicable, are also included in Appendix I. The Table of Contents included in Appendix I lists titles and corresponding numbers for all laboratory SOPs contained in the appendix.

Internal laboratory analytical QC requirements beyond those used for instrument calibration QC are highlighted in the remainder of this section. Additional QC requirements, specific to the NFESC QA Program, are also specified, as applicable, for each of the QC checks. Target precision and accuracy values (control limits) are presented in Tables 3-2 through 3-17. The applicable analytical SOPs should be consulted for calibration QC measures.

8.2.1 Laboratory Control Samples

LCSs provide a means to monitor the overall performance of each step during the analysis, including the sample preparation. These are solid samples (soil and sediment analyses) or blank spikes (water analyses) that contain concentrations of analytes that are known with a specified degree of certainty.

Based on the requirements of the NFESC QA program, LCSs for metals analyses must contain all analytes of interest, whereas LCSs for multiple-analyte organic methods must contain at least two targeted analytes from each major class of compounds subject to analysis. Target analytes for LCSs are listed in Tables 3-3, 3-5, 3-7, 3-9, 3-11, 3-13, 3-15, and 3-17.

Based on NFESC QA program requirements, if recovery of an LCS falls outside the control limits (see Tables 3-3, 3-5, 3-7, 3-9, 3-11, 3-13, 3-15, and 3-17), the laboratory will reject the data for the analytical batch and take corrective action. The associated samples, extracts, or digestates may be reanalyzed a single time, and if the LCS recoveries meet acceptance criteria, the data will be reported. If LCS analyte recovery is still outside the acceptance limits, the associated samples in the preparation batch will be reprocessed, if sufficient sample is available and holding times have not lapsed. If re-preparation or

reanalysis is not possible, the data will be flagged and the sample delivery group (SDG) narrative will include details of the failed LCS.

8.2.2 Laboratory Duplicates

Laboratory duplicates will be analyzed for metals and miscellaneous parameters (TOC and pH) to measure the cumulative uncertainty (i.e., precision) of the sample handling, subsampling, preparation, laboratory storage, and analysis operations within the laboratory, as well as sample heterogeneity that is not eliminated through simple mixing in the laboratory. Laboratory duplicates are two subsamples obtained by the laboratory analyst after mixing the sample. If chemical analysis RPD values exceed QC limits for laboratory duplicates (Tables 3-4 and 3-16), the analytical process will be investigated to assess whether the observed RPD is an indication of a deficient analytical system or of excess sample heterogeneity.

8.2.3 Internal Standards

Internal standards are added to each sample analyzed by GC/MS to ensure that the analysis sensitivity and response are stable during every analytical run. Internal standard area counts for samples and blanks must not vary by more than a factor of two (- 50% to + 100%) from the associated 12-hour calibration standard except for dioxin/furan analyses. In the dioxin/furan analyses, the internal standards are added to the sample prior to extraction. Therefore, dioxin internal standards measure extraction efficiency and must recover within the control limits of 40% and 135%.

8.2.4 Laboratory Method Blanks

Laboratory method blanks or preparation blanks are an analyte-free matrix prepared and analyzed in accordance with the analytical method employed to determine whether contaminants originating from laboratory sources have been introduced and have affected environmental sample analyses. Analyte-free water is used as a blank for water analyses. A method blank for organic soil sample analysis consists of an aliquot of sand (or in some cases sodium sulfate) that is subjected to the same preparation and analysis as the environmental samples. The solid method blank results are presented on a dry-weight basis assuming 100 percent solids. Native soils devoid of acid leachable metals do not exist. Therefore, a method blank for inorganic soil sample analysis consists of an aliquot of analyte-free water that is subjected to the same preparation and analysis procedures as the environmental samples undergoing analysis. The aqueous results are normalized to a fictitious soil sample and presented on a dry-weight basis assuming 100 percent solids.

Acceptance criteria for laboratory method blanks and corrective actions for non-compliant results are described in the applicable analytical SOPs included in Appendix I. Under no circumstances should laboratory method blank contaminant values be subtracted from environmental sample analytical results.

8.2.5 Matrix Spikes

MSs are environmental samples to which known quantities of analytes are added prior to sample preparation (digestion or extraction). These samples provide information about the heterogeneity of the samples as well as the effect of the sample matrix on the sample digestion and measurement methodology.

Matrix spikes, to conform to NFESC requirements, will contain as many representative analytes as practicable. For many analyses, the spiking list will consist of most or all of the target analytes. For VOC and SVOC analyses, a shortened spiking list will be used (see Tables 3-6 and 3-8).

If the MS recovery is not within applicable control limits (as listed in Tables 3-2, 3-4, 3-6, 3-8, 3-10, 3-12, 3-14, and 3-16), the laboratory will assess the batch to determine whether the spike results are attributable to a matrix effect or are the result of other problems in the analytical process. Based on NFESC requirements, if all the batch QC elements that are not affected by the sample matrix are in control (e.g., method blank, LCS, calibration checks) and if there is no evidence that spiking was not properly performed, the poor spike recovery may be attributed to matrix effects. In this case, the associated data will be flagged, but repreparation and reanalysis will not be required. If any of the batch QC elements which are not affected by the sample matrix are out of control, or if there is any evidence that spiking may have been improperly performed, the MS sample will be reprocessed through the entire analytical sequence. If insufficient sample is available, or if holding times have passed, the laboratory will flag the associated data. Details of noncompliant and laboratory duplicate results will be included in the SDG narrative.

8.2.6 Matrix Spike Duplicates

MSDs are duplicates of matrix spikes and are used for estimating the precision of organic target analyte analyses. They are used in lieu of simple duplicate samples because native environmental samples frequently do not exhibit detectable levels of organic target analytes, which otherwise prevents the calculation of RPD values. Precision criteria for MSDs are presented in Tables 3-2, 3-6, 3-8, 3-10, 3-12, 3-14, and 3-16.

8.2.7 Post Digestion Spikes

PDSs are similar to MSs except that the sample digestate, rather than the original soil sample, is spiked. These spikes are analyzed only for metal target analytes if the matrix spike recovery falls outside control limits. Comparing %Rs for PDSs and MSs helps to identify where in the analytical process accuracy problems are occurring. PDSs will contain all target analytes of interest and will be used to assist in determining whether unacceptable MS recoveries are a result of matrix effects.

8.2.8 Surrogates

Surrogates are organic compounds (typically brominated, fluorinated, or isotopically labeled) that are similar in nature to the compounds of concern and are not likely to be present in environmental media. They are spiked into each sample, standard, and method blank before analysis, and are used in organic chromatographic analytical procedures as a check of method effectiveness. Corrective actions for noncompliant surrogate recoveries are presented in the relevant SOPs included in Appendix I of this QAPP. Details of noncompliant surrogate recoveries will be included in the SDG narrative. Accuracy criteria for surrogates are included in Tables 3-2, 3-6, 3-8, 3-10, 3-12, 3-14, and 3-16.

8.2.9 Additional Laboratory QC Checks

Additional internal laboratory QC checks include mass tuning for GC/MS analysis, second-column confirmation for GC and HPLC analyses, source checks for radiological analyses, etc. Specific QC requirements for each of these QC checks are provided in the applicable SOPs included in Appendix I of this QAPP.

9.0 DATA REDUCTION, VALIDATION, AND REPORTING

This section describes the procedures to be used for data reduction, validation, and reporting. Data generated during the course of the field investigations will be maintained in hard copy form in the Administrative Record at NSWC Crane.

9.1 DATA REDUCTION

9.1.1 Field Data Reduction Procedures

All field logs containing observations will be inspected and approved by the FOL. All field observations will be recorded in the logs immediately after observations are made. No data reduction will be required in the field.

Concentration measurements will be reported in the units indicated in Table 1-4.

If errors are made in recording or transcribing observations, erroneous observations will be legibly crossed out using a single line, initialed, dated by the field member, and corrected in a space adjacent to the crossed-out entry. The FOL is responsible for assuring that errors are identified and assessed relative to the intent of the QAPP.

Errors judged to affect the use of the sample results within the context of this investigation shall be brought to the immediate attention of the TOM.

9.1.2 Laboratory Data Reduction Procedures

Data reduction will be completed by Laucks Testing Laboratories, Inc., Triangle Laboratories, and APC Laboratories, Inc. in accordance with the method-specific laboratory SOPs included in Appendix I. In addition, data are reviewed in accordance with the laboratory QA plans.

Laboratory analytical data will be reported using standard concentration units to ensure comparability with previous analytical results. Ground water and surface water sample results will be reported in units of micrograms per liter (µg/L); soil and sediment sample results will be reported on a dry-weight basis in units of micrograms per kilogram (µg/kg) for organic parameters and milligrams per kilogram (mg/kg) for inorganic parameters.

9.2 DATA VALIDATION

Validation of field measurements and laboratory analytical data are presented in this section.

9.2.1 Procedures Used to Validate Field Data

Field measurements will not be subjected to a formal data validation process. Validation of field data will be limited to real-time inspection by the FOL of observations relative to actual site conditions and activities. In addition, field technicians will ensure that the equipment used for sample collection is performing adequately via compliance with the applicable SOPs.

9.2.2 Procedures Used to Validate Laboratory Data

One hundred percent of the laboratory analytical data will be subjected to data validation to ensure that the data are of evidentiary quality. Validation of analytical data will be completed by the TtNUS Environmental Chemistry/Toxicology Department located in the TtNUS Pittsburgh office. Final review and approval of validation deliverables will be completed by the department's Data Validation Manager. The Data Validation Manager is responsible for ensuring that data validation deliverables are prepared in accordance with the guidance methods specified in this QAPP and are complete and correct.

Prior to statistical analyses, analytical results will be validated *versus* the applicable analytical methods, the SOPs included in Appendix I, and the requirements of this QAPP. Validation of these data will conform to the U.S. EPA Region 5 Standard Operating Procedures for Validation of CLP Inorganic and Organic Data (U.S. EPA, 1993b/c) and the National Functional Guidelines for Inorganic and Organic Data Review (U.S. EPA, 1994a/b) to the greatest extent practicable. Data validators will review the chemical analytical data packages submitted by the laboratory. The data validators will check that the data were obtained using approved methodology, that the appropriate level of QC and reporting was conducted, and that the results are in conformance with QC criteria.

On the basis of the data validation results, the data validator will generate a report describing detected data limitations. The report will be reviewed internally by the Data Validation Manager prior to submittal to the TOM. Data review will be extended beyond this routine validation by involving the project chemist, statistician, and risk assessor, as appropriate, to examine the data for anomalies (See Section 12.4). This additional review may result in more detailed inspections of the data to determine the cause of, and to rectify, individual anomalies. The impact of data qualifiers on data usability will also be assessed, and any qualifications that are indicated during use of the data shall be documented in the RFI report.

The data validation process will provide an estimate of the number of usable data points. This completeness check will be effected by computing the number of data points that are rejected relative to the total number of data points for a given analyte in a given environmental medium. Completeness is addressed in Section 12.3.

9.3 DATA REPORTING

9.3.1 Field Data Reporting

Field data will be transcribed from the site logbook or sample logsheets to the electronic database and will be reviewed for accuracy by an independent reviewer.

All records regarding field measurements (i.e., field logbooks, sampling logbooks, and sample logsheets) will be placed in the TtNUS central files upon completion of the field effort. Entry of these results in the database will require removal of these records from the files. Outcards (date, person, subject matter) will be used to document the removal of any such documentation from the files. After database entry is complete, all records will be copied for placement in the TtNUS central files. All original records will be sent to NSWC Crane for inclusion in the final evidence files, as described in Section 5.3.

9.3.2 Laboratory Data Reporting

To achieve the investigation objectives, a confirmational level of analytical quality is needed. This provides the highest level of data quality necessary to address potential risks. These analyses require full documentation of the chosen analytical methods and sample preparation steps, data packages, and data validation sufficient to provide defensible data. QC must be sufficient to define the overall precision and accuracy of these procedures. Therefore, data reported by Laucks, Triangle Laboratories, and APC Laboratories for all analytical fractions will be in a CLP-like reporting format. Hard-copy data deliverables shall be generated at the time of analysis. All pertinent QC data (including raw data and summary forms for blanks, standards analysis, calibration information, etc.), will be provided for all analyses. Case narratives will be provided for each SDG. SOP LTL-1018 (Appendix I) provides further details regarding the information that will be included in CLP-type packages produced by the laboratories.

Validation will be completed using the hard copy data. After validation the validated data will be reviewed by the Data Validation Manager, and the validation qualifiers will be entered into the electronic database and will be subjected to independent review for accuracy. During this review process, the electronic database printout also will be compared with the hard copy data to ensure that the hard copy data and electronic data are consistent.

9.3.3 Project Reports

With each round of data collection, data will be summarized and assessed to determine whether additional data collection is required for determining the extent of contamination at the Little Sulphur Creek/Jeep Trail site. A Phase III RFI report will be issued summarizing the findings of the investigation when no more data collection is necessary. If detected, the location, concentrations and boundaries of representative contaminants will be described and depicted on summary maps and diagrams, as appropriate. The results of ground water data evaluations used to estimate ground water contaminant concentrations relative to RBTLs and background values at the study areas will be summarized. The evaluation of soil data will also be presented summarizing the measured soil concentrations relative to background soil concentrations and RBTLs. Discussions with U. S. EPA Region 5 concerning the need for future investigations will be summarized, and, if appropriate, recommendations for future investigations will be presented.

Recipients of the Phase III RFI report will include EPA Region 5, IDEM, Navy SOUTHDIV, and NSWC Crane.

9.4 DATA ACQUISITION REQUIREMENTS AND DATA MANAGEMENT

The overall data management scheme and specific requirements for database content, format and integrity are presented in the TtNUS CTO-126 Data Management Plan (Appendix F). A brief summary is presented in the following paragraphs.

Data acquisition and management will begin with the identification and collection of past data and newly acquired project samples. The samples will be labeled and tagged, packaged for shipment, and shipped to the analytical laboratory in accordance with TtNUS SOPs provided in Appendix H. The samples will be received at the laboratory and analyzed, the analytical results will be reported by the analyst along with QC check data, and the data will be reviewed within the laboratory, in accordance with laboratory SOPs provided in Appendix I. Data will then be transmitted from the laboratory in both hardcopy and electronic formats according to laboratory SOPs provided in Appendix I. The data deliverable requirements are specified in TtNUS's basic ordering agreements with analytical laboratories. This agreement requires the analytical laboratory to provide data in both hardcopy and electronic form. Upon receipt by TtNUS, the data will be validated, analyzed, assessed, and ultimately archived.

The electronic database will include pertinent sampling information such as sample number, sampling date, and sample point location, as well as analytical information. Sample-specific MDLs/IDLs/RLs will be reported for nondetected analytes. Units will be clearly summarized in the database and will conform to those identified in Section 9.1.2. The original electronic diskettes and data validation reports for this investigation will be maintained in the Administrative Record at NSWC Crane, and copies will be maintained in TtNUS central files.

10.0 PERFORMANCE AND SYSTEM AUDITS

Performance and system audits will be conducted periodically to ensure that work is being implemented in accordance with the approved QAPP and in an overall satisfactory manner. Some examples of pertinent audits are as follows:

- The FOL will supervise and check daily that the field observations are made accurately, equipment is thoroughly decontaminated, samples are collected and handled properly, and fieldwork is documented accurately and neatly.

- The TOM will maintain contact with the FOL and Data Validation Manager to ensure that management of the acquired data proceeds in an organized and expeditious manner.

Details regarding additional audit responsibilities, frequency, and procedures are provided in the remainder of this section. Field performance and system audits are addressed in Section 10.1. Laboratory performance and system audits are addressed in Section 10.2.

10.1 FIELD PERFORMANCE AND SYSTEM AUDITS

This section presents the responsibilities, frequencies, and procedures associated with internal and external field performance and system audits.

10.1.1 Internal Field Audits

10.1.1.1 Internal Field Audit Responsibilities

In addition to the daily checks performed by the FOL, the TtNUS QAM or designee may conduct an independent performance and system audit of field activities. Such audits are scheduled as part of the NSWC Crane RCRA Environmental Investigation Program, which includes this and other environmental projects. Individual projects are selected for audit by the QAM without the involvement of the TOM. If a formal field audit is conducted for this study, the QAM (or designee) will be responsible for ensuring that sample collection, handling, and shipping protocols, as well as equipment decontamination and field documentation procedures, are being performed in accordance with the approved QAPP and SOPs.

10.1.1.2 Internal Field Audit Frequency

As explained in Section 10.1.1.1, internal field audits are scheduled as part of the NSWC Crane RCRA Environmental Investigation Program, which includes this and other environmental projects. Individual projects are selected for audit by the QAM without the involvement of the TOM.

10.1.1.3 Internal Field Audit Procedure

Internal field audits will be conducted in accordance with the following procedure:

- Prior to an audit, the auditor will prepare a detailed checklist to be used as an auditing guide. An example audit checklist is provided in Appendix G.
- Upon arrival at the audit location, the auditor shall conduct a pre-audit meeting with the responsible management of the organization or project to be reviewed.
- Field audits will include a review of required project documentation (logbooks, sample log sheets, etc.) and field operations (sample COC, sample handling, etc.) to evaluate completeness and compliance with applicable SOPs.
- The audit checklist will be used to record observations including any noted nonconformances.
- A formal post-audit debriefing will be conducted, and potential immediate corrective actions will be discussed.
- The auditor will generate a formal audit report that will address corrective actions. The auditor will provide this report to the TOM.
- The TOM will ensure that all corrective actions are addressed and will provide written verification of corrective action implementation to the auditor.
- The auditor will manage corrective action verification and audit closure.

- The following audit records will be maintained by the QAM:

  - Audit checklists
  - Audit reports
  - Response evaluations
  - Verification of corrective actions
  - Follow-up checklists and audit reports

10.1.2 External Field Audits

10.1.2.1 External Field Audit Responsibilities

IDEM, U.S. EPA Region 5, or both may conduct external field audits.

10.1.2.2 External Field Audit Frequency

External field audits may be conducted at any time during field activities at the discretion of IDEM and U.S. EPA Region 5. If an audit is to be conducted, scheduling should be coordinated through the TtNUS QAM to ensure that personnel and equipment are available as necessary. Personnel being audited may or may not be informed of the impending audit at the discretion and request of the auditing body.

10.1.2.3 Overview of the External Field Audit Process

External audit procedures are at the discretion of U.S. EPA Region 5 and IDEM.

10.2 LABORATORY PERFORMANCE AND SYSTEMS AUDITS

This section presents the responsibilities, frequencies, and procedures associated with internal and external laboratory performance and system audits.

10.2.1 Internal Laboratory Audits

10.2.1.1 Internal Laboratory Audit Responsibilities

The QAO or appropriate designee of the subcontracted laboratory performs routine internal audits of the laboratory. The U.S. Navy, through the NFESC, also conducts internal laboratory audits. TtNUS holds no responsibility for such audits. Performance and system audits of laboratories are coordinated through the NFESC by an independent QA contractor. It is the responsibility of the NFESC and its contractor to

ensure that the subcontracted laboratories comply with good laboratory practices and the general requirements of all analytical services provided by the laboratories.

10.2.1.2 Internal Laboratory Audit Frequency

Internal audits are performed approximately annually at Laucks Testing Laboratories, Triangle Laboratories, and APC Laboratories. In addition, each laboratory department at Laucks Laboratories, Triangle Laboratories, and APC Laboratories analyzes blind performance evaluation (PE) samples as described in their applicable SOPs (Appendix I) and QA plans.

The U.S. Navy completes internal laboratory performance and system audits for each contracted laboratory on an 18-month schedule.

10.2.1.3 Internal Laboratory Audit Procedures

Internal systems audits are conducted to detect any problems in sample flow, analytical procedures, or documentation and to ensure adherence to laboratory SOPs. The internal audit procedures for Laucks Laboratories, Triangle Laboratories, and APC Laboratories are presented in Appendix I.

Internal U.S. Navy laboratory audit procedures, as performed by a Navy contractor, include a pre-screening process that requires review of the laboratory's QA plan, analysis of performance evaluation samples, generation of data deliverables for those samples, an on-site technical systems audit of the laboratory, and satisfactory resolution of all deficiencies and findings.

10.2.2 External Laboratory Audits

10.2.2.1 External Laboratory Audit Responsibilities

IDEM and U.S. EPA Region 5 may perform external audits at their discretion. U.S. EPA Region 5 has recently audited Laucks Testing Laboratories, Inc. for another related U.S. Navy Crane project, and the outcome was favorable. The Triangle and APC Laboratories have not been evaluated by U.S. EPA Region 5.

Laucks is also involved in various other external audits and performance evaluation studies throughout the year, as required, to maintain certifications and approvals by other regulatory agencies or programs.

10.2.2.2 External Laboratory Audit Frequency

U.S. EPA Region 5 or IDEM may conduct an external laboratory audit prior to or during sampling and analysis activities.

10.2.2.3 Overview of the External Laboratory Audit Process

External audit procedures are at the discretion of U.S. EPA Region 5 and IDEM. External laboratory audits may include (but are not limited to) review of laboratory analytical procedures, laboratory on-site audits, and submission of PE samples to the laboratory for analysis.

11.0 PREVENTIVE MAINTENANCE PROCEDURES

Equipment used to collect samples will be maintained in accordance with the manufacturers' operation and maintenance manuals. Equipment and instruments will be calibrated in accordance with the procedures and at the frequencies presented in Section 6.0 (Calibration Procedures and Frequency). Preventive maintenance for field and laboratory equipment is addressed in the remainder of this section.

11.1 FIELD EQUIPMENT PREVENTIVE MAINTENANCE

The TtNUS equipment manager and the equipment operator will be responsible for ensuring that equipment is operating properly prior to use and that routine maintenance is performed and documented. Field measurements of pH, specific conductance, temperature, and turbidity in ground water will be measured using an electronic instrument. Maintenance procedures for the instrument are detailed in SOP CTO 126-14. Any problems encountered while operating the instrument will be recorded in the field logbook, including a description of the symptoms and corrective actions taken. If problems with the equipment are detected and service is required, the equipment will be logged, tagged, and segregated from equipment in proper working order. Use of the equipment will not resume until the problem is corrected.

11.2 LABORATORY INSTRUMENT PREVENTIVE MAINTENANCE

Proper maintenance of laboratory instruments and equipment is essential. Depending on manufacturers' recommendations, maintenance intervals are established for each instrument. All instruments will be labeled with a model number and serial number, and a maintenance logbook will be maintained for each instrument. Personnel will be alert to the maintenance status of the equipment they are using at all times. Table 11-1 provides a summary of preventive maintenance procedures performed by Laucks Testing Laboratories, Triangle Laboratories, and APC Laboratories for key analytical instruments and equipment associated with this project.

The use of manufacturer-recommended grades or better of supporting supplies and reagents is also a form of preventive maintenance. For example, gases used in the ICP instruments are of sufficient grade to minimize fouling of the instrument. The routine use of other supporting supplies from reputable manufacturers will assist in averting unnecessary periods of instrument downtime. An inventory of critical spare parts will also be maintained by the laboratory to minimize instrument downtime.

11.3 INSPECTION/ACCEPTANCE REQUIREMENTS FOR SUPPLIES AND CONSUMABLES

All field equipment shall be inspected prior to use to ensure that necessary parts are available. Most equipment planned for use in this project is simple, with few to no moving parts. Therefore, a visual inspection prior to use shall be sufficient to ensure that the equipment is suitable for use. This visual inspection shall occur during mobilization and during each use by the person using the equipment.

Laboratory inspection and acceptance requirements are provided in the laboratory Quality Assurance Plans. The plans present the following specifications for inspection and acceptance of supplies and consumables:

- Requirements to follow individual SOP specifications for grades of chemicals necessary to achieve acceptable analytical performance. SOPs are required to detail the necessary grade of chemicals, including compressed gases.

- Requirements to obtain primary chemical standards from reliable sources that use calibrated glassware in the preparation of the standards and to maintain all certificates supplied with the standards. Emphasis is on obtaining NIST-traceable standards where possible.

- Storage of chemical standards in accordance with applicable SOPs and in a manner that preserves their integrity.

- Routine monitoring of deionized water and other solvents to ensure that analytical systems, samples, and standards are not contaminated.

- Requirements to record the date received and the date opened on each container of chemical used for analysis.

TABLE 11-1

PREVENTIVE MAINTENANCE FOR SWLO AND THE ECBC LABORATORY ANALYTICAL AND SUPPORT INSTRUMENTS NSWC CRANE, CRANE, INDIANA PAGE 1 OF 2

Instrument	Preventive Maintenance	Maintenance Frequency
HPLC (Laucks)	Change Filter Frits	Monthly
	Change Column Prefilters	As needed
	Change Pump Seals	As needed
GC/MS (Laucks)	Change Pump oil.	Every 6 months
	Change Septum	As needed
	Clean source and rods, check power supplies in QEM box, clean inside and outside of printer, general cleaning of instrument.	As needed
	Service in accordance with manufacturer specifications under the contractor maintenance agreement.	As needed
GC (Laucks)	Change carrier and make-up gas filters	As needed
Triangle	Change trap, clean flame ionization detector (FID) jet, trim column.	As needed
ICP/AES (Laucks)	Service Intercooler.	Annually.
	Rinse and clean nebulizer cap and spray chamber.	Monthly or as needed.
	Clean torch, vacuum filters.	Bi-monthly.
	Profile instrument, examine autosampler tubing and replace as needed.	Daily.
	Empty rinse container, fill rinse water reservoir.	As needed.
Mercury Analyzer (Laucks)	Check and replace pump tubing, check and replace membrane, check and clean windows.	As needed.
Spectro-photometer (Laucks)	Clean sample compartment.	Semi-annually.
	Check wavelength calibration.	Annually.
Ion Chromato-graph (Laucks)	Replace pump seals.	Annually.
	Lubricate analytical pump motor.	Semi-annually
	Check chromatography module and all gas lines for leaks.	Every run
	Clean conductivity detector cell electrodes, check cell calibration.	Monthly
	Replace bed supports, clean columns, clean membrane supressor, replace autosampler pipette tip.	As needed.

TABLE 11-1

PREVENTIVE MAINTENANCE FOR SWLO AND THE ECBC LABORATORY ANALYTICAL AND SUPPORT INSTRUMENTS NSWC CRANE, CRANE, INDIANA PAGE 2 OF 2

Instrument	Preventive Maintenance	Maintenance Frequency
Ion Analyzer (XYZ)	Clean RAS sampler and sample trays	Daily
	Flush manifold	Daily
	Clean proportioning pump rollers	Weekly
	Replace flared tubing	Monthly
	Check / Replace O-Rings	Monthly / As Needed
TOC Analyzer (Laucks)	Replace pump tubing.	Each run.
	Change other tubing, change furnace tubes, change LiOH tube, change tin trap, adjust optical balance, change septum, change permeation dryer tubing	As needed
	Change IR filter screen, change gas tubing	Check monthly.
Refrigerators (Laucks, Triangle, APCL)	Monitor temperature	Daily.
Ovens (Laucks, Triangle,APCL)	Monitor temperature	Daily.
Balances (laucks, triangle, APCL)	Certify Class S weights	Annually.
	Routine service by outside party	Annually.
	Certify and/or service in accordance with the Test, Measurement and Evaluation Division of the Army Calibration System.	Annually.
Thermometers (laucks, triangle, APCL)	Calibrate against NIST thermometer	Annually.
	Recertify NIST Thermometer	Annually.
	Certify and/or service in accordance with the Test, Measurement and Evaluation Division of the Army Calibration System.	Annually.
Micropipets	Check gravimetrically	Monthly.
	Clean o-rings	As needed.

12.0 SPECIFIC ROUTINE PROCEDURES USED TO ASSESS DATA PRECISION, ACCURACY, AND COMPLETENESS

Compliance with quantitative QC objectives for laboratory accuracy and precision as outlined in Tables 3-2 through 3-17 will be evaluated during data validation (Section 9.0). Compliance with completeness objectives for field and laboratory data will be computed. Sections 12.1 and 12.2 present equations to be used for computing accuracy and precision values, respectively. Section 12.3 describes the means and presents the equation for determining completeness. Section 12.4 addresses the overall data assessment process.

In general, data validation requires that data be evaluated batch by batch based on the results of quality indicators for the respective batches. Section 12.4 presents additional data quality considerations to be evaluated after data validation. These considerations are designed to incorporate data quality factors that extend beyond evaluation of the simple quantitative estimators for precision, accuracy, and completeness.

12.1 ACCURACY ASSESSMENT

Sample collection accuracy cannot be evaluated because there is no standard by which to judge such accuracy. Instead of a quantitative evaluation of sample collection accuracy, compliance with field SOPs as described in Appendix H will be the metric. Background comparisons of data generated by similar sampling and analysis methods incorporate similar biases and are expected to be directly comparable without any adjustments or compensations.

Accuracy of chemical analyses will be assessed through the use of surrogate spikes, MSs, PDSs, LCSs, calibration check standards, internal standards, and blanks. Blanks will be used to infer the potential for positive biases because of contamination. To assure the accuracy of the analytical procedures, at least 1 of every 20 environmental samples will be spiked with known amounts of target analytes (i.e., MSs) prior to preparation for analysis. The spiked samples will be analyzed and the concentrations of each target analyte observed in the spiked sample will be compared to the reported value of the analyte in the unspiked sample to determine the %R of the analyte. Control charts are plotted by the laboratory for each target analyte and are kept on matrix- and analyte-specific bases. The %R for a spiked sample is calculated by using the following formula:

$$\%R = \frac{\text{Amount in Spiked Sample} - \text{Amount in Sample}}{\text{Known Amount Added}} \times 100\%$$

As discussed in Section 3.2.3, LCSs and surrogate spikes are also analyzed to assess accuracy. The %R calculation for LCSs and surrogate spikes is as follows:

$$\%R = \frac{\text{Experimental Concentration}}{\text{Certified or Known Concentration}} \times 100\%$$

12.2 PRECISION ASSESSMENT

As presented in Section 3.1.3, laboratory duplicate samples (for inorganic analyses) and MSD samples (for organic analyses) will be prepared and analyzed at a minimum frequency of 1 per every 20 environmental samples per matrix. As described in Section 3.1.2, field duplicate samples also will be collected at a minimum frequency of 1 per 10 environmental samples per matrix. The RPD between a sample or MS (Sample 1) and its duplicate or MSD (Sample 2) is calculated for chemical analyses using to the following formula:

$$RPD = \frac{|\text{Amount in Sample 1} - \text{Amount in Sample 2}|}{0.5\,(\text{Amount in Sample 1} + \text{Amount in Sample 2})} \times 100\%$$

12.3 COMPLETENESS ASSESSMENT

Completeness for this project will be determined based on the number of sample results for each target analyte and each sample type that are usable as determined through data validation and data assessment. Data values rejected during data validation (indicated by an "R" or "UR" flag) will be considered unusable unless additional review and documentation by one or more technical team members demonstrates that the rejection was erroneous. To monitor completeness, the number of usable, valid results for each soil type and analyte will be counted and compared to the completeness objectives in Sections 3.3.2 and 3.3.3.

Percent completeness will be calculated using the following equation:

$$\%\,\text{Completeness} = \frac{(\text{number of valid measurements})}{(\text{number of measurements planned})} \times 100\%$$

Because the many parameters to be measured for this project are interrelated in many different ways, a single completeness criterion cannot be established for the project. Instead, the ability to attain project objectives will be evaluated at the end of each sampling round by how effectively the necessary decisions and data evaluations can be made.

12.4 DATA ASSESSMENT

The assessment of data obtained from this investigation is a critical part of determining the next step in data collection and decision making. It must be determined whether the data are of appropriate type, quality, quantity, and representativeness to support the project objectives. The effect of the loss of data deemed unacceptable for use, for whatever reason, will be evaluated.

12.4.1 Reconciliation with Data Quality Objectives

Field data will be examined immediately after generation for errors. Laboratory data will be examined upon receipt from the laboratory in a cascading series of evaluations. The first step will be a data verification and validation as described in Section 9.0.

After data validation, the data will be reconciled with DQOs to determine whether sufficient data of acceptable quality are available for decisionmaking. In addition to the evaluations described in Sections 12.1 through 12.3, a series of inspections and statistical analyses will be performed to estimate several of the data set characteristics. The statistical evaluations will include simple summary statistics for target analytes, such as the maximum concentration, minimum concentration, number of samples exhibiting no detectable analyte, the number of samples exhibiting detectable analytes, and the proportion of samples with detectable and undetectable analytes. The data will be presented in a tabular format. These inspections and statistical analyses will be designed to:

- Identify deviations, if any, from the field sampling SOPs (inspection).
- Identify deviations, if any, from the laboratory analytical SOPs (inspection).
- Identify deviations, if any, from the QAPP (inspection).

- Identify deviations, if any, from the data validation process (inspection).
- Identify and explain the impacts of elevated MDLs and IDLs (inspection).
- Identify unusable data (i.e., data qualified as "R") (inspection).
- Evaluate project assumptions such as ground water direction (inspection).
- Characterize data set distributions (e.g., Shapiro-Wilk W test) if enough data are available (statistics).
- Identify unanticipated data set characteristics such as a laboratory variance greater than the sampling variance (i.e., ANOVA, *t*-test) if enough data are available (statistics).
- Identify and evaluate potential data outliers (95% confidence goodness-of-fit test on probability plot data). The plotted data will be transformed, if necessary, depending on the observed distribution. (statistics).
- Evaluate adherence to investigation objectives and decision rules (inspection and statistics, as applicable).
- Ensure completion of corrective actions (inspection).
- Evaluate effects of deviations from planned procedures and processes on the interpretation and utility of the data (inspection and statistics, as applicable).
- Identify the existence of remaining data gaps (inspection/statistics).

For statistical comparisons and mathematical manipulations, analytes that are not detected at the applicable sample-specific MDL will be represented by a concentration equal to one-half the sample-specific MDL.

Statistical tests for outlier validity will be based on the Procedural Guidance for Statistically Analyzing Environmental Background Data (NFEC, 1998). Potential outliers will be removed if a review of field and laboratory documents indicates that the results are true outliers. If no identifiable reason for the outlier can be identified, the datum will not be removed from the data set.

If necessary, investigation objectives may be revised in anticipation of additional data collection.

The suitability of any given statistical test will be assessed based on the completeness of the data sets and the conditions observed at the site. For example, when a single data value is available for soils or water samples at a given sampling location, statistical tests cannot be conducted for that individual sampling location. However, pooling of data across sampling locations may be possible and, if logical to do so, may be implemented at the discretion of the TOM. For example, when evaluating COPCs, multiple soil sample results of a given depth and grain size within a depositional environment may be pooled for statistical comparison to the background data set from soil of the same depth, grain size and depositional environment. Statistical testing will generally be conducted at the 5% significance level. Statistical testing at other significance levels may also be warranted to provide perspective on the results of testing a 5% significance. If other significance levels are used, they will be supported with rationales for their use.

13.0 CORRECTIVE ACTION

The TtNUS QA/QC program requires that any and all personnel noting conditions adverse to quality should report these conditions immediately to the TOM and QAM. These parties, in turn, are charged with implementing appropriate corrective action in a timely manner. It is ultimately the responsibility of the QAM to document all findings and corrective actions taken and to monitor the effectiveness of the corrective measures performed. A brief summary of corrective actions for some specific field and laboratory QC check samples is presented in Section 3.0, Table 3-1.

13.1 FIELD CORRECTIVE ACTION

Field nonconformances or conditions adverse to quality must be identified and corrected as quickly as possible so that work integrity or product quality is not compromised. The need for corrective action may arise based on deviations from project plans and procedures, adverse field conditions, or other unforeseen circumstances. Corrective action needs may become apparent during the performance of daily work tasks or as a consequence of internal or external field audits.

Corrective action may include resampling and may involve amending previously approved field procedures. Minor modifications to field activities, such as the collection of additional samples, will be initiated at the discretion of the FOL, subject to on-site approval by NSWC Crane personnel. Major modifications, such as the elimination of a sampling point or other situations that affect compliance with or achievement of DQOs, must be approved and documented via a Field Task Modification Request (FTMR). Approval of the corrective action will be obtained by the U.S. Navy (in conjunction with U.S. EPA Region 5 and IDEM). The FOL is responsible for initiating FTMRs. A FTMR will be prepared for all deviations from the project plan documents, as applicable. An example FTMR is provided in SOP CTO 126-3 (Appendix H). Copies of all FTMRs will be maintained with the on-site project planning documents and will be placed in the final evidence file.

13.2 LABORATORY CORRECTIVE ACTION

In general, laboratory corrective actions are warranted whenever an out-of-control event or potential out-of-control event is noted. The specific corrective action taken depends on the specific analysis and the nature of the event. Generally, the following occurrences alert laboratory personnel that corrective action may be necessary:

- QC data are outside established warning or control limits
- Method blank analyses yield concentrations of target analytes above acceptable levels
- Undesirable trends are detected in spike %Rs or in duplicate RPDs
- There is an unexplained change in compound detection capability
- Inquiries concerning data quality are received
- Deficiencies are detected by laboratory QA staff during audits or from PE sample test results

Specific procedures for laboratory corrective actions are specified in the associated laboratory SOP. Any corrective action taken above the analyst level that cannot be performed immediately at the instrument will be documented. Corrective actions typically are documented for out-of-control situations in accordance with laboratory procedures.

Laboratory corrective actions must be documented and included as part of the final evidence file. The TtNUS TOM will be informed of all major corrective actions that do not bring DQO-related nonconformances into conformance with project DQOs. The TtNUS TOM will advise all levels of project management in accordance with Section 14.0 of this QAPP.

13.3 CORRECTIVE ACTION DURING DATA VALIDATION AND DATA ASSESSMENT

The need for corrective action may become apparent during data validation, interpretation, or presentation activities. Rework (i.e., resampling or reanalysis), a change in work procedures, or additional or refresher training are possible corrective actions relevant to data evaluation activities. The TOM will be responsible for approving the implementation of a corrective action and ensuring that it is documented appropriately. Analytical data may be qualified during data validation to alert data users of the potential that particular analytical results are potentially deficient relative to expected performance standards. Such validation practices are described in Section 9.2. When conducting data assessment for project decisionmaking, a number of situation-dependent qualifications of data or decisions are possible. The number of possible situations or conditions precludes enumeration of all possible corrective actions; however the approach used to identify and impose such qualifications is described in Section 12.4.

14.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

QA reports to management will be provided in four primary formats during the course of this investigation: data validation reports, reports summarizing accomplishments and QA/QC issues during the field investigation, project-wide progress reports, and laboratory QA reports. The report frequencies, content, preparers, and recipients are summarized in Table 14-1.

Data validation reports will address all major and minor laboratory noncompliances as well as noted sample matrix effects. In the event that major problems occur with the analytical laboratory (e.g., repeated or extreme holding time exceedances or calibration noncompliances, etc.), the Data Validation Manager will notify the TOM, QAM, Program Manager, Technical Coordinator, and Laboratory Services Coordinator. Such notifications (if necessary) are typically provided via internal memoranda and are placed in the project file. These reports contain a summary of the noncompliance, a synopsis of the impact on individual projects, and recommendations regarding corrective action and compensation adjustments. Corrective actions for major noncompliances are initiated at the program level.

The FOL will provide the TOM with daily verbal field progress reports during the course of the sampling event. These reports will explain accomplishments, deviations from the QAPP, upcoming activities, and a QA summary. The TOM provides a monthly progress report to the Navy which addresses the project budget, schedule, accomplishments, planned activities, and QA/QC issues and intended corrective actions.

Laucks Testing Laboratories, Triangle Laboratories, and APC Laboratories will provide QA reports to TtNUS if QC limits are updated or if other significant plan deviations resulted from unanticipated circumstances. Because MDLs will be included in the analytical data packages for NSWC Crane samples, it is not necessary for the laboratories to include updated MDLs in their QA reports unless the updates result in MDLs which exceed RBTLs.

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TABLE 14-1

SUMMARY OF REPORTS
NSWC CRANE, CRANE, INDIANA

Report	Content	Preparer	Frequency of Submittal	Recipient(s)
Data Validation Report	All major and minor laboratory noncompliances as well as noted sample matrix effects.	Data Validation Manager or designee	Per SDG	TOM, project file
Major Analysis Problem Identification Report (internal memorandum)	Notification of persistent or major problems with analytical laboratory performance. Summary of the noncompliances, a synopsis of the impact on the project, and recommendations regarding corrective action and compensation adjustments.	Data Validation Manager or designee	When persistent analysis problems are detected	TOM, QAM, Program Manager, Technical Coordinator, Laboratory Services Coordinator, project file
Project Monthly Progress Report	Summary of the project budget, schedule, accomplishments, planned activities, and QA/QC issues and intended corrective actions.	TOM	Monthly for duration of project	Navy, project file
Field Progress Reports	Accomplishments, deviations from the SAP, upcoming activities, and a QA summary.	FOL	Daily, verbal, during the course of sampling	TOM
Laboratory QA Report	Summary of updated QC limits or significant deviations from planned activities/performance.	Laucks, Triangle and APC Laboratories	When QC limits are updated or when other significant plan deviations result from unanticipated circumstances	TtNUS, project file; U.S. EPA Region 5, if changes in RLs/MDLs/IDLs cause them to exceed RBTLs or if QAPP deviations impact DQOs

SDG = Sample Delivery Group
TOM = Task Order Manager
QAM = Quality Assurance Manager
RL = Reporting Limit
FOL = Field Operations Leader
SAP = Sampling and Analysis Plan

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APPENDIX A

HISTORICAL DATA

ANALYTICAL RESULTS FOR GROUND WATER
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03B02	03B02	03B02	03B04	03B04	03B04	03B02	03B02	03B02	03B04	03C02P2
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	AB021A99	AB022A99	AB023A99	AB041A99	AB042A99	AB043A99	ABG03B02GW01	ABG03B02GW01-AVG	ABG03B02GW01-D	ABG03B04GW01	ABG03C02P2GW01
DUPLICATE	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	DUP	AVG	DUP	NORMAL	NORMAL
SAMPLE DATE	3/10/1999	5/18/1999	9/9/1999	2/23/1999	5/17/1999	9/9/1999	11/5/1998	11/5/1998	11/5/1998	11/9/1998	11/9/1998
Volatile Organics (ug/L)											
1,1,1-TRICHLOROETHANE	0.5 U	0.5 UJ	0.5 U	0.5 U	0.5 UJ	0.5 U					
1,1-DICHLOROETHANE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U					
1,1-DICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-DICHLOROETHANE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U					
BENZENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U					
CARBON TETRACHLORIDE	0.5 U	0.3 UJ	0.3 U	0.5 U	0.3 UJ	0.3 U					
CHLOROETHANE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U					
CHLOROFORM	0.5 U	0.3 U	0.3 U	0.5 U	0.3 U	0.3 U					
CIS-1,2-DICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1.7
ETHYLBENZENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U					
METHYLENE CHLORIDE	0.5 U	1 U	1 U	0.5 U	1 U	1 U					
TETRACHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U					
TOLUENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U					
TRANS-1,2-DICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
TRICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	28
VINYL CHLORIDE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
XYLENES, TOTAL	0.5 U	1 U	1 U	0.5 U	1 U	1 U					
Dissolved Gases (ug/L)											
ETHANE	0.081	0.087	0.091	1.494	0.033	0.048	0.092 U	0.085 U	0.078 U	0.033 U	
ETHENE	0.045	0.024	0.028	0.232	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.009	
METHANE	8.426	9.715	7.4	13.569	8.027	7.2	7.723 J	7.2465 J	6.77 J	2.667 U	
Energetics (ug/L)											
1,3,5-TRINITROBENZENE	0.58 U	0.95 UJ	0.3 U	0.94 U	0.52 U	0.64 U	0.53 U	0.965 U	1.4 U	0.42 U	0.48 U
1,3-DINITROBENZENE	0.58 U	0.95 UJ	0.3 U	0.94 U	0.52 U	0.64 U	0.53 U	0.965 U	1.4 U	0.42 U	0.48 U
2,4,6-TRINITROTOLUENE	0.58 U	0.95 UJ	0.3 U	0.94 U	0.52 U	0.64 U	0.53 U	0.965 U	1.4 U	0.42 U	0.48 U
2,4-DIAMINO-6-NITROTOLUENE	0.58 U	0.95 UJ	0.3 U	0.94 U	0.52 U	0.64 U	0.53 U	0.965 U	1.4 U	0.42 U	
2,4-DINITROTOLUENE	0.58 U	0.95 UJ	0.3 U	0.94 U	0.52 U	0.64 U	0.53 U	0.965 U	1.4 U	0.42 U	0.48 U
2,6-DIAMINO-4-NITROTOLUENE	0.58 U	0.95 UJ	0.3 U	0.94 U	0.52 U	0.64 U	0.53 U	0.965 U	1.4 U	0.42 U	
2,6-DINITROTOLUENE	0.58 U	0.95 UJ	0.3 U	0.94 U	0.52 U	0.64 U	0.53 U	0.965 U	1.4 U	0.42 U	0.48 U
2-AMINO-4,6-DINITROTOLUENE	0.58 U	0.95 UJ	0.3 U	0.94 U	0.52 U	0.64 U	0.53 U	0.965 U	1.4 U	0.42 U	0.48 U
2-NITROTOLUENE	0.58 U	0.95 UJ	0.3 U	0.94 U	0.52 U	0.64 U	0.53 U	0.965 U	1.4 U	0.42 U	0.48 U
3,5-DINITROANILINE	0.58 U	0.95 UJ	0.3 U	0.94 U	0.52 U	0.64 U	2.9 U	5.1 U	7.3 U	2.2 U	
3-NITROTOLUENE	0.58 U	0.95 UJ	0.3 U	0.94 U	0.52 U	0.64 U	0.53 U	0.965 U	1.4 U	0.42 U	0.48 U
4,4'-TN-AZOXY	0.58 U	0.95 UJ	0.3 U	0.94 U	0.52 U	0.64 U	0.53 U	0.965 U	1.4 U	0.42 U	
4-AMINO-2,6-DINITROTOLUENE	0.58 U	0.95 UJ	0.3 U	0.94 U	0.52 U	0.64 U	0.53 U	0.965 U	1.4 U	0.42 U	0.48 U
4-NITROTOLUENE	0.58 U	0.95 UJ	0.3 U	0.94 U	0.52 U	0.64 U	0.53 U	0.965 U	1.4 U	0.42 U	0.48 U
HMX	0.58 U	0.95 UJ	0.3 U	0.94 U	0.52 U	0.64 U	0.53 U	0.965 U	1.4 U	0.42 U	28
MNX	0.58 U	0.95 UJ	0.3 U	0.94 U	0.52 U	0.64 U	0.53 U	0.965 U	1.4 U	0.42 U	
NITROBENZENE	0.58 U	0.95 UJ	0.3 U	0.94 U	0.52 U	0.64 U	0.53 U	0.965 U	1.4 U	0.42 U	0.48 U
NITROCELLULOSE	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1100 U
NITROGLYCERIN	5.8 U	9.5 UJ	3 U	9.4 U	5.2 U	6.4 U	5.3 U	9.65 U	14 U	4.2 U	4.8 U

APPENDIX A-1

ANALYTICAL RESULTS FOR GROUND WATER
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03B02	03B02	03B02	03B04	03B04	03B04	03B02	03B02	03B02	03B04	03C02P2
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	AB021A99	AB022A99	AB023A99	AB041A99	AB042A99	AB043A99	ABG03B02GW01	ABG03B02GW01-AVG	ABG03B02GW01-D	ABG03B04GW01	ABG03C02P2GW01
DUPLICATE	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	DUP	AVG	DUP	NORMAL	NORMAL
SAMPLE DATE	3/10/1999	5/18/1999	9/9/1999	2/23/1999	5/17/1999	9/9/1999	11/5/1998	11/5/1998	11/5/1998	11/9/1998	11/9/1998
PENTAERYTHRITOL TETRANITRATE	2.9 U	4.7 UJ	1.5 U	4.6 U	2.6 U	3.1 U	2.6 U	4.65 U	6.7 U	2 U	2.4 U
PICRIC ACID	1.0 UJ	1 U	1 U	1.0 UJ	1 U	1 U	1.1 U	1.15 U	1.2 U	1.0 U	
RDX	0.58 U	0.95 UJ	0.3 U	0.94 U	0.52 U	0.64 U	0.53 U	0.965 U	1.4 U	0.42 U	21
TETRYL	0.58 U	0.95 UJ	0.3 U	0.94 U	0.52 U	0.64 U	0.53 U	0.965 U	1.4 U	0.42 U	0.48 U
TNX	0.58 U	0.95 UJ	0.3 U	0.94 U	0.52 U	0.64 U	0.53 U	0.965 U	1.4 U	0.42 U	
Total Metals (ug/L)											
ANTIMONY	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
ARSENIC	6.7	7.7	10.3	4.1	5.4	6.3	9.8	9.6	9.4	2.4	1.1 U
BARIUM	76.1	82.2	88.0	77.4	83.9	95.0	87.4	86.6	85.8	69.8	96.2
BERYLLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CADMIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CHROMIUM	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U
COBALT	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
COPPER	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
IRON	13500	12900	12100	6160	6850	6790	12400 J	12200 J	12000 J	2890 J	148
LEAD	1.1 U	1.1 U	1.1 UJ	1.1 U	1.1 U	1.1 UJ	1.1 UR	1.1 UR	1.1 UR	1.1 UR	1.1 U
MANGANESE	1430	1240	1210	1650	1700	1760	1340	1305	1270	1070	16.7 U
MERCURY	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.2 U	0.20 U	0.20 U	0.20 U
NICKEL	11.1 U	11.1 U	11.1 U	137	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
SELENIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	2.3
SILVER	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
THALLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
TIN	11.1 U	11.1 U	11.1 U	11.1 UJ	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
VANADIUM	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
ZINC	11.1 U	41.0	11.1 UJ	58.8 J	11.1 U	13.4 J	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
Disolved Metals (ug/L)											
ANTIMONY	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
ARSENIC	6.0	6.8	10.9	3.6	4.1	6.4	10.2	10.1	10.0	2.6	1.1 U
BARIUM	75.2	74.8	91.3	95.9	74.0	107	86.9	88.75	90.6	72.2	94.8
BERYLLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CADMIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CALCIUM	44100	42100	47300	25100	23300	29500	44700	44200	43700	56000	119000
CHROMIUM	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U
COBALT	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
COPPER	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
LEAD	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
MAGNESIUM	6210	7430	5920	3790	3410	4150	6080	6020	5960	10400	17900
MANGANESE	1420	1260	1250	1660	1670	1730	1390	1370	1350	1120	16.7 U
MERCURY	0.20 U	0.20 U	0.2 U	0.20 U	0.20 UJ	0.2 U	0.20 U	0.2 U	0.20 U	0.20 U	0.20 U
NICKEL	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
POTASSIUM	1130	1110 U	1350	1230	1110 U	1110 U	1120	1120	1120	1110 U	2860
SELENIUM	1.1 U	1.1 U	1.1 U	1.1	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	2.1

ANALYTICAL RESULTS FOR GROUND WATER
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03B02	03B02	03B02	03B04	03B04	03B04	03B02	03B02	03B02	03B04	03C02P2
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	AB021A99	AB022A99	AB023A99	AB041A99	AB042A99	AB043A99	ABG03B02GW01	ABG03B02GW01-AVG	ABG03B02GW01-D	ABG03B04GW01	ABG03C02P2GW01
DUPLICATE	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	DUP	AVG	DUP	NORMAL	NORMAL
SAMPLE DATE	3/10/1999	5/18/1999	9/9/1999	2/23/1999	5/17/1999	9/9/1999	11/5/1998	11/5/1998	11/5/1998	11/9/1998	11/9/1998
SILVER	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
SODIUM	9020	9020	9560	5470	5200	5790	10200	10060	9920	4480	33000
THALLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
TIN	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
VANADIUM	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
ZINC	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
Miscellaneous Parameters (mg/L)											
ALKALINITY	148.8	152	129	78.4	75.2	80.8					
ALKALINITY AS CACO3							130 J	125 J	120 J	150 J	220 J
BICARBONATE ALKALINITY	148.8	152	129	74.4	75.2	80.8	130 J	125 J	120 J	150 J	220 J
CARBON DIOXIDE	86	92	120	93.6	62.4	60					
CARBONATE ALKALINITY							2.0 U	2 U	2.0 U	2.0 U	2 U
CARBONATE ALKALINITY - FIELD	0	0	0	0	0	0					
CHLORIDE	3	5 U	4	2	5 U	1	4.0	4	4.0	3.0	
CYANIDE	0.01 U	0.010 U	0.005 U	0.01 U	0.010 U	0.005 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
DISSOLVED OXYGEN - FIELD - HACH (MG/L)	0.41	0	0.2	0	0.49	1.5					
DISSOLVED OXYGEN - FIELD - METER (MG/L)	2.27	0.84	1.10	1.12	0.97	3.11	0.45	0.45		1.34	6.55
FERROUS IRON	3.30	3.3	3.3 >	3.30	3.3	3.3 >					
HYDROXIDE ALKALINITY	0	0	0	0	0	0					
NITRATE	0	0	0	0	0.02	0	0.20 U	0.2 U	0.20 U	0.20 U	3.4
NITRITE	0	0	0	0	0	0	0.10 U	0.1 U	0.10 U	0.10 U	
OXIDATION REDUCTION POTENTIAL MV	-116.9	-125.9	-141.5	-30.4	-81.5	-98	-146.0	-146		-74.6	169.4
PH	7.16	7.21	7.26	6.99	6.98	6.88	7.23	7.23		7.17	6.89
PHOSPHORUS	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.02 U	0.02 U	0.02 U	0.01 U	0.04
SPECIFIC CONDUCTIVITY MS/CM	0.334	0.343	0.373	0.206	0.198	0.215	0.417	0.417		0.446	0.765
SULFATE	26 J	27	28	16	16	17	27.0	26.5	26.0	23.0	58 J
SULFIDE	1 U	1 U	1 UJ	1 U	1 U	1 UJ					
SULFIDE - FIELD	0.06	0.03	0.04	0	0	0.01					
TEMPERATURE C	8.9	12.5	16.5	9.0	12.8	16.05	15	15		14	13.89
TOTAL ORGANIC CARBON	1.4	1.5	5.1 J	1 U	1.1	7.3 J	1.0 UJ	1 UJ	1.0 UJ	1.0 UJ	1.6
TOTAL ORGANIC HALIDES	0.02 U	0.02 U	0.02 U	0.03	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
TURBIDITY NTU	8	8	3.3	2	6	1	0.9	0.9		0	3
WATER LEVEL FT	6.00	5.33	6.51	6.58	6.52	8.03					

APPENDIX A-1

ANALYTICAL RESULTS FOR GROUND WATER
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03C03	03C04	03C07	03C08P2	03C09P2	03C09P2	03C09P2	03C10
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	ABG03C03GW01	ABG03C04GW01	ABG03C07GW01	ABG03C08P2GW01	ABG03C09P2GW01	ABG03C09P2GW01-AVG	ABG03C09P2GW01-D	ABG03C10GW01
DUPLICATE	NORMAL	NORMAL	NORMAL	NORMAL	DUP	AVG	DUP	DUP
SAMPLE DATE	11/6/1998	11/11/1998	11/11/1998	11/10/1998	11/8/1998	11/8/1998	11/8/1998	11/8/1998
Volatile Organics (ug/L)								
1,1,1-TRICHLOROETHANE								
1,1-DICHLOROETHANE								
1,1-DICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-DICHLOROETHANE								
BENZENE								
CARBON TETRACHLORIDE								
CHLOROETHANE								
CHLOROFORM								
CIS-1,2-DICHLOROETHENE	0.5 U	0.5 U	0.5 U	12	0.5 U	0.5 U	0.5 U	0.5 U
ETHYLBENZENE								
METHYLENE CHLORIDE								
TETRACHLOROETHENE								
TOLUENE								
TRANS-1,2-DICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
TRICHLOROETHENE	0.5 U	0.5 U	4.1	59	160 J	155 J	150	59
VINYL CHLORIDE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
XYLENES, TOTAL								
Dissolved Gases (ug/L)								
ETHANE	0.140 J	0.024 U						0.053 U
ETHENE	0.005 U	0.017						0.005 U
METHANE	13.897 J	37.82 J						1.833 U
Energetics (ug/L)								
1,3,5-TRINITROBENZENE	0.78 U	0.71 U	0.65 U	1.2 U	1.2 U	0.89 U	0.58 U	1.4 U
1,3-DINITROBENZENE	0.78 U	0.71 U	0.65 U	1.2 U	1.2 U	0.89 U	0.58 U	1.4 U
2,4,6-TRINITROTOLUENE	0.78 U	0.71 U	0.65 U	1.2 U	1.2 U	0.89 U	0.58 U	1.4 U
2,4-DIAMINO-6-NITROTOLUENE	0.78 U	0.71 U						1.4 U
2,4-DINITROTOLUENE	0.78 U	0.71 U	0.65 U	1.2 U	1.2 U	0.89 U	0.58 U	1.4 U
2,6-DIAMINO-4-NITROTOLUENE	0.78 U	0.71 U						1.4 U
2,6-DINITROTOLUENE	0.78 U	0.71 U	0.65 U	1.2 U	1.2 U	0.94	0.94	1.4 U
2-AMINO-4,6-DINITROTOLUENE	0.78 U	0.71 U	0.65 U	2.1	1.2 U	0.89 U	0.58 U	1.4 U
2-NITROTOLUENE	0.78 U	0.71 U	0.65 U	1.2 U	1.2 U	0.89 U	0.58 U	1.4 U
3,5-DINITROANILINE	4.2 U	3.9 U						7.3 U
3-NITROTOLUENE	0.78 U	0.71 U	0.65 U	1.2 U	1.2 U	0.89 U	0.58 U	1.4 U
4,4'-TN-AZOXY	0.78 U	0.71 U						1.4 U
4-AMINO-2,6-DINITROTOLUENE	0.78 U	0.71 U	0.65 U	3.7 J	1.2 U	0.89 U	0.58 U	1.4 U
4-NITROTOLUENE	0.78 U	0.71 U	0.65 U	1.2 U	1.2 U	0.89 U	0.58 U	1.4 U
HMX	0.78 U	0.71 U	7.3	33	3.8 J	3.8 J	3.8 J	6.3
MNX	0.78 U	0.71 U						2.8
NITROBENZENE	0.78 U	0.71 U	0.65 U	1.2 U	1.2 U	0.89 U	0.58 U	1.4 U
NITROCELLULOSE	1000 U	1200 U	1400 U	1200 U	1300 U	1150 U	1000 U	1000 U
NITROGLYCERIN	7.8 U	7.2 U	6.5 U	12 U	12 U	8.9 U	5.8 U	14 U

ANALYTICAL RESULTS FOR GROUND WATER
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03C03	03C04	03C07	03C08P2	03C09P2	03C09P2	03C09P2	03C10
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	ABG03C03GW01	ABG03C04GW01	ABG03C07GW01	ABG03C08P2GW01	ABG03C09P2GW01	ABG03C09P2GW01-AVG	ABG03C09P2GW01-D	ABG03C10GW01
DUPLICATE	NORMAL	NORMAL	NORMAL	NORMAL	DUP	AVG	DUP	DUP
SAMPLE DATE	11/6/1998	11/11/1998	11/11/1998	11/10/1998	11/8/1998	11/8/1998	11/8/1998	11/8/1998
PENTAERYTHRITOL TETRANITRATE	3.8 U	3.5 U	3.2 U	5.9 U	5.8 U	4.35 U	2.9 U	6.7 U
PICRIC ACID	1.0 U	1 U						1.0 U
RDX	0.78 U	0.71 U	36	100	170	155	140	130
TETRYL	0.78 U	0.71 U	0.65 U	1.2 U	1.2 U	0.89 U	0.58 U	1.4 U
TNX	0.78 U	0.71 U						1.4 U
Total Metals (ug/L)								
ANTIMONY	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
ARSENIC	1.1 U	1.2	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
BARIUM	40.3	41.8	29.0	68.6	15.8	15.05	14.3	42.2
BERYLLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CADMIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CHROMIUM	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U
COBALT	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
COPPER	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
IRON	169 J	531	107	129	477 J	448 J	419 J	207 J
LEAD	1.2 UR	1.1 U	1.1 U	1.1 U	1.1 UR	1.1 UR	1.1 UR	1.1 UR
MANGANESE	16.7 U	334	37.8	16.7 U	72.3	69.05	65.8	16.7 U
MERCURY	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.2 U	0.20 U	0.20 U
NICKEL	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
SELENIUM	1.1 U	3.6	2.0	1.3	1.2	1.3	1.4	2.0
SILVER	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
THALLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
TIN	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
VANADIUM	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
ZINC	11.1 U	11.1 U	11.1 U	11.1 U	20.8	13.175	11.1 U	11.1 U
Disolved Metals (ug/L)								
ANTIMONY	1.1 U		1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
ARSENIC	1.1 U		1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
BARIUM	42.1		29.1	62.9	13.6	13.5	13.4	42.2
BERYLLIUM	1.1 U		1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CADMIUM	1.1 U		1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CALCIUM	1200		102000	123000	76700	80400	84100	93600
CHROMIUM	5.6 U		5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U
COBALT	3.3 U		3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
COPPER	2.2 U		5.4	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
LEAD	1.1 U		1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
MAGNESIUM	1110 U		48700	41900	15200	15550	15900	12000
MANGANESE	16.7 U		34.3	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U
MERCURY	0.20 U		0.20 U	0.20 U	0.20 U	0.2 U	0.20 U	0.20 U
NICKEL	11.1 U		11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
POTASSIUM	1110 U		1740	10400	1200	1230	1260	1110 U
SELENIUM	1.1 U		1.9	1.3	1.1 U	1.1 U	1.1 U	2.0

APPENDIX A-1

ANALYTICAL RESULTS FOR GROUND WATER
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03C03	03C04	03C07	03C08P2	03C09P2	03C09P2	03C09P2	03C10
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	ABG03C03GW01	ABG03C04GW01	ABG03C07GW01	ABG03C08P2GW01	ABG03C09P2GW01	ABG03C09P2GW01-AVG	ABG03C09P2GW01-D	ABG03C10GW01
DUPLICATE	NORMAL	NORMAL	NORMAL	NORMAL	DUP	AVG	DUP	DUP
SAMPLE DATE	11/6/1998	11/11/1998	11/11/1998	11/10/1998	11/8/1998	11/8/1998	11/8/1998	11/8/1998
SILVER	3.3 U		3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
SODIUM	240000		23200	16900	4730	4800	4870	7210
THALLIUM	1.1 U		1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
TIN	11.1 U		11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
VANADIUM	2.2 U		2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
ZINC	11.1 U		11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
Miscellaneous Parameters (mg/L)								
ALKALINITY								
ALKALINITY AS CACO3	370 J	350 J	350 J	340 J	190 J	190 J	190 J	210 J
BICARBONATE ALKALINITY	270 J	350 J	350 J	340 J	190 J	190 J	190 J	210 J
CARBON DIOXIDE								
CARBONATE ALKALINITY	100	2 U	2 U	2 U	2.0 U	2 U	2.0 U	2.0 U
CARBONATE ALKALINITY - FIELD								
CHLORIDE	2.0	7						9.0
CYANIDE	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
DISSOLVED OXYGEN - FIELD - HACH (MG/L)								
DISSOLVED OXYGEN - FIELD - METER (MG/L)	0.29	10.68	4.43	3.15	4.73	4.73		3.76
FERROUS IRON								
HYDROXIDE ALKALINITY								
NITRATE	0.20 U	0.2 U	0.8	2.7 J	4.7	4.7	4.7	2.1
NITRITE	0.10 U	0.1 UR						0.10 U
OXIDATION REDUCTION POTENTIAL MV	-45.2	-30.3	117.2	145.9	245.1	245.1		141.9
PH	9.62	7.27	7.15	7.10	6.80	6.8		6.45
PHOSPHORUS	0.03 U	0.01 U	0.01 U	0.01 U	0.06 J	0.0425 J	0.05 U	0.02 U
SPECIFIC CONDUCTIVITY MS/CM	1.050	1.598	0.874	1.024	0.469	0.469		0.642
SULFATE	400	770 J	78 J	110 J	43.0	43	43.0	56.0
SULFIDE								
SULFIDE - FIELD								
TEMPERATURE C	13.70	11.3	11.2	12.4	13.4	13.4		14.11
TOTAL ORGANIC CARBON	1.0 UJ	1.6	1.0 U	3.7	1.0 UJ	1 UJ	1.0 UJ	1.0 UJ
TOTAL ORGANIC HALIDES	0.02 U	0.02 U	0.05	0.06	0.11	0.1	0.09	0.06
TURBIDITY NTU	5	1	1	0	17	17		2
WATER LEVEL FT								

ANALYTICAL RESULTS FOR GROUND WATER
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03C10	03C10	03C11	03C12	03C15	03C17	03C20	03C25	03C26
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	ABG03C10GW01-AVG	ABG03C10GW01-D	ABG03C11GW01	ABG03C12GW01	ABG03C15GW01	ABG03C17GW01	ABG03C20GW01	ABG03C25GW01	ABG03C26GW01
DUPLICATE	AVG	DUP	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE	11/8/1998	11/8/1998	11/6/1998	11/8/1998	11/10/1998	11/9/1998	11/10/1998	11/7/1998	11/10/1998
Volatile Organics (ug/L)									
1,1,1-TRICHLOROETHANE									
1,1-DICHLOROETHANE									
1,1-DICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-DICHLOROETHANE									
BENZENE									
CARBON TETRACHLORIDE									
CHLOROETHANE									
CHLOROFORM									
CIS-1,2-DICHLOROETHENE	0.5 U	0.5 U	18	0.7 J	0.5 U	0.5 U	59	0.5 U	0.5 U
ETHYLBENZENE									
METHYLENE CHLORIDE									
TETRACHLOROETHENE									
TOLUENE									
TRANS-1,2-DICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	8.8	0.5 U	0.5 U
TRICHLOROETHENE	62.5	66	1500	21	0.5 U	0.5 U	3400	0.5 U	8.1
VINYL CHLORIDE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
XYLENES, TOTAL									
Dissolved Gases (ug/L)									
ETHANE	0.045 U	0.037 U	0.403 J	0.037 U				0.132 J	
ETHENE	0.005 U	0.005 U	0.005 U	0.005 U				0.005 U	
METHANE	1.649 U	1.465 U	2220 J	1.446 U				53.68 J	
Energetics (ug/L)									
1,3,5-TRINITROBENZENE	0.945 U	0.49 U	1.2 U	0.68 U	0.75 U	0.95 U	6.5 J	1.4 U	0.65 U
1,3-DINITROBENZENE	0.945 U	0.49 U	1.2 U	0.68 U	0.75 U	0.95 U	0.39 U	1.4 U	0.65 U
2,4,6-TRINITROTOLUENE	0.945 U	0.49 U	1.2 U	0.68 U	0.75 U	0.95 U	0.54	1.4 U	0.65 U
2,4-DIAMINO-6-NITROTOLUENE	1.4 U	1.4 R	1.2 U	0.68 U				1.4 U	
2,4-DINITROTOLUENE	0.945 U	0.49 U	1.2 U	0.68 U	0.75 U	0.95 U	0.39 U	1.4 U	0.65 U
2,6-DIAMINO-4-NITROTOLUENE	0.945 U	0.49 U	1.2 U	0.68 U				1.4 U	
2,6-DINITROTOLUENE	0.58 J	0.58 J	1.2 U	0.68 U	0.75 U	0.95 U	0.39 U	1.4 U	0.65 U
2-AMINO-4,6-DINITROTOLUENE	0.945 U	0.49 U	1.2 U	0.68 U	0.75 U	0.95 U	12	1.4 U	0.65 U
2-NITROTOLUENE	0.945 U	0.49 U	1.2 U	0.68 U	0.75 U	0.95 U	0.39 U	1.4 U	0.65 U
3,5-DINITROANILINE	5 U	2.7 U	6.7 U	3.6 U				7.3 U	
3-NITROTOLUENE	0.945 U	0.49 U	1.2 U	0.68 U	0.75 U	0.95 U	0.39 U	1.4 U	0.65 U
4,4'-TN-AZOXY	0.945 U	0.49 U	1.2 U	0.68 U				1.4 U	
4-AMINO-2,6-DINITROTOLUENE	1.055 U	0.71 R	1.2 U	0.68 U	0.75 U	0.95 U	17	1.4 U	0.65 U
4-NITROTOLUENE	0.945 U	0.49 U	1.2 U	0.68 U	0.75 U	0.95 U	0.39 U	1.4 U	0.65 U
HMX	6.4	6.5	4.6	35	0.75 U	0.95 U	27	1.4 U	0.65 U
MNX	2.65	2.5	1.2 U	0.68 U				1.4 U	
NITROBENZENE	0.945 U	0.49 U	1.2 U	0.68 U	0.75 U	0.95 U	0.39 U	1.4 U	0.65 U
NITROCELLULOSE	1400 U	1800 U	1000 U	1600 U	1300 U	1000 U	1400 U	1000 U	1100 U
NITROGLYCERIN	9.45 U	4.9 U	12 U	6.8 U	7.5 U	9.5 U	3.9 U	14 U	6.5 U

APPENDIX A-1

ANALYTICAL RESULTS FOR GROUND WATER
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03C10	03C10	03C11	03C12	03C15	03C17	03C20	03C25	03C26
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	ABG03C10GW01-AVG	ABG03C10GW01-D	ABG03C11GW01	ABG03C12GW01	ABG03C15GW01	ABG03C17GW01	ABG03C20GW01	ABG03C25GW01	ABG03C26GW01
DUPLICATE	AVG	DUP	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE	11/8/1998	11/8/1998	11/6/1998	11/8/1998	11/10/1998	11/9/1998	11/10/1998	11/7/1998	11/10/1998
PENTAERYTHRITOL TETRANITRATE	4.55 U	2.4 U	6.1 U	3.3 U	3.7 U	4.7 U	1.9 U	6.7 U	3.2 U
PICRIC ACID	1 U	1.0 U	1.1 U	1.2 U				1.0 U	
RDX	135	140	27	32	0.75 U	0.95 U	190	1.4 U	0.70
TETRYL	0.945 U	0.49 U	1.2 U	0.68 U	0.75 U	0.95 U	0.39 U	1.4 U	0.65 U
TNX	0.57	0.57	1.2 U	0.68 U				1.4 U	
Total Metals (ug/L)									
ANTIMONY	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
ARSENIC	1.1 U	1.1 U	1.1 U	1.1 U	1.2	2.4	1.1 U	1.1 U	1.1 U
BARIUM	42.1	42.0	24.7	90.7	28.4	12.8	30.6	16.8	39.4
BERYLLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CADMIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CHROMIUM	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U
COBALT	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
COPPER	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
IRON	207.5 J	208 J	272 J	120 J	528	1810 J	112	263 J	110
LEAD	1.1 UR	1.1 UR	1.1 UR	1.1 UR	1.1 U	1.1 UR	1.1 U	1.1 UR	1.1 U
MANGANESE	16.7 U	16.7 U	16.7 U	16.7 U	34.7	132	16.7 U	22.3	43.8
MERCURY	0.2 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
NICKEL	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
SELENIUM	1.9	1.8	2.2	1.1 U	1.1	1.1 U	1.2	1.1 U	1.1 U
SILVER	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
THALLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
TIN	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
VANADIUM	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
ZINC	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	16.4
Disolved Metals (ug/L)									
ANTIMONY	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
ARSENIC	1.1 U	1.1 U	1.1 U	1.1 U	1.2	2.2	1.1 U	1.1 U	1.1 U
BARIUM	43.05	43.9	24.3	90.9	27.4	12.9	30.9	16.4	38.6
BERYLLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CADMIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CALCIUM	93600	93600	213000	102000	104000	201000	88400	99600	98500
CHROMIUM	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U
COBALT	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
COPPER	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
LEAD	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
MAGNESIUM	12250	12500	122000	7210	39600	205000	31700	59800	54500
MANGANESE	16.7 U	16.7 U	16.7 U	16.7 U	32.7	137	16.7 U	23.2	54.8
MERCURY	0.2 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
NICKEL	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
POTASSIUM	1110 U	1110 U	2640	1960	1630	3140	1950	2550	1800
SELENIUM	1.8	1.6	2.6	1.1 U	1.1 U	1.1 U	1.2	1.1 U	1.1 U

ANALYTICAL RESULTS FOR GROUND WATER
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03C10	03C10	03C11	03C12	03C15	03C17	03C20	03C25	03C26
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	ABG03C10GW01-AVG	ABG03C10GW01-D	ABG03C11GW01	ABG03C12GW01	ABG03C15GW01	ABG03C17GW01	ABG03C20GW01	ABG03C25GW01	ABG03C26GW01
DUPLICATE	AVG	DUP	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE	11/8/1998	11/8/1998	11/6/1998	11/8/1998	11/10/1998	11/9/1998	11/10/1998	11/7/1998	11/10/1998
SILVER	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
SODIUM	7445	7680	110000	12300	18300	119000	12700	69300	17400
THALLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
TIN	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
VANADIUM	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
ZINC	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
Miscellaneous Parameters (mg/L)									
ALKALINITY									
ALKALINITY AS CACO3	205 J	200 J	320 J	190 J	280 J	420 J	230 J	360 J	360 J
BICARBONATE ALKALINITY	205 J	200 J	320 J	190 J	280 J	420 J	230 J	360 J	360 J
CARBON DIOXIDE									
CARBONATE ALKALINITY	2 U	2.0 U	2.0 U	2.0 U	2 U	2.0 U	2 U	2.0 U	2 U
CARBONATE ALKALINITY - FIELD									
CHLORIDE	9	9.0	43.0	29.0				2.0	
CYANIDE	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
DISSOLVED OXYGEN - FIELD - HACH (MG/L)									
DISSOLVED OXYGEN - FIELD - METER (MG/L)	3.76		7.75	10.12	2.02	2.00	2.46	1.09	2.92
FERROUS IRON									
HYDROXIDE ALKALINITY									
NITRATE	2.1	2.1	1.3	1.5	0.2 U	0.20 U	2.1 J	0.20 U	0.2 U
NITRITE	0.1 U	0.10 U	0.10 U	0.10 U				0.10 U	
OXIDATION REDUCTION POTENTIAL MV	141.9		-49.6	115.0	12.5	-7.7	159.8	-88.0	151.8
PH	6.45		7.19	7.14	7.12	6.98	7.18	7.16	7.09
PHOSPHORUS	0.02 U	0.02 U	0.01 U	0.02 U	0.01	0.01 U	0.01	0.01 U	0.01
SPECIFIC CONDUCTIVITY MS/CM	0.642		2.220	0.850	0.862	2.084	0.626	1.229	0.760
SULFATE	55.5	55.0	740	56.0	140 J	830	91 J	220	89 J
SULFIDE									
SULFIDE - FIELD									
TEMPERATURE C	14.11		12.47	13.0	13.8	12.1	13.40	11.6	15.11
TOTAL ORGANIC CARBON	1 UJ	1.0 UJ	3.2 J	1.0 UJ	1.0 U	1.0 UJ	1.5	1.0 UJ	3.3
TOTAL ORGANIC HALIDES	0.06	0.06	1.1	0.02 U	0.02 U	0.02 U	1.5	0.02 U	0.02 U
TURBIDITY NTU	2		0	0	2	0	1	2.0	0
WATER LEVEL FT									

APPENDIX A-1

ANALYTICAL RESULTS FOR GROUND WATER
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03C27	03C30	03C02P2	03C02P2	03C02P2	03C02P2	03C02P2	03C02P2	03C02P2	03C03	03C03
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	ABG03C27GW01	ABG03C30GW01	AC02P21A99	AC02P22A99	AC02P22A99-AVG	AC02P22A99-D	AC02P23A99	AC02P23A99-AVG	AC02P23A99-D	AC031A99	AC032A99
DUPLICATE	NORMAL	NORMAL	NORMAL	DUP	AVG	DUP	DUP	AVG	DUP	NORMAL	NORMAL
SAMPLE DATE	11/9/1998	11/11/1998	2/26/1999	5/19/1999	5/19/1999	5/19/1999	9/7/1999	9/7/1999	9/7/1999	2/27/1999	5/18/1999
Volatile Organics (ug/L)											
1,1,1-TRICHLOROETHANE										0.5 U	0.5 UJ
1,1-DICHLOROETHANE										0.5 U	0.5 U
1,1-DICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-DICHLOROETHANE										0.5 U	0.5 U
BENZENE										0.5 U	0.5 U
CARBON TETRACHLORIDE										0.5 U	0.3 UJ
CHLOROETHANE										0.5 U	0.5 U
CHLOROFORM										0.5 U	0.3 U
CIS-1,2-DICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
ETHYLBENZENE										0.5 U	0.5 U
METHYLENE CHLORIDE										0.5 U	1 U
TETRACHLOROETHENE										0.5 U	0.5 U
TOLUENE										0.5 U	0.5 U
TRANS-1,2-DICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
TRICHLOROETHENE	4.9	0.5 U	7.7	3.2	3.2	3.2	10	10	10	0.5 U	0.5 U
VINYL CHLORIDE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
XYLENES, TOTAL										0.5 U	1 U
Dissolved Gases (ug/L)											
ETHANE										0.195	0.012
ETHENE										0.042	0.005 U
METHANE										13.376	5.308
Energetics (ug/L)											
1,3,5-TRINITROBENZENE	0.92 U	1.4 U	0.49 U	0.68 U	0.695 U	0.71 U	0.95 U	0.715 U	0.48 U	1.0 U	0.20 U
1,3-DINITROBENZENE	0.92 U	1.4 U	0.49 U	0.68 U	0.695 U	0.71 U	0.95 U	0.715 U	0.48 U	1.0 U	0.20 U
2,4,6-TRINITROTOLUENE	0.92 U	1.4 U	0.49 U	0.68 U	0.695 U	0.71 U	0.95 U	0.715 U	0.48 U	1.0 U	0.20 U
2,4-DIAMINO-6-NITROTOLUENE										1.0 U	0.20 U
2,4-DINITROTOLUENE	0.92 U	1.4 U	0.49 U	0.68 U	0.695 U	0.71 U	0.95 U	0.715 U	0.48 U	1.0 U	0.20 U
2,6-DIAMINO-4-NITROTOLUENE										1.0 U	0.20 U
2,6-DINITROTOLUENE	0.92 U	1.4 U	0.49 U	0.68 U	0.695 U	0.71 U	0.95 U	0.715 U	0.48 U	1.0 U	0.20 U
2-AMINO-4,6-DINITROTOLUENE	0.92 U	1.4 U	0.49 U	0.68 U	0.695 U	0.71 U	0.95 U	0.715 U	0.48 U	1.0 U	0.20 U
2-NITROTOLUENE	0.92 U	1.4 U	0.49 U	0.68 U	0.695 U	0.71 U	0.95 U	0.715 U	0.48 U	1.0 U	0.20 U
3,5-DINITROANILINE										1.0 U	0.20 U
3-NITROTOLUENE	0.92 U	1.4 U	0.49 U	0.68 U	0.695 U	0.71 U	0.95 U	0.715 U	0.48 U	1.0 U	0.20 U
4,4'-TN-AZOXY										1.0 U	0.20 U
4-AMINO-2,6-DINITROTOLUENE	0.92 U	1.4 U	0.49 U	0.68 U	0.695 U	0.71 U	0.95 U	0.715 U	0.48 U	1.0 U	0.20 U
4-NITROTOLUENE	0.92 U	1.4 U	0.49 U	0.68 U	0.695 U	0.71 U	0.95 U	0.715 U	0.48 U	1.0 U	0.20 U
HMX	0.92 U	1.4 U	5.1	9.3	9.2	9.1	29	28	27	1.0 U	0.20 U
MNX										1.0 U	0.20 U
NITROBENZENE	0.92 U	1.4 U	0.49 U	0.68 U	0.695 U	0.71 U	0.95 U	0.715 U	0.48 U	1.0 U	0.20 U
NITROCELLULOSE	1200 U	1100 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U
NITROGLYCERIN	9.2 U	14 U	4.9 U	6.8 U	6.95 U	7.1 U	9.5 U	7.15 U	4.8 U	10 U	1.9 U

ANALYTICAL RESULTS FOR GROUND WATER
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03C27	03C30	03C02P2	03C02P2	03C02P2	03C02P2	03C02P2	03C02P2	03C02P2	03C03	03C03
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	ABG03C27GW01	ABG03C30GW01	AC02P21A99	AC02P22A99	AC02P22A99-AVG	AC02P22A99-D	AC02P23A99	AC02P23A99-AVG	AC02P23A99-D	AC031A99	AC032A99
DUPLICATE	NORMAL	NORMAL	NORMAL	DUP	AVG	DUP	DUP	AVG	DUP	NORMAL	NORMAL
SAMPLE DATE	11/9/1998	11/11/1998	2/26/1999	5/19/1999	5/19/1999	5/19/1999	9/7/1999	9/7/1999	9/7/1999	2/27/1999	5/18/1999
PENTAERYTHRITOL TETRANITRATE	4.5 U	7 U	2.4 U	3.4 U	3.5 U	3.6 U	4.7 U	3.55 U	2.4 U	5.1 U	0.97 U
PICRIC ACID										1.1 UJ	1 U
RDX	0.92 U	1.4 U	2.9	1.9	1.9	1.9	17	16.5	16	1.0 U	0.20 U
TETRYL	0.92 U	1.4 U	0.49 U	0.68 U	0.695 U	0.71 U	0.95 U	0.715 U	0.48 U	1.0 U	0.20 U
TNX										1.0 U	0.20 U
Total Metals (ug/L)											
ANTIMONY	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
ARSENIC	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
BARIUM	34.0	65.1	61.2	85.9	86.1	86.3	105	105	105	38.3	39.0
BERYLLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CADMIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CHROMIUM	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U
COBALT	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
COPPER	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.8	2.2 U
IRON	145	184								111 U	111 U
LEAD	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	4.0 J	2.275 J	1.1 UJ	1.1 U	1.1 U
MANGANESE	16.7 U	48.7	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U
MERCURY	0.20 U	0.20 U	0.20 U	0.20 U	0.2 U	0.20 U	0.20 U	0.2 U	0.20 U	0.20 U	0.20 U
NICKEL	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
SELENIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	3.1	2.55	2.0	1.1 U	1.1 U
SILVER	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
THALLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
TIN	11.1 U	11.1 U	11.1 UJ	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 UJ	11.1 U
VANADIUM	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
ZINC	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	193 J	99.275 J	11.1 UJ	44.2 J	16.0
Disolved Metals (ug/L)											
ANTIMONY	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
ARSENIC	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
BARIUM	32.9	64.6	71.6	76.3	75.95	75.6	105	105	105	47.8	35.4
BERYLLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CADMIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CALCIUM	58400	69400	36600	49000	47650	46300	119000	120500	122000	1140	1110 U
CHROMIUM	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U
COBALT	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
COPPER	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
LEAD	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
MAGNESIUM	3420	38600	8340	9480	9380	9280	17600	17650	17700	1110 U	1110 U
MANGANESE	16.7 U	55.3	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U
MERCURY	0.20 U	0.20 U	0.20 U	0.20 U	0.2 U	0.20 U	0.2 U	0.2 U	0.2 U	0.20 U	0.20 U
NICKEL	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
POTASSIUM	1190	3090	2150	2470	2470	2470	2930	2940	2950	1110 U	1110 U
SELENIUM	1.2	1.1 U	1.6	1.1 U	0.875	1.2	3.3	3.05	2.8	1.1 U	1.1 U

APPENDIX A-1

ANALYTICAL RESULTS FOR GROUND WATER
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03C27	03C30	03C02P2	03C02P2	03C02P2	03C02P2	03C02P2	03C02P2	03C02P2	03C03	03C03
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	ABG03C27GW01	ABG03C30GW01	AC02P21A99	AC02P22A99	AC02P22A99-AVG	AC02P22A99-D	AC02P23A99	AC02P23A99-AVG	AC02P23A99-D	AC031A99	AC032A99
DUPLICATE	NORMAL	NORMAL	NORMAL	DUP	AVG	DUP	DUP	AVG	DUP	NORMAL	NORMAL
SAMPLE DATE	11/9/1998	11/11/1998	2/26/1999	5/19/1999	5/19/1999	5/19/1999	9/7/1999	9/7/1999	9/7/1999	2/27/1999	5/18/1999
SILVER	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
SODIUM	7210	68200	21300	34100	34200	34300	33800	33300	32800	218000	207000
THALLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
TIN	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
VANADIUM	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
ZINC	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	32.2	18.875	11.1 U	11.1 U	11.1 U
Miscellaneous Parameters (mg/L)											
ALKALINITY			80	110	110		235	235		356	373
ALKALINITY AS CACO3	150 J	300 J									
BICARBONATE ALKALINITY	150 J	300 J	80	110	110		235	235		356	373
CARBON DIOXIDE			NA	NA	0		113.8	113.8		64	75
CARBONATE ALKALINITY	2 U	2 U									
CARBONATE ALKALINITY - FIELD			0	0	0		0	0		0	0
CHLORIDE			37	68	69	70	77	75	73	2	5 U
CYANIDE	0.01 U	0.01 U	0.01 U	0.010 U	0.01 U	0.010 U	0.005 U	0.005 U	0.005 U	0.01 U	0.010 U
DISSOLVED OXYGEN - FIELD - HACH (MG/L)			NA	NA	0		9.0	9		0.31	0.74
DISSOLVED OXYGEN - FIELD - METER (MG/L)	13.11	1.06	12.84	13.66	13.66		9.4	9.4		0.65	1.11
FERROUS IRON			NA	NA	0		NA			0.05	0
HYDROXIDE ALKALINITY			0	0	0		0	0		0	0
NITRATE	0.2 U	0.2 U	NA	NA	0		NA			0.207	0.01
NITRITE			NA	NA	0		NA			0.003	0.001
OXIDATION REDUCTION POTENTIAL MV	140.4	-115.1	162.1	142	142		146	146		-5.8	54.1
PH	7.66	8.43	7.04	7.12	7.12		6.73	6.73		9.22	9.24
PHOSPHORUS	0.04	0.02	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
SPECIFIC CONDUCTIVITY MS/CM	0.373	0.730	0.349	0.494	0.494		0.843	0.843		0.887	0.901
SULFATE	8 J	130 J	35	28	28	28	62	61	60	76	88
SULFIDE										1 U	1 U
SULFIDE - FIELD			NA	NA	0		NA			0.04	0
TEMPERATURE C	12.2	12.22	12.0	13.2	13.2		15.8	15.8		13.7	15.7
TOTAL ORGANIC CARBON	1.0 U	1.0 U	1.6	2	2	2	10 J	9.95 J	9.9	1.6	1 U
TOTAL ORGANIC HALIDES	0.02 U	0.02	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
TURBIDITY NTU	8	2	8	7	7		2	2		1	3
WATER LEVEL FT			37.43	37.34	37.34		37.6	37.6		87.77	87.81

ANALYTICAL RESULTS FOR GROUND WATER
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03C03	03C03	03C03	03C04	03C04	03C04	03C07	03C07	03C07	03C08P2	03C08P2	03C08P2	03C09P2
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	AC033A99	AC033A99-AVG	AC033A99-D	AC041A99	AC042A99	AC043A99	AC071A99	AC072A99	AC073A99	AC08P21A99	AC08P22A99	AC08P23A99	AC09P21A99
DUPLICATE	DUP	AVG	DUP	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE	9/11/1999	9/11/1999	9/11/1999	2/27/1999	5/21/1999	9/11/1999	2/26/1999	5/19/1999	9/11/1999	3/12/1999	5/24/1999	9/12/1999	3/1/1999
Volatile Organics (ug/L)													
1,1,1-TRICHLOROETHANE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U							
1,1-DICHLOROETHANE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U							
1,1-DICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-DICHLOROETHANE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U							
BENZENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U							
CARBON TETRACHLORIDE	0.3 U	0.3 U	0.3 U	0.5 U	0.3 U	0.3 U							
CHLOROETHANE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U							
CHLOROFORM	0.3 U	0.3 U	0.3 U	0.5 U	0.3 U	0.3 U							
CIS-1,2-DICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	14	14	14	0.5 U
ETHYLBENZENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U							
METHYLENE CHLORIDE	1 UJ	1 UJ	1 UJ	0.5 U	1 U	1 UJ							
TETRACHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U							
TOLUENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U							
TRANS-1,2-DICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
TRICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.6	0.5 U	4.7	3	4.3	71	61	63	160
VINYL CHLORIDE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
XYLENES, TOTAL	0.5 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U							
Dissolved Gases (ug/L)													
ETHANE	0.005 U	0.005 U	0.005 U	0.069	0.011	0.005 U							
ETHENE	0.005 U	0.005 U	0.005 U	0.027	0.021	0.005 U							
METHANE	0.37	0.34	0.31	8.794	7.51	1.8							
Energetics (ug/L)													
1,3,5-TRINITROBENZENE	0.70 U	0.59 U	0.48 U	0.46 U	1 U	1.5 U	1.2 U	0.64 U	0.23 U	1.2 U	0.44 U	0.79 U	0.44 U
1,3-DINITROBENZENE	0.70 U	0.59 U	0.48 U	0.46 U	1 U	1.5 U	1.2 U	0.64 U	0.23 U	1.2 U	0.44 U	0.79 U	0.44 U
2,4,6-TRINITROTOLUENE	0.70 U	0.59 U	0.48 U	0.46 U	1 U	1.5 U	1.2 U	0.64 U	0.23 U	1.2 U	0.44 U	0.79 U	0.44 U
2,4-DIAMINO-6-NITROTOLUENE	0.70 U	0.59 U	0.48 U	0.46 U	1 U	1.5 U							
2,4-DINITROTOLUENE	0.70 U	0.59 U	0.48 U	0.46 U	1 U	1.5 U	1.2 U	0.64 U	0.23 U	1.2 U	0.44 U	0.79 U	0.44 U
2,6-DIAMINO-4-NITROTOLUENE	0.70 U	0.59 U	0.48 U	0.46 U	1 U	1.5 U							
2,6-DINITROTOLUENE	0.70 U	0.59 U	0.48 U	0.46 U	1 U	1.5 U	1.2 U	0.64 U	0.23 U	1.2 U	0.44 U	0.79 U	0.70 J
2-AMINO-4,6-DINITROTOLUENE	0.70 U	0.59 U	0.48 U	0.46 U	1 U	1.5 U	1.2 U	0.64 U	0.23 U	2.6	2.6	2.1 J	0.44 U
2-NITROTOLUENE	0.70 U	0.59 U	0.48 U	0.46 U	1 U	1.5 U	1.2 U	0.64 U	0.23 U	1.2 U	0.44 U	0.79 U	0.44 U
3,5-DINITROANILINE	0.70 U	0.59 U	0.48 U	0.46 U	1 U	1.5 U							
3-NITROTOLUENE	0.70 U	0.59 U	0.48 U	0.46 U	1 U	1.5 U	1.2 U	0.64 U	0.23 U	1.2 U	0.44 U	0.79 U	0.44 U
4,4'-TN-AZOXY	0.70 U	0.59 U	0.48 U	0.46 U	1 U	1.5 U							
4-AMINO-2,6-DINITROTOLUENE	0.70 U	0.59 U	0.48 U	0.46 U	1 U	1.5 U	1.2 U	0.64 U	0.4 J	4.5	0.44 U	3.9 J	0.44 U
4-NITROTOLUENE	0.70 U	0.59 U	0.48 U	0.46 U	1 U	1.5 U	1.2 U	0.64 U	0.23 U	1.2 U	0.44 U	0.79 U	0.44 U
HMX	0.70 U	0.59 U	0.48 U	0.46 U	1 U	1.5 U	4.4	4.5 J	5.3 J	31	32	31	2.8
MNX	0.70 U	0.59 U	0.48 U	0.46 U	1 U	1.5 U							
NITROBENZENE	0.70 U	0.59 U	0.48 U	0.46 U	1 U	1.5 U	1.2 U	0.64 U	0.23 U	1.2 U	0.44 U	0.79 U	0.44 U
NITROCELLULOSE	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1300	1000 U	1000 U
NITROGLYCERIN	7 U	5.9 U	4.8 U	4.5 U	10 U	15 U	12 U	6.4 U	2.3 U	12 U	4.4 U	7.9 U	4.4 U

APPENDIX A-1

ANALYTICAL RESULTS FOR GROUND WATER
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03C03	03C03	03C03	03C04	03C04	03C04	03C07	03C07	03C07	03C08P2	03C08P2	03C08P2	03C09P2
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	AC033A99	AC033A99-AVG	AC033A99-D	AC041A99	AC042A99	AC043A99	AC071A99	AC072A99	AC073A99	AC08P21A99	AC08P22A99	AC08P23A99	AC09P21A99
DUPLICATE	DUP	AVG	DUP	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE	9/11/1999	9/11/1999	9/11/1999	2/27/1999	5/21/1999	9/11/1999	2/26/1999	5/19/1999	9/11/1999	3/12/1999	5/24/1999	9/12/1999	3/1/1999
PENTAERYTHRITOL TETRANITRATE	3.5 U	2.95 U	2.4 U	2.2 U	5 U	7.4 U	6.1 U	3.2 U	1.2 U	6.1 U	2.2 U	3.9 U	2.2 U
PICRIC ACID	1 U	1 U	1 U	1.1 UJ	1.1 U	1.1 U							
RDX	0.70 U	0.59 U	0.48 U	0.46 U	1 U	1.5 U	23	19	21	110	81	86	130
TETRYL	0.70 U	0.59 U	0.48 U	0.46 U	1 U	1.5 U	1.2 U	0.64 U	0.23 U	1.2 U	0.44 U	0.79 U	0.44 U
TNX	0.70 U	0.59 U	0.48 U	0.46 U	1 U	1.5 U							
Total Metals (ug/L)													
ANTIMONY	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
ARSENIC	1.1 U	1.1 U	1.1 U	1.1 U	1.4	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
BARIUM	42.3	43	43.7	31.4	28.7	30.6	29.6	30.7	31.9	70.2	16.4	81.8	15.4
BERYLLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CADMIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CHROMIUM	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U
COBALT	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
COPPER	2.2 U	3	4.9	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	30.1	18.2	2.2 U	2.2 U	2.2 U
IRON	111 U	111 U	111 U	134	111 U	190							
LEAD	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	8.3	3.1	1.1 U	1.1 U	1.1 U
MANGANESE	16.7 U	16.7 U	16.7 U	76.3	75.3	908	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	59.6
MERCURY	0.2 U	0.2 U	0.2 U	0.20 U	0.20 U	0.2 U	0.20 U	0.20 U	0.2 U	0.20 U	0.20 U	0.2 U	0.20 U
NICKEL	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
SELENIUM	1.1 U	1.1 U	1.1 U	2.1	3.8	2.3	1.9	2.1	1.8	2.6	1.1 U	2.6	2.1
SILVER	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
THALLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
TIN	11.1 U	11.1 U	11.1 U	11.1 UJ	11.1 U	11.1 U	11.1 UJ	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
VANADIUM	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
ZINC	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	33.9	11.1 U	11.1 U	11.1 U	11.1 U
Disolved Metals (ug/L)													
ANTIMONY	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
ARSENIC	1.1 U	1.1 U	1.1 U	1.6	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
BARIUM	49.7	47.35	45	49	29.2	31.7	41	26.0	32.9	63.1	62.9	89.6	13.4
BERYLLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CADMIUM	1.1 U	1.1 U	1.1 U	1.1 U	2.6	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CALCIUM	1430	1450	1470	149000	139000	147000	100000	92200	97100	112000	119000	119000	81300
CHROMIUM	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	7.6	5.6 U	5.6 U	5.6 U	5.6 U
COBALT	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
COPPER	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	4.2 J	2.2 U	2.2 U	2.2 U	2.2 U
LEAD	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
MAGNESIUM	1110 U	1110 U	1110 U	199000	191000	193000	48500	46600	46000	39700	39300	41300	15700
MANGANESE	16.7 U	16.7 U	16.7 U	665	70.6	102	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U
MERCURY	0.2 U	0.2 U	0.2 U	0.20 U	0.20 U	0.2 U	0.20 U	0.20 U	0.2 U	0.20 U	0.20 U	0.2 U	0.20 U
NICKEL	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	24	11.1 U	11.1 U	13.1	11.1 U	11.1 U	15.6	11.1 U
POTASSIUM	1190	1245	1300	3690	3010	3220	5160	4710	3500	30800	15200	26800	1290
SELENIUM	1.1 U	1.1 U	1.1 U	2.2	2.4	2.6	2.3	1.7	2	2.2	1.1	1.8	2.2

ANALYTICAL RESULTS FOR GROUND WATER
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03C03	03C03	03C03	03C04	03C04	03C04	03C07	03C07	03C07	03C08P2	03C08P2	03C08P2	03C09P2
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	AC033A99	AC033A99-AVG	AC033A99-D	AC041A99	AC042A99	AC043A99	AC071A99	AC072A99	AC073A99	AC08P21A99	AC08P22A99	AC08P23A99	AC09P21A99
DUPLICATE	DUP	AVG	DUP	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE	9/11/1999	9/11/1999	9/11/1999	2/27/1999	5/21/1999	9/11/1999	2/26/1999	5/19/1999	9/11/1999	3/12/1999	5/24/1999	9/12/1999	3/1/1999
SILVER	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
SODIUM	221000	228000	235000	63900	48800	51100	23800	22500	22400	19700	14400	19000	4790
THALLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
TIN	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
VANADIUM	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
ZINC	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
Miscellaneous Parameters (mg/L)													
ALKALINITY	338	342.5	347	366	344	343	346	330	295	323	356	290	196
ALKALINITY AS CACO3													
BICARBONATE ALKALINITY	338	342.5	347	NA	344	343	346	330	295	323	356	290	196
CARBON DIOXIDE	33.0	33.55	34.1	250	208	106	NA	NA	NA	NA	NA	NA	NA
CARBONATE ALKALINITY													
CARBONATE ALKALINITY - FIELD	0	0	0	NA	0	0	0	0	0	0	0	0	0
CHLORIDE	1	1	1	7	6	6	9	9	8	12	13	13	5
CYANIDE	0.005	0.00375	0.005 U	0.01 U	0.010 U	0.005 U	0.01 U	0.010 U	0.005 U	0.01 U	0.010 U	0.005 U	0.01 U
DISSOLVED OXYGEN - FIELD - HACH (MG/L)	0.15	0.15	0.15	2.51	1.8	2	NA	NA	NA	NA	NA	NA	NA
DISSOLVED OXYGEN - FIELD - METER (MG/L)	3.15	3.15	3.15	13.38	2.6	6.57	6.97	2.02	3.82	10.94	6.74	7.01	8.01
FERROUS IRON	0	0	0	1.09	0.04	0.03	NA	NA	NA	NA	NA	NA	NA
HYDROXIDE ALKALINITY	0	0	0	NA	0	0	0	0	0	0	0	0	0
NITRATE	0.05	0.05	0.05	0	0.124	0.02	NA	NA	NA	NA	NA	NA	NA
NITRITE	0	0.0025	0.005	0	0.006	0	NA	NA	NA	NA	NA	NA	NA
OXIDATION REDUCTION POTENTIAL MV	2	1		-18.2	-35.7	-3	117.9	183.2	107.5	165.3	169	93	165.6
PH	9.21	4.605		7.28	7.26	7.18	7.16	7.28	7.24	7.22	7.34	7.22	6.87
PHOSPHORUS	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
SPECIFIC CONDUCTIVITY MS/CM	0.903	0.4515		1.92	1.657	1.884	0.789	0.846	0.87	0.937	0.875	0.829	0.492
SULFATE	83	84.5	86	950	830	810	86	98	92	120 J	130	130	43 J
SULFIDE	1 UJ	1 UJ	1 UJ	1 U	1 U	1 UJ							
SULFIDE - FIELD	0.01	0.005	0	0	0.02	0	NA	NA	NA	NA	NA	NA	NA
TEMPERATURE C	15.5	7.75		8.2	18.05	18.9	12.4	18.3	23.33	10.0	16.4	21.5	13.0
TOTAL ORGANIC CARBON	7.7 J	8.3 J	8.9 J	1.6	1 U	7.8 J	1.9	1 U	8 J	2	1.4	7.4 J	2.6
TOTAL ORGANIC HALIDES	0.04	0.025	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02	0.06	0.04	0.05	0.13
TURBIDITY NTU	1	0.5		3	5	2	8	4	0	0	1	2	8
WATER LEVEL FT	88.0	44		76.10	76.14	76.13	78.80	78.99	78.76	74.78	74.88	74.7	45.45

APPENDIX A-1

ANALYTICAL RESULTS FOR GROUND WATER
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03C09P2	03C09P2	03C10	03C10	03C10	03C11	03C11	03C11	03C11	03C11	03C12	03C12	03C12	03C15
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	AC09P22A99	AC09P23A99	AC101A99	AC102A99	AC103A99	AC111A99	AC111A99-AVG	AC111A99-D	AC112A99	AC113A99	AC121A99	AC122A99	AC123A99	AC151A99
DUPLICATE	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	DUP	AVG	DUP	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE	5/19/1999	9/11/1999	2/25/1999	5/22/1999	9/8/1999	2/25/1999	2/25/1999	2/25/1999	5/21/1999	9/10/1999	2/25/1999	5/22/1999	9/8/1999	3/1/1999
Volatile Organics (ug/L)														
1,1,1-TRICHLOROETHANE			0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	
1,1-DICHLOROETHANE			0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	
1,1-DICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-DICHLOROETHANE			29	23	25	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	
BENZENE			0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	
CARBON TETRACHLORIDE			1.6	1.2	1.4	0.5 U	0.5 U	0.5 U	0.3 U	0.3 U	0.5 U	0.3 U	0.3 U	
CHLOROETHANE			0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	
CHLOROFORM			2.2	1.9	1.9	2	2	2	1.4	2.1	0.5 U	0.3 U	0.3 U	
CIS-1,2-DICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	13	13	13	120	8.9	0.7	0.5 U	0.5 U	0.5 U
ETHYLBENZENE			0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	
METHYLENE CHLORIDE			0.5 U	1 U	1 U	0.5 U	0.5 U	0.5 U	1 U	1 UJ	0.5 U	1 U	1 U	
TETRACHLOROETHENE			0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	
TOLUENE			0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	
TRANS-1,2-DICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
TRICHLOROETHENE	150	170	63	63	61	2100	2100	2100	760	2300	22	19	21	0.5 U
VINYL CHLORIDE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	8	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
XYLENES, TOTAL			0.5 U	1 U	1 U	0.5 U	0.5 U	0.5 U	1 U	1 U	0.5 U	1 U	1 U	
Dissolved Gases (ug/L)														
ETHANE			0.274	0.012	0.005 U	0.372	0.3225	0.273	0.632	0.005 U	0.163	0.012	0.005 U	
ETHENE			0.054	0.005 U	0.005 U	0.057	0.048	0.039	0.07	0.005 U	0.03	0.005 U	0.005 U	
METHANE			1.798	1.352	0.095	800	730	660	5320	0.051	0.912	0.722	0.08	
Energetics (ug/L)														
1,3,5-TRINITROBENZENE	0.75 U	0.31 U	1.5 U	0.65 U	0.49 U	1.0 U	1.05 U	1.1 U	0.71 U	0.51 U	0.74 U	0.30 U	0.75 U	0.49 U
1,3-DINITROBENZENE	0.75 U	0.31 U	1.5 U	0.65 U	0.49 U	1.0 U	1.05 U	1.1 U	0.71 U	0.51 U	0.74 U	0.30 U	0.75 U	0.49 U
2,4,6-TRINITROTOLUENE	0.75 U	0.31 U	1.5 U	0.65 U	0.49 U	1.0 U	1.05 U	1.1 U	0.71 U	0.51 U	0.74 U	0.30 U	0.75 U	0.49 U
2,4-DIAMINO-6-NITROTOLUENE			1.5 U	0.65 U	0.49 U	1.0 U	1.05 U	1.1 U	0.71 U	0.51 U	0.74 U	0.30 U	0.75 U	
2,4-DINITROTOLUENE.	0.75 U	0.31 U	1.5 U	0.65 U	0.49 U	1.0 U	1.05 U	1.1 U	0.71 U	0.51 U	0.74 U	0.30 U	0.75 U	0.49 U
2,6-DIAMINO-4-NITROTOLUENE			1.5 U	0.65 U	0.49 U	1.0 U	1.05 U	1.1 U	0.71 U	0.51 U	0.74 U	0.30 U	0.75 U	
2,6-DINITROTOLUENE	0.75 U	0.94	1.5 U	0.65 U	0.58 J	1.0 U	1.05 U	1.1 U	0.71 U	0.51 U	0.74 U	0.30 U	0.75 U	0.49 U
2-AMINO-4,6-DINITROTOLUENE	0.75 U	0.31 U	1.5 U	0.65 U	0.49 U	1.0 U	1.05 U	1.1 U	0.71 U	0.51 U	0.74 U	0.30 U	0.75 U	0.49 U
2-NITROTOLUENE	0.75 U	0.31 U	1.5 U	0.65 U	0.49 U	1.0 U	1.05 U	1.1 U	0.71 U	0.51 U	0.74 U	0.30 U	0.75 U	0.49 U
3,5-DINITROANILINE			1.5 U	0.65 U	0.49 U	1.0 U	1.05 U	1.1 U	0.71 U	0.51 U	0.74 U	0.30 U	0.75 U	
3-NITROTOLUENE	0.75 U	0.31 U	1.5 U	0.65 U	0.49 U	1.0 U	1.05 U	1.1 U	0.71 U	0.51 U	0.74 U	0.30 U	0.75 U	0.49 U
4,4'-TN-AZOXY			1.5 U	0.65 U	0.49 U	1.0 U	1.05 U	1.1 U	0.71 U	0.51 U	0.74 U	0.30 U	0.75 U	
4-AMINO-2,6-DINITROTOLUENE	0.75 U	0.31 U	1.5 U	0.65 U	1.3 J	1.0 U	1.05 U	1.1 U	0.71 U	0.56 J	0.74 U	0.30 U	0.75 U	0.49 U
4-NITROTOLUENE	0.75 U	0.31 U	1.5 U	0.65 U	0.49 U	1.0 U	1.05 U	1.1 U	0.71 U	0.51 U	0.74 U	0.30 U	0.75 U	0.49 U
HMX	3.2	2.9	6.7	6.8	6.8	5.5	5.55	5.6	2.9	5.4	27	29	38	0.49 U
MNX			3.1	2.9	3	1.0 U	1.05 U	1.1 U	0.71 U	0.51 U	0.74 U	0.32	0.75 U	
NITROBENZENE	0.75 U	0.31 U	1.5 U	0.65 U	0.49 U	1.0 U	1.05 U	1.1 U	0.71 U	0.51 U	0.74 U	0.30 U	0.75 U	0.49 U
NITROCELLULOSE	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1100	1000 U	1000 U
NITROGLYCERIN	7.5 U	3.1 U	15 U	6.5 U	4.9 U	10 U	10.5 U	11 U	7.1 U	5.1 U	7.4 U	3 U	7.5 U	4.9 U

ANALYTICAL RESULTS FOR GROUND WATER
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03C09P2	03C09P2	03C10	03C10	03C10	03C11	03C11	03C11	03C11	03C11	03C12	03C12	03C12	03C15
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	AC09P22A99	AC09P23A99	AC101A99	AC102A99	AC103A99	AC111A99	AC111A99-AVG	AC111A99-D	AC112A99	AC113A99	AC121A99	AC122A99	AC123A99	AC151A99
DUPLICATE	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	DUP	AVG	DUP	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE	5/19/1999	9/11/1999	2/25/1999	5/22/1999	9/8/1999	2/25/1999	2/25/1999	2/25/1999	5/21/1999	9/10/1999	2/25/1999	5/22/1999	9/8/1999	3/1/1999
PENTAERYTHRITOL TETRANITRATE	3.8 U	1.5 U	7.4 U	3.2 U	2.4 U	5.1 U	5.25 U	5.4 U	3.6 U	2.5 U	3.6 U	1.5 U	3.7 U	2.4 U
PIGRIC ACID			1.0 U	1 U	1 U	1.1 UJ	1.1 UJ	1.1 UJ	1 U	1 U	1.1 UJ	1 U	1 U	
RDX	150	130	140	100	100	34	34	34	12	25	14	11	28	0.49 U
TETRYL	0.75 U	0.31 U	1.5 U	0.65 U	0.49 U	1.0 U	1.05 U	1.1 U	0.71 U	0.51 U	0.74 U	0.30 U	0.75 U	0.49 U
TNX			1.5 U	0.66	0.49 U	1.0 U	1.05 U	1.1 U	0.71 U	0.51 U	0.74 U	0.30 U	0.75 U	
Total Metals (ug/L)														
ANTIMONY	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
ARSENIC	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	2.2	1.1 U	1.1 U	1.1 U	1.1 U	1.2
BARIUM	14.8	15.2	42.4	44.3	46.6	22.9	22.45	22.0	54.3	23.1	88.7	90.9	96.9	23.1
BERYLLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CADMIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CHROMIUM	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	82.9	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U
COBALT	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
COPPER	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
IRON			121	111 U	111 U	111 U	111 U	111 U	111 U	111 U	111 U	289	111 U	
LEAD	1.1 U	1.1 U	1.1 U	1.1 U	1.1 UJ	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 UJ	1.1 U
MANGANESE	49.7	30.9	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	36.2
MERCURY	0.20 U	0.2 U	0.20 U	0.20 U	0.20 U	0.20 U	0.2 U	0.20 U	0.20 U	0.2 U	0.20 U	0.20 U	0.20 U	0.20 U
NICKEL	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
SELENIUM	1.8	2	3.2	4.3	3.0	3.7	3.85	4.0	8.7	4.4	1.2	2.6	1.2	1.9
SILVER	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
THALLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
TIN	11.1 U	11.1 U	11.1 UJ	11.1 U	11.1 U	11.1 UJ	11.1 UJ	11.1 UJ	11.1 U	11.1 U	11.1 UJ	11.1 U	11.1 U	11.1 U
VANADIUM	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
ZINC	11.1 U	11.1 U	44.8 J	11.1 U	11.1 UJ	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 UJ	11.1 U
Disolved Metals (ug/L)														
ANTIMONY	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
ARSENIC	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
BARIUM	11.8	15.3	47.7	44.3	44.0	26.2	26.5	26.8	38.3	27	105	89.3	99.6	22.9
BERYLLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CADMIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CALCIUM	75900	76800	91300	92400	99300	233000	233500	234000	119000	237000	99600	97100	106000	104000
CHROMIUM	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	99	7.3	5.6 U	5.6 U	5.6 U	5.6 U
COBALT	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
COPPER	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.6	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
LEAD	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
MAGNESIUM	14600	14900	11800	11900	12300	130000	129500	129000	61400	121000	8130	7970	7510	45100
MANGANESE	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	35.1
MERCURY	0.20 U	0.2 U	0.20 U	0.20 U	0.2 U	0.20 U	0.2 U	0.20 U	0.20 U	0.2 U	0.20 U	0.20 U	0.2 U	0.20 U
NICKEL	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	33.4	11.1 U	11.1 U	11.1 U	11.1 U
POTASSIUM	1110 U	1450	1110 U	1110 U	1130	3180	3185	3190	165000	4770	2060	1900	2160	1960
SELENIUM	1.7	1.6	3.2	2.8	4.2	3.9	4.05	4.2	7.2	3.4	1.4	1.2	1.3	1.9

APPENDIX A-1

ANALYTICAL RESULTS FOR GROUND WATER
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03C09P2	03C09P2	03C10	03C10	03C10	03C11	03C11	03C11	03C11	03C11	03C12	03C12	03C12	03C15
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	AC09P22A99	AC09P23A99	AC101A99	AC102A99	AC103A99	AC111A99	AC111A99-AVG	AC111A99-D	AC112A99	AC113A99	AC121A99	AC122A99	AC123A99	AC151A99
DUPLICATE	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	DUP	AVG	DUP	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE	5/19/1999	9/11/1999	2/25/1999	5/22/1999	9/8/1999	2/25/1999	2/25/1999	2/25/1999	5/21/1999	9/10/1999	2/25/1999	5/22/1999	9/8/1999	3/1/1999
SILVER	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
SODIUM	4350	4810	7190	7070	7660	94500	93400	92300	209000	88400	13400	14400	12900	26900
THALLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
TIN	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
VANADIUM	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
ZINC	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	81 J	11.1 U	233 J	11.1 U	11.1 U
Miscellaneous Parameters (mg/L)														
ALKALINITY	182	149	200	186	170	290	290		84	244	216	152	158.8	286
ALKALINITY AS CACO3														
BICARBONATE ALKALINITY	182	149	200	186	170	290	290		84	244	216	152	158.8	286
CARBON DIOXIDE	NA	NA	183	98.8	101	165	165		2000 >	131	136	59.8	63.6	NA
CARBONATE ALKALINITY														
CARBONATE ALKALINITY - FIELD	0	0	0	0	0	0	0	NA	0	0	0	0	0	0
CHLORIDE	5	5	9	9	8	40	40	40	29	46	32	41	34	4
CYANIDE	0.010 U	0.005 U	0.01 U	0.010 U	0.005 U	0.01 U	0.01 U	0.01 U	0.010 U	0.005 U	0.01 U	0.010 U	0.005 U	0.01 U
DISSOLVED OXYGEN - FIELD - HACH (MG/L)	NA	NA	2.53	3.01	2.5	5.32	5.32		5.02	5	7.02	6.88	8	NA
DISSOLVED OXYGEN - FIELD - METER (MG/L)	8.81	8.04	3.58	3.08	3.71	7.69	3.845	NA	1.48	8.45	8.46	8.56	7.48	1.89
FERROUS IRON	NA	NA	0	0.01	0.02	0.02	0.02		0.01	0.04	0.01	0.01	0	NA
HYDROXIDE ALKALINITY	0	0	0	0	0	0	0	NA	0	0	0	0	0	0
NITRATE	NA	NA	0.39	1.739	2.43 >	0.726	0.726		0.928	2.43 >	0.550	2.407	2.43	NA
NITRITE	NA	NA	0.002	0.001	0	0.01	0.01		0.012	0.006	0	0.003	0.001	NA
OXIDATION REDUCTION POTENTIAL MV	133.2	96	158.6	214.6	182.9	-54.5	-27.25	NA	-110.8	-5.8	139.4	194.2	167	3.5
PH	6.84	6.77	6.53	6.65	6.57	7.15	3.575	NA	11.06	7.19	7.25	7.3	7.11	7.15
PHOSPHORUS	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
SPECIFIC CONDUCTIVITY MS/CM	0.492	0.488	0.521	0.506	0.561	1.9	0.95	NA	2.106	1.92	0.643	0.62	0.782	0.826
SULFATE	49	51	58	64	58	710	815	920	980	820	58	61	61	170 J
SULFIDE			1 U	1 U	1 J	1 U	1 U	1 U	1 U	1 UJ	1 U	1 U	2 J	
SULFIDE - FIELD	NA	NA	0	0	0.03	0.47	0.47		0.38	0.03	0	0	0.01	NA
TEMPERATURE C	16	17.1	13.1	16.3	18.33	10.7	5.35	NA	18.2	19.41	13.3	17.4	17.37	12.9
TOTAL ORGANIC CARBON	1.1	11 J	1.6	1.4	7 J	3.3	2.6	1.9	10	7.2 J	1.7	1.3	8.6 J	1.3
TOTAL ORGANIC HALIDES	0.11	0.13	0.06	0.06	0.06	0.86	0.93	1	0.8	1.4	0.02	0.02 U	0.04	0.02 U
TURBIDITY NTU	9	6	6	0	1.8	1	0.5	NA	240	3.8	0	5.8	0	1
WATER LEVEL FT	45.53	45.32	50.14	50.21	49.97	44.40	22.2	NA	44.44	44.15	41.86	41.85	41.85	64.71

ANALYTICAL RESULTS FOR GROUND WATER
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03C15	03C15	03C15	03C15	03C17	03C17	03C17	03C20	03C20	03C20	03C25	03C25	03C25	03C26
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	AC152A99	AC152A99-AVG	AC152A99-D	AC153A99	AC171A99	AC172A99	AC173A99	AC201A99	AC202A99	AC203A99	AC251A99	AC252A99	AC253A99	AC261A99
DUPLICATE	DUP	AVG	DUP	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE	5/23/1999	5/23/1999	5/23/1999	9/8/1999	3/8/1999	5/18/1999	9/9/1999	3/11/1999	5/22/1999	9/14/1999	2/24/1999	5/25/1999	9/10/1999	3/2/1999
Volatile Organics (ug/L)														
1,1,1-TRICHLOROETHANE											0.5 U	0.5 U	0.5 U	
1,1-DICHLOROETHANE											0.5 U	0.5 U	0.5 U	
1,1-DICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-DICHLOROETHANE											0.5 U	0.5 U	0.5 U	
BENZENE											0.5 U	0.5 U	0.5 U	
CARBON TETRACHLORIDE											0.5 U	0.3 U	0.3 U	
CHLOROETHANE											0.5 U	0.5 U	0.5 U	
CHLOROFORM											0.5 U	0.3 U	0.3 U	
CIS-1,2-DICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	67	63	77	0.5 U	0.5 U	0.5 U	0.5 U
ETHYLBENZENE											0.5 U	0.5 U	0.5 U	
METHYLENE CHLORIDE											0.5 U	1 U	1 U	
TETRACHLOROETHENE											0.5 U	0.5 U	0.5 U	
TOLUENE											0.5 U	0.5 U	0.5 U	
TRANS-1,2-DICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	7.3	7.3	7.2	0.5 U	0.5 U	0.5 U	0.5 U
TRICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	3700	3300	3400	0.5 U	0.5 U	0.5 U	4.2
VINYL CHLORIDE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
XYLENES, TOTAL											0.5 U	1 U	1 U	
Dissolved Gases (ug/L)														
ETHANE											0.583	0.064	0.044	
ETHENE											0.099	0.005 U	0.005 U	
METHANE											55.04	49.4	43.8	
Energetics (ug/L)														
1,3,5-TRINITROBENZENE	1.1 U	0.84 U	0.58 U	1.4 U	1.2 U	0.36 U	1.4 U	6.1	6.2	6.7 J	1.2 U	1 U	0.79 U	1.4 U
1,3-DINITROBENZENE	1.1 U	0.84 U	0.58 U	1.4 U	1.2 U	0.36 U	1.4 U	0.56 U	0.68 U	1.1 U	1.2 U	1 U	0.79 U	1.4 U
2,4,6-TRINITROTOLUENE	1.1 U	0.84 U	0.58 U	1.4 U	1.2 U	0.36 U	1.4 U	0.56 U	0.68 U	1.1 U	1.2 U	1 U	0.79 U	1.4 U
2,4-DIAMINO-6-NITROTOLUENE	1.1 U	1.1 U									1.2 U	1 U	0.79 U	
2,4-DINITROTOLUENE	1.1 U	0.84 U	0.58 U	1.4 U	1.2 U	0.36 U	1.4 U	0.56 U	0.68 U	1.1 U	1.2 U	1 U	0.79 U	1.4 U
2,6-DIAMINO-4-NITROTOLUENE	1.1 U	1.1 U									1.2 U	1 U	0.79 U	
2,6-DINITROTOLUENE	1.1 U	0.84 U	0.58 U	1.4 U	1.2 U	0.36 U	1.4 U	0.56 U	0.68 U	1.1 U	1.2 U	1 U	0.79 U	1.4 U
2-AMINO-4,6-DINITROTOLUENE	1.1 U	0.84 U	0.58 U	1.4 U	1.2 U	0.36 U	1.4 U	12.0	11	12	1.2 U	1 U	0.79 U	1.4 U
2-NITROTOLUENE	1.1 U	0.84 U	0.58 U	1.4 U	1.2 U	0.36 U	1.4 U	0.56 U	0.68 U	1.1 U	1.2 U	1 U	0.79 U	1.4 U
3,5-DINITROANILINE	1.1 U	1.1 U									1.2 U	1 U	0.79 U	
3-NITROTOLUENE	1.1 U	0.84 U	0.58 U	1.4 U	1.2 U	0.36 U	1.4 U	0.56 U	0.68 U	1.1 U	1.2 U	1 U	0.79 U	1.4 U
4,4'-TN-AZOXY	1.1 U	1.1 U									1.2 U	1 U	0.79 U	
4-AMINO-2,6-DINITROTOLUENE	1.1 U	0.84 U	0.58 U	1.4 U	1.2 U	0.36 U	1.4 U	18.0	17	19	1.2 U	1 U	0.79 U	1.4 U
4-NITROTOLUENE	1.1 U	0.84 U	0.58 U	1.4 U	1.2 U	0.36 U	1.4 U	0.56 U	0.68 U	1.1 U	1.2 U	1 U	0.79 U	1.4 U
HMX	1.1 U	0.84 U	0.58 U	1.4 U	1.2 U	0.36 U	1.4 U	25	24	26	1.2 U	1 U	0.79 U	1.4 U
MNX	1.1 U	1.1 U									1.2 U	1 U	0.79 U	
NITROBENZENE	1.1 U	0.84 U	0.58 U	1.4 U	1.2 U	0.36 U	1.4 U	0.56 U	0.68 U	1.1 U	1.2 U	1 U	0.79 U	1.4 U
NITROCELLULOSE	1200	850	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1400	1000 U	1000 U
NITROGLYCERIN	11 U	8.4 U	5.8 U	14 U	12 U	3.6 U	14 U	5.6 U	6.8 U	11 U	12 U	10 U	7.9 U	14 U

APPENDIX A-1

ANALYTICAL RESULTS FOR GROUND WATER
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03C15	03C15	03C15	03C15	03C17	03C17	03C17	03C20	03C20	03C20	03C25	03C25	03C25	03C26
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	AC152A99	AC152A99-AVG	AC152A99-D	AC153A99	AC171A99	AC172A99	AC173A99	AC201A99	AC202A99	AC203A99	AC251A99	AC252A99	AC253A99	AC261A99
DUPLICATE	DUP	AVG	DUP	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE	5/23/1999	5/23/1999	5/23/1999	9/8/1999	3/8/1999	5/18/1999	9/9/1999	3/11/1999	5/22/1999	9/14/1999	2/24/1999	5/25/1999	9/10/1999	3/2/1999
PENTAERYTHRITOL TETRANITRATE	5.6 U	4.25 U	2.9 U	6.7 U	6.1 U	1.8 U	6.7 U	2.8 U	3.4 U	5.2 U	5.7 U	5.1 U	3.9 U	6.7 U
PICRIC ACID											1.0 UJ	1 U	1 U	
RDX	1.1 U	0.84 U	0.58 U	1.4 U	1.2 U	0.36 U	1.4 U	180	150	170	1.2 U	1 U	0.79 U	1.4 U
TETRYL	1.1 U	0.84 U	0.58 U	1.4 U	1.2 U	0.36 U	1.4 U	0.56 U	0.68 U	1.1 U	1.2 U	1 U	0.79 U	1.4 U
TNX	1.1 U	1.1 U									1.2 U	1 U	0.79 U	
Total Metals (ug/L)														
ANTIMONY	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
ARSENIC	1.1 U	1.1 U	1.1 U	1.1	1.9	2.3	2.2	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
BARIUM	23.0	22.4	21.8	25.1	11.0	11.7	13.2	29.7	33.9	30.4	15.6	1.1 U	16.8	37.4
BERYLLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CADMIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CHROMIUM	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U
COBALT	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
COPPER	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
IRON											140	158	201	
LEAD	1.1 U	1.1 U	1.1 U	1.1 UJ	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
MANGANESE	34.7	34.3	33.9	36.2	114	114	140	16.7 U	16.7 U	16.7 U	24.1	24.4	29.7	40.0
MERCURY	0.20 U	0.2 U	0.20 U	0.20 U	0.20 U	0.20 U	0.2 U	0.20 U	0.20 U	0.2 U	0.20 U	0.20 U	0.2 U	0.20 U
NICKEL	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
SELENIUM	2.0	1.95	1.9	2.0	1.6	1.4	1.3	1.3	1.6	1.3	1.1 U	1.1 U	1.1 U	1.3
SILVER	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
THALLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
TIN	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 UJ	11.1 U	11.1 U	11.1 U
VANADIUM	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
ZINC	11.1 U	19.6 U	28.1 U	11.1 UJ	11.1 U	15.0	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
Disolved Metals (ug/L)														
ANTIMONY	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
ARSENIC	1.1 U	1.1 U	1.1 U	1.2	2.1	1.7	2	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
BARIUM	21.0	21.15	21.3	24.9	11.0	10.0	13.8	29.9	30.6	34.4	20.8	15.8	18.1	36.9
BERYLLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CADMIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CALCIUM	99300	101650	104000	105000	201000	179000	204000	86000	89100	92200	106000	104000	104000	98700
CHROMIUM	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U
COBALT	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
COPPER	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
LEAD	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
MAGNESIUM	43700	44000	44300	43800	199000	173000	196000	29900	29900	31100	60700	58200	59600	53100
MANGANESE	34.1	35.35	36.6	35.7	110	105	130	16.7 U	16.7 U	16.7 U	24.7	24.0	23.8	39.9
MERCURY	0.20 U	0.2 U	0.20 U	0.2 U	0.20 U	0.20 U	0.2 U	0.20 U	0.20 U	0.2 U	0.20 U	0.20 U	0.2 U	0.20 U
NICKEL	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	30.7	11.1 U	11.1 U	11.1	11.1 U	11.1 U	15.7	11.1 U
POTASSIUM	1790	1705	1620	2110	3220	2720	3300	1990	1720	2130	2650	2460	2640	2110
SELENIUM	1.1	1.1	1.1	2.2	1.9	1.2	1.3	1.4	1.1 U	1.1 U	1.1	1.1 U	1.1 U	1.6

ANALYTICAL RESULTS FOR GROUND WATER
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03C15	03C15	03C15	03C15	03C17	03C17	03C17	03C20	03C20	03C20	03C25	03C25	03C25	03C26
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	AC152A99	AC152A99-AVG	AC152A99-D	AC153A99	AC171A99	AC172A99	AC173A99	AC201A99	AC202A99	AC203A99	AC251A99	AC252A99	AC253A99	AC261A99
DUPLICATE	DUP	AVG	DUP	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE	5/23/1999	5/23/1999	5/23/1999	9/8/1999	3/8/1999	5/18/1999	9/9/1999	3/11/1999	5/22/1999	9/14/1999	2/24/1999	5/25/1999	9/10/1999	3/2/1999
SILVER	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
SODIUM	25500	25450	25400	25400	115000	101000	119000	12000	11700	12700	63600	60400	66100	16800
THALLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
TIN	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
VANADIUM	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
ZINC	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	14 J	11.1 U	11.1 U	14.6 J	14.0
Miscellaneous Parameters (mg/L)														
ALKALINITY	271	271		255	389	125.6	353	246	214	198	180	318	328	322
ALKALINITY AS CACO3														
BICARBONATE ALKALINITY	271	271		255	389	125.6	353	246	214	198	180	318	328	322
CARBON DIOXIDE	NA	0		NA	NA	NA	NA	NA	NA	NA	191	83.8	93	NA
CARBONATE ALKALINITY														
CARBONATE ALKALINITY - FIELD	0	0		0	0	0	0	0	0	0	0	0	0	0
CHLORIDE	4	4.5	5	4	4	5 U	3	6	6	5	2	2	2	4
CYANIDE	0.010 U	0.01 U	0.010 U	0.005 U	0.01 U	0.010 U	0.005 U	0.01 U	0.010 U	0.005 U	0.01 U	0.010 U	0.005 U	0.01 U
DISSOLVED OXYGEN - FIELD - HACH (MG/L)	NA	0		NA	NA	NA	NA	NA	NA	NA	0	0.3	0.28	NA
DISSOLVED OXYGEN - FIELD - METER (MG/L)	1.84	1.84		3.3	1.26	2.24	2.14	4.21	4.95	4.66	3.14	4.89	1.4	4.04
FERROUS IRON	NA	0		NA	NA	NA	NA	NA	NA	NA	0.12	0.15	0.15	NA
HYDROXIDE ALKALINITY	0	0		0	0	0	0	0	0	0	0	0	0	0
NITRATE	NA	0		NA	NA	NA	NA	NA	NA	NA	0	0.129	0.03	NA
NITRITE	NA	0		NA	NA	NA	NA	NA	NA	NA	0	0.001	0.002	NA
OXIDATION REDUCTION POTENTIAL MV	-39.1	-39.1		-50	-22.9	-52.4	-71.0	169.2	168.1	125.0	-74.1	-74.8	-70.3	106.1
PH	7.19	7.19		7.02	7.01	7	7.02	7.13	7.23	7.25	7.11	7.2	7.16	7.11
PHOSPHORUS	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
SPECIFIC CONDUCTIVITY MS/CM	0.781	0.781		0.856	2.209	2.19	2.26	0.656	0.6	0.577	1.063	0.981	1.09	0.780
SULFATE	170	170	170	160	1100 J	1300	1000	100 J	110	99	270	260	270	92 J
SULFIDE											1 U	1 U	1 UJ	
SULFIDE - FIELD	NA	0		NA	NA	NA	NA	NA	NA	NA	0.04	0.06	0.13	NA
TEMPERATURE C	13.6	13.6		14.99	11.3	14.5	17.21	11.1	14.9	16.16	10.8	12.7	13.6	11.2
TOTAL ORGANIC CARBON	1 U	0.75	1	7.4 J	1.4	1.2	8.8 J	1.2	1.6	11 J	1 U	1 U	8.6 J	1 U
TOTAL ORGANIC HALIDES	0.03	0.02	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	3	1.5	2.3	0.03	0.02 U	0.02 U	0.02 U
TURBIDITY NTU	1	1		0	0	1.2	0	0	1	0	0	0	1.5	0
WATER LEVEL FT	64.76	64.76		64.54	138.12	138.22	138.07	89.50	89.63	89.4	46.81	46.97	46.76	82.67

APPENDIX A-1

ANALYTICAL RESULTS FOR GROUND WATER
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03C26	03C26	03C27	03C27	03C27	03C27	03C27	03C30	03C30	03C30
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	AC262A99	AC263A99	AC271A99	AC271A99-AVG	AC271A99-D	AC272A99	AC273A99	AC301A99	AC302A99	AC303A99
DUPLICATE	NORMAL	NORMAL	DUP	AVG	DUP	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE	5/23/1999	9/12/1999	3/2/1999	3/2/1999	3/2/1999	5/24/1999	9/8/1999	3/8/1999	5/24/1999	9/10/1999
Volatile Organics (ug/L)										
1,1,1-TRICHLOROETHANE										
1,1-DICHLOROETHANE										
1,1-DICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-DICHLOROETHANE										
BENZENE										
CARBON TETRACHLORIDE										
CHLOROETHANE										
CHLOROFORM										
CIS-1,2-DICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
ETHYLBENZENE										
METHYLENE CHLORIDE										
TETRACHLOROETHENE										
TOLUENE										
TRANS-1,2-DICHLOROETHENE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
TRICHLOROETHENE	9.1	8.9	4	6.45	8.9	3.8	4.2	0.5 U	0.5 U	0.5 U
VINYL CHLORIDE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
XYLENES, TOTAL										
Dissolved Gases (ug/L)										
ETHANE										
ETHENE										
METHANE										
Energetics (ug/L)										
1,3,5-TRINITROBENZENE	0.81 U	0.61 U	1.3 U	0.925 U	0.55 U	0.55 U	0.86 U	0.56 U	0.79 U	0.25 U
1,3-DINITROBENZENE	0.81 U	0.61 U	1.3 U	0.925 U	0.55 U	0.55 U	0.86 U	0.56 U	0.79 U	0.25 U
2,4,6-TRINITROTOLUENE	0.81 U	0.61 U	1.3 U	0.925 U	0.55 U	0.55 U	0.86 U	0.56 U	0.79 U	0.25 U
2,4-DIAMINO-6-NITROTOLUENE										
2,4-DINITROTOLUENE	0.81 U	0.61 U	1.3 U	0.925 U	0.55 U	0.55 U	0.86 U	0.56 U	0.79 U	0.25 U
2,6-DIAMINO-4-NITROTOLUENE										
2,6-DINITROTOLUENE	0.81 U	0.61 U	1.3 U	0.925 U	0.55 U	0.55 U	0.86 U	0.56 U	0.79 U	0.25 U
2-AMINO-4,6-DINITROTOLUENE	0.81 U	0.61 U	1.3 U	0.925 U	0.55 U	0.55 U	0.86 U	0.56 U	0.79 U	0.25 U
2-NITROTOLUENE	0.81 U	0.61 U	1.3 U	0.925 U	0.55 U	0.55 U	0.86 U	0.56 U	0.79 U	0.25 U
3,5-DINITROANILINE										
3-NITROTOLUENE	0.81 U	0.61 U	1.3 U	0.925 U	0.55 U	0.55 U	0.86 U	0.56 U	0.79 U	0.25 U
4,4'-TN-AZOXY										
4-AMINO-2,6-DINITROTOLUENE	0.81 U	0.61 U	1.3 U	0.925 U	0.55 U	0.55 U	0.86 U	0.56 U	0.79 U	0.25 U
4-NITROTOLUENE	0.81 U	0.61 U	1.3 U	0.925 U	0.55 U	0.55 U	0.86 U	0.56 U	0.79 U	0.25 U
HMX	0.81 U	0.61 U	1.3 U	0.925 U	0.55 U	0.55 U	0.86 U	0.56 U	0.79 U	0.25 U
MNX										
NITROBENZENE	0.81 U	0.61 U	1.3 U	0.925 U	0.55 U	0.55 U	0.86 U	0.56 U	0.79 U	0.25 U
NITROCELLULOSE	1100	1000 U	1000 UR	1000 U	1000 U	1200	1000 U	1000 U	1100	1000 U
NITROGLYCERIN	8.1 U	6.1 U	13 U	9.25 U	5.5 U	5.5 U	8.6 U	5.6 U	7.9 U	2.5 U

ANALYTICAL RESULTS FOR GROUND WATER
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03C26	03C26	03C27	03C27	03C27	03C27	03C27	03C30	03C30	03C30
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	AC262A99	AC263A99	AC271A99	AC271A99-AVG	AC271A99-D	AC272A99	AC273A99	AC301A99	AC302A99	AC303A99
DUPLICATE	NORMAL	NORMAL	DUP	AVG	DUP	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE	5/23/1999	9/12/1999	3/2/1999	3/2/1999	3/2/1999	5/24/1999	9/8/1999	3/8/1999	5/24/1999	9/10/1999
PENTAERYTHRITOL TETRANITRATE	4 U	3 U	6.4 U	4.55 U	2.7 U	2.7 U	4.2 U	2.8 U	4 U	1.2 U
PICRIC ACID										
RDX	0.81 U	0.8	1.3 U	0.925 U	0.55 U	0.55 U	0.86 U	0.56 U	0.79 U	0.25 U
TETRYL	0.81 U	0.61 U	1.3 U	0.925 U	0.55 U	0.55 U	0.86 U	0.56 U	0.79 U	0.25 U
TNX										
Total Metals (ug/L)										
ANTIMONY	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
ARSENIC	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
BARIUM	37.9	41.6	34.3	33.3	32.3	31.9	33.0	61.1	69.1	17.2
BERYLLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CADMIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CHROMIUM	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U
COBALT	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
COPPER	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
IRON			111 U	111 U						
LEAD	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 UJ	1.1 U	1.1 U	1.1 U
MANGANESE	23.8	20.1	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	30.3	19.1	26.7
MERCURY	0.20 U	0.2 U	0.20 U	0.2 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.2 U
NICKEL	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
SELENIUM	1.7	1.3	1.1	1.35	1.6	1.2	1.1 U	1.1 U	2.3	1.1 U
SILVER	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
THALLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
TIN	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
VANADIUM	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
ZINC	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	20.6 J	11.1 U	11.1 U	11.1 U
Disolved Metals (ug/L)										
ANTIMONY	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
ARSENIC	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
BARIUM	35.2	47.3	32.7	32.3	31.9	31.1	33.2	57.7	66.4	73
BERYLLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CADMIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
CALCIUM	91800	106000	59800	58400	57000	52500	57100	71000	54500	52800
CHROMIUM	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U	5.6 U
COBALT	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
COPPER	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	11.2	2.2 U	2.2 U
LEAD	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
MAGNESIUM	49600	55700	3280	3215	3150	2830	3030	36700	33200	33300
MANGANESE	24.3	20.7	16.7 U	16.7 U	16.7 U	16.7 U	16.7 U	39.4	17.8	16.7 U
MERCURY	0.20 U	0.2 U	0.20 U	0.2 U	0.20 U	0.20 U	0.2 U	0.20 U	0.20 U	0.2 U
NICKEL	11.1 U	12.9	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
POTASSIUM	2210	3110	1220	1220	1220	1110 U	1400	2790	2690	3630
SELENIUM	1.1 U	1.2	1.3	1.65	2	1.1 U	1.2	1.1 U	1.1 U	1.1 U

ANALYTICAL RESULTS FOR GROUND WATER
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03C26	03C26	03C27	03C27	03C27	03C27	03C27	03C30	03C30	03C30
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	AC262A99	AC263A99	AC271A99	AC271A99-AVG	AC271A99-D	AC272A99	AC273A99	AC301A99	AC302A99	AC303A99
DUPLICATE	NORMAL	NORMAL	DUP	AVG	DUP	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE	5/23/1999	9/12/1999	3/2/1999	3/2/1999	3/2/1999	5/24/1999	9/8/1999	3/8/1999	5/24/1999	9/10/1999
SILVER	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U
SODIUM	15700	18500	5980	5890	5800	5340	5720	68000	71100	80700
THALLIUM	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
TIN	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
VANADIUM	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
ZINC	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U	11.1 U
Miscellaneous Parameters (mg/L)										
ALKALINITY	274	301	156	149.5	143	127	116.4	408	240	229
ALKALINITY AS CACO3										
BICARBONATE ALKALINITY	274	301	156	149.5	143	127	116.4	408	240	229
CARBON DIOXIDE	NA	NA	NA	0	NA	NA	NA	NA	NA	NA
CARBONATE ALKALINITY										
CARBONATE ALKALINITY - FIELD	0	0	0	0	0	0	0	0	0	0
CHLORIDE	4	3	3	3	3	3	3	2	2	2
CYANIDE	0.010 U	0.005 U	0.01 U	0.01 U	0.01 U	0.010 U	0.005 U	0.01 U	0.010 U	0.005 U
DISSOLVED OXYGEN - FIELD - HACH (MG/L)	NA	NA	NA	0	NA	NA	NA	NA	NA	NA
DISSOLVED OXYGEN - FIELD - METER (MG/L)	28.39	5.50	7.87	3.935	NA	12.31	10.46	0.77	14.22	3.04
FERROUS IRON	NA	NA	NA	0	NA	NA	NA	NA	NA	NA
HYDROXIDE ALKALINITY	0	0	0	0	0	0	0	0	0	0
NITRATE	NA	NA	NA	0	NA	NA	NA	NA	NA	NA
NITRITE	NA	NA	NA	0	NA	NA	NA	NA	NA	NA
OXIDATION REDUCTION POTENTIAL MV	63.7	125.9	164.9	82.45	NA	164.4	210.5	-112.9	-89.7	-61
PH	7.03	7.22	7.59	3.795	NA	7.66	7.62	8.32	9.59	9.44
PHOSPHORUS	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
SPECIFIC CONDUCTIVITY MS/CM	0.71	0.744	0.304	0.152	NA	0.283	0.314	0.778	0.557	0.675
SULFATE	100	94	17 J	14.5 J	12 J	9	12	130 J	120	120
SULFIDE										
SULFIDE - FIELD	NA	NA	NA	0	NA	NA	NA	NA	NA	NA
TEMPERATURE C	17.4	27.08	8.2	4.1	NA	12.5	14.7	10.9	14.22	16.0
TOTAL ORGANIC CARBON	1.3	8.7 J	1.4	1.25	1.1	1 U	7	1.8	1 U	7.8 J
TOTAL ORGANIC HALIDES	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.05	0.02 U	0.02 U
TURBIDITY NTU	1.3	0	8	4	NA	2	1.4	0	0.7	0
WATER LEVEL FT	82.8	82.58	60.73	30.365	NA	60.75	60.88	223.38	223.51	223.39

ANALYTICAL RESULTS FOR SOIL
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03/10-01	03/10-01	03/10-01	03/10-02	03/10-03	03/10-05	03/10-05	03/10-06	03/10-06	03/10-07	03/10-07
MEDIA	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO
SAMPLE	03/10-01-93-1	03/10-01-93-1-D	03/10-01-93-1-MAX	03/10-02-93-1	03/10-03-93-2	03/10-05-93-1	03/10-05-93-2	03/10-06-93-1	03/10-06-93-2	03/10-07-93-1	03/10-07-93-2
DUPLICATE	DUP	DUP	MAX	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
TOP DEPTH (FT)	0	0	0	0	30	0	30	0	30	0	30
BOTTOM DEPTH (FT)	30	30	30	30	60	30	60	30	60	30	60
SAMPLE DATE	8/21/1993	8/22/1993	8/21/1993	8/21/1993	8/21/1993	8/20/1993	8/20/1993	8/20/1993	8/20/1993	8/21/1993	8/21/1993
Dioxins/Furans (ng/kg)											
1,2,3,4,6,7,8-HPCDD											
1,2,3,4,6,7,8-HPCDF											
1,2,3,4,7,8,9-HPCDF											
1,2,3,4,7,8-HXCDD											
1,2,3,4,7,8-HXCDF											
1,2,3,6,7,8-HXCDD											
1,2,3,6,7,8-HXCDF											
1,2,3,7,8,9-HXCDD											
1,2,3,7,8,9-HXCDF											
1,2,3,7,8-PECDD											
1,2,3,7,8-PECDF											
2,3,4,6,7,8-HXCDF											
2,3,4,7,8-PECDF											
2,3,7,8-TCDD											
2,3,7,8-TCDF											
OCDD											
OCDF											
Semivolatile Organics (ug/kg)											
2,4-DINITROTOLUENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U	4200	250 U	250 U	250 U
2,6-DINITROTOLUENE	260 U	260 U	260 U	260 U	260 U	260 U	260 U	115 J	260 U	260 U	260 U
Energetics (ug/kg)											
1,3,5-TRINITROBENZENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
1,3-DINITROBENZENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
2,4,6-TRINITROTOLUENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U	805	138 J	250 U	250 U
2-AMINO-4,6-DINITROTOLUENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
4-AMINO-2,6-DINITROTOLUENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U	60 J	250 U	250 U	250 U
HMX	2200 U	2200 U	2200 U	2200 U	2200 U	2200 U	2200 U	1280 J	99 J	2200 U	2200 U
RDX	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	85 J	1000 U	1000 U	100 U
TETRYL	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U

APPENDIX A-2

ANALYTICAL RESULTS FOR SOIL
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03/10-08	03/10-08	03/10-08	03/10-09	03/10-10	03/10-10	03/10-11	03/10-11	03/10-12	03/10-12	03/10-12
MEDIA	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO
SAMPLE	03/10-08-93-1	03/10-08-93-1-D	03/10-08-93-1-MAX	03/10-09-93-1	03/10-10-93-1	03/10-10-93-2	03/10-11-93-1	03/10-11-93-2	03/10-12-93-1	03/10-12-93-2	03/10-12-93-3
DUPLICATE	DUP	DUP	MAX	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
TOP DEPTH (FT)	0	0	0	0	0	30	0	30	0	30	60
BOTTOM DEPTH (FT)	30	30	30	30	30	60	30	60	30	60	90
SAMPLE DATE	8/21/1993	8/21/1993	8/21/1993	8/21/1993	8/19/1993	8/19/1993	8/19/1993	8/19/1993	8/22/1993	8/22/1993	8/22/1993
Dioxins/Furans (ng/kg)											
1,2,3,4,6,7,8-HPCDD											
1,2,3,4,6,7,8-HPCDF											
1,2,3,4,7,8,9-HPCDF											
1,2,3,4,7,8-HXCDD											
1,2,3,4,7,8-HXCDF											
1,2,3,6,7,8-HXCDD											
1,2,3,6,7,8-HXCDF											
1,2,3,7,8,9-HXCDD											
1,2,3,7,8,9-HXCDF											
1,2,3,7,8-PECDD											
1,2,3,7,8-PECDF											
2,3,4,6,7,8-HXCDF											
2,3,4,7,8-PECDF											
2,3,7,8-TCDD											
2,3,7,8-TCDF											
OCDD											
OCDF											
Semivolatile Organics (ug/kg)											
2,4-DINITROTOLUENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	11600	250 U	250 U
2,6-DINITROTOLUENE	260 U	260 U	260 U	260 U	260 U	260 U	260 U	260 U	375	260 U	260 U
Energetics (ug/kg)											
1,3,5-TRINITROBENZENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
1,3-DINITROBENZENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
2,4,6-TRINITROTOLUENE	250 U	250 U	250 U	181 J	250 U	250 U	195 J	250 U	250 U	250 U	250 U
2-AMINO-4,6-DINITROTOLUENE	250 U	250 U	250 U	196 J	215 J	250 U	200 J	250 U	250 U	250 U	250 U
4-AMINO-2,6-DINITROTOLUENE	250 U	250 U	250 U	426	110 J	250 U	245 J	250 U	250 U	250 U	250 U
HMX	2200 U	2200 U	2200 U	9850	450 J	1240 J	1110 J	2200 U	2200 U	2200 U	2200 U
RDX	1000 U	1000 U	1000 U	19200	770 J	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U
TETRYL	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U

ANALYTICAL RESULTS FOR SOIL
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03/10-13	03/10-13	03/10-14	03/10-14	03/10-15	03/10-16	03/10-16	03/10-16	03/10-17	03/10-17	03/10-17
MEDIA	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO
SAMPLE	03/10-13-93-1	03/10-13-93-2	03/10-14-93-1	03/10-14-93-2	03/10-15-93-1	03/10-16-93-1	03/10-16-93-1-D	03/10-16-93-1-MAX	03/10-17-93-1	03/10-17-93-2	03/10-17-93-3
DUPLICATE	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	DUP	DUP	MAX	NORMAL	NORMAL	NORMAL
TOP DEPTH (FT)	0	30	0	30	0	0	0	0	0	30	60
BOTTOM DEPTH (FT)	30	60	30	60	30	30	30	30	30	60	90
SAMPLE DATE	8/21/1993	8/21/1993	8/22/1993	8/22/1993	8/25/1993	8/25/1993	8/25/1993	8/25/1993	8/25/1993	8/25/1993	8/25/1993
Dioxins/Furans (ng/kg)											
1,2,3,4,6,7,8-HPCDD											
1,2,3,4,6,7,8-HPCDF											
1,2,3,4,7,8,9-HPCDF											
1,2,3,4,7,8-HXCDD											
1,2,3,4,7,8-HXCDF											
1,2,3,6,7,8-HXCDD											
1,2,3,6,7,8-HXCDF											
1,2,3,7,8,9-HXCDD											
1,2,3,7,8,9-HXCDF											
1,2,3,7,8-PECDD											
1,2,3,7,8-PECDF											
2,3,4,6,7,8-HXCDF											
2,3,4,7,8-PECDF											
2,3,7,8-TCDD											
2,3,7,8-TCDF											
OCDD											
OCDF											
Semivolatile Organics (ug/kg)											
2,4-DINITROTOLUENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	170	75 J	250 U
2,6-DINITROTOLUENE	260 U	260 U	260 U	260 U	260 U	260 U	260 U	260 U	260 U	260 U	260 U
Energetics (ug/kg)											
1,3,5-TRINITROBENZENE	250 U	250 U	250 U	250 U	2450	250 U	250 U	250 U	2100	2960	250 U
1,3-DINITROBENZENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
2,4,6-TRINITROTOLUENE	250 U	250 U	250 U	250 U	1610	250 U	125 J	125 J	7550	60700	2280
2-AMINO-4,6-DINITROTOLUENE	250 U	250 U	250 U	250 U	260	250 U	250 U	250 U	2200	1240	250 U
4-AMINO-2,6-DINITROTOLUENE	250 U	250 U	250 U	250 U	180 J	250	250	250	2480	2160	105 J
HMX	2200 U	2200 U	2200 U	2200 U	2200 U	520 J	2200 U	520 J	14600	61000	3360
RDX	1000 U	1000 U	1000 U	1000 U	1000	60 J	75 J	75 J	18800	274000	10200
TETRYL	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U

APPENDIX A-2

ANALYTICAL RESULTS FOR SOIL
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03/10-19	03/10-19	03/10-19	03/10-21	03/10-21	03/10-21	03/10-22	03/10-22	03/10-22	03/10-23	03/10-23
MEDIA	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO
SAMPLE	03/10-19-93-1	03/10-19-93-2	03/10-19-93-3	03/10-21-93-1	03/10-21-93-2	03/10-21-93-3	03/10-22-93-1	03/10-22-93-2	03/10-22-93-3	03/10-23-93-1	03/10-23-93-2
DUPLICATE	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
TOP DEPTH (FT)	0	30	60	0	30	60	0	30	60	0	30
BOTTOM DEPTH (FT)	30	60	90	30	60	90	30	60	90	30	60
SAMPLE DATE	8/25/1993	8/25/1993	8/25/1993	8/22/1993	8/22/1993	8/22/1993	8/21/1993	8/21/1993	8/21/1993	8/25/1993	8/25/1993
Dioxins/Furans (ng/kg)											
1,2,3,4,6,7,8-HPCDD											
1,2,3,4,6,7,8-HPCDF											
1,2,3,4,7,8,9-HPCDF											
1,2,3,4,7,8-HXCDD											
1,2,3,4,7,8-HXCDF											
1,2,3,6,7,8-HXCDD											
1,2,3,6,7,8-HXCDF											
1,2,3,7,8,9-HXCDD											
1,2,3,7,8,9-HXCDF											
1,2,3,7,8-PECDD											
1,2,3,7,8-PECDF											
2,3,4,6,7,8-HXCDF											
2,3,4,7,8-PECDF											
2,3,7,8-TCDD											
2,3,7,8-TCDF											
OCDD											
OCDF											
Semivolatile Organics (ug/kg)											
2,4-DINITROTOLUENE	90 J	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
2,6-DINITROTOLUENE	260 U	260 U	260 U	260 U	260 U	260 U	260 U	260 U	260 U	260 U	260 U
Energetics (ug/kg)											
1,3,5-TRINITROBENZENE	660	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
1,3-DINITROBENZENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
2,4,6-TRINITROTOLUENE	360	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	335	250 U
2-AMINO-4,6-DINITROTOLUENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	125 J	250 U
4-AMINO-2,6-DINITROTOLUENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	80 J	250 U
HMX	16000	2200 U	2200 U	2200 U	2200 U	2200 U	2200 U	2200 U	2200 U	250 J	80 J
RDX	1410	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U
TETRYL	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U

ANALYTICAL RESULTS FOR SOIL
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03/10-23	03/10-24	03/10-25	03/10-25	03/10-28	03/10-28	03/10-28	03/10-29	03/10-29	03/10-31	03/10-32
MEDIA	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO
SAMPLE	03/10-23-93-3	03/10-24-93-1	03/10-25-93-1	03/10-25-93-2	03/10-28-93-1	03/10-28-93-2	03/10-28-93-3	03/10-29-93-1	03/10-29-93-2	03/10-31-93-1	03/10-32-93-1
DUPLICATE	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
TOP DEPTH (FT)	60	0	0	30	0	30	60	0	30	0	0
BOTTOM DEPTH (FT)	90	30	30	60	30	60	90	30	60	30	30
SAMPLE DATE	8/25/1993	8/22/1993	8/24/1993	8/24/1993	8/24/1993	8/24/1993	8/24/1993	8/24/1993	8/24/1993	8/24/1993	8/24/1993
Dioxins/Furans (ng/kg)											
1,2,3,4,6,7,8-HPCDD											
1,2,3,4,6,7,8-HPCDF											
1,2,3,4,7,8,9-HPCDF											
1,2,3,4,7,8-HXCDD											
1,2,3,4,7,8-HXCDF											
1,2,3,6,7,8-HXCDD											
1,2,3,6,7,8-HXCDF											
1,2,3,7,8,9-HXCDD											
1,2,3,7,8,9-HXCDF											
1,2,3,7,8-PECDD											
1,2,3,7,8-PECDF											
2,3,4,6,7,8-HXCDF											
2,3,4,7,8-PECDF											
2,3,7,8-TCDD											
2,3,7,8-TCDF											
OCDD											
OCDF											
Semivolatile Organics (ug/kg)											
2,4-DINITROTOLUENE	250 U	250 U	250 U	250 U	250 U	250 U	30 J	65 J	250 U	100 J	250 U
2,6-DINITROTOLUENE	260 U	260 U	260 U	260 U	260 U	260 U	260 U	260 U	260 U	260 U	260 U
Energetics (ug/kg)											
1,3,5-TRINITROBENZENE	250 U	250 U	250 U	250 U	65 J	250 U	250 U	2260	250 U	260	250 U
1,3-DINITROBENZENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
2,4,6-TRINITROTOLUENE	250 U	250 U	250 U	250 U	12300	1250	260	685	20 J	40 J	250 U
2-AMINO-4,6-DINITROTOLUENE	250 U	250 U	250 U	250 U	25 J	250 U	85 J	1560	125 J	10 J	250 U
4-AMINO-2,6-DINITROTOLUENE	250 U	250 U	250 U	250 U	250 U	20 J	80 J	1570	60 J	125 J	250 U
HMX	2200 U	2200 U	2200 U	2200 U	5450	3800	2200 U	128000	600 J	1290 J	410 J
RDX	265	1000 U	1000 U	1000 U	16400	2060	1000 U	41200	350 J	235 J	1000 U
TETRYL	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U

APPENDIX A-2

ANALYTICAL RESULTS FOR SOIL
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03/10-33	03/10-33	03/10-33	03/10-34	03/10-34	03/10-35	03/10-35	03/10-36	03/10-37	03/10-37
MEDIA	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO
SAMPLE	03/10-33-93-1	03/10-33-93-1-D	03/10-33-93-1-MAX	03/10-34-93-1	03/10-34-93-2	03/10-35-93-1	03/10-35-93-2	03/10-36-93-1	03/10-37-93-1	03/10-37-93-1-D
DUPLICATE	DUP	DUP	MAX	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	DUP	DUP
TOP DEPTH (FT)	0	0	0	0	30	0	30	0	0	0
BOTTOM DEPTH (FT)	30	30	30	30	60	30	60	30	30	30
SAMPLE DATE	8/23/1993	8/23/1993	8/23/1993	8/22/1993	8/22/1993	8/23/1993	8/23/1993	8/22/1993	8/22/1993	8/21/1993
Dioxins/Furans (ng/kg)										
1,2,3,4,6,7,8-HPCDD										
1,2,3,4,6,7,8-HPCDF										
1,2,3,4,7,8,9-HPCDF										
1,2,3,4,7,8-HXCDD										
1,2,3,4,7,8-HXCDF										
1,2,3,6,7,8-HXCDD										
1,2,3,6,7,8-HXCDF										
1,2,3,7,8,9-HXCDD										
1,2,3,7,8,9-HXCDF										
1,2,3,7,8-PECDD										
1,2,3,7,8-PECDF										
2,3,4,6,7,8-HXCDF										
2,3,4,7,8-PECDF										
2,3,7,8-TCDD										
2,3,7,8-TCDF										
OCDD										
OCDF										
Semivolatile Organics (ug/kg)										
2,4-DINITROTOLUENE	250 U	250 U	250 U	250 U	250 U	60 J	25000 U	250 U	250 U	250 U
2,6-DINITROTOLUENE	260 U	260 U	260 U	260 U	260 U	260 U	26000 U	260 U	260 U	260 U
Energetics (ug/kg)										
1,3,5-TRINITROBENZENE	250 U	250 U	250 U	250 U	250 U	225 J	37500	250 U	250 U	250 U
1,3-DINITROBENZENE	250 U	250 U	250 U	250 U	250 U	250 U	25000 U	250 U	250 U	250 U
2,4,6-TRINITROTOLUENE	250 U	20 J	20 J	250 U	250 U	2780	2030000	250 U	250 U	250 U
2-AMINO-4,6-DINITROTOLUENE	250 U	250 U	250 U	250 U	250 U	1380	25000 U	250 U	250 U	250 U
4-AMINO-2,6-DINITROTOLUENE	250 U	250 U	250 U	250 U	250 U	1180	25000 U	250 U	250 U	250 U
HMX	2200 U	35 J	35 J	2200 U	2200 U	117000	232000	2200 U	2200 U	2200 U
RDX	1000 U	1000 U	1000 U	1000 U	1000 U	1350	60500 J	1000 U	1000 U	1000 U
TETRYL	65000 U	650 U	65000 U	650 U	650 U	650 U	65000 U	650 U	650 U	650 U

ANALYTICAL RESULTS FOR SOIL
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03/10-37	03/10-38	03/10-38	03/10-39	03/10-40	03/10-41	03/10-42	03/10-43	03/10-44	03/10-45	03/10-46
MEDIA	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO
SAMPLE	03/10-37-93-1-MAX	03/10-38-93-1	03/10-38-93-2	03/10-39-93-1	03/10-40-93-1	03/10-41-93-1	03/10-42-93-1	03/10-43-93-1	03/10-44-93-1	03/10-45-93-1	03/10-46-93-1
DUPLICATE	MAX	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
TOP DEPTH (FT)	0	0	30	6	6	6	6	6	6	6	6
BOTTOM DEPTH (FT)	30	30	60	18	18	18	18	18	18	18	18
SAMPLE DATE	8/22/1993	8/23/1993	8/23/1993	8/10/1993	8/10/1993	8/10/1993	8/16/1993	8/17/1993	8/17/1993	8/17/1993	8/10/1993
Dioxins/Furans (ng/kg)											
1,2,3,4,6,7,8-HPCDD											
1,2,3,4,6,7,8-HPCDF											
1,2,3,4,7,8,9-HPCDF											
1,2,3,4,7,8-HXCDD											
1,2,3,4,7,8-HXCDF											
1,2,3,6,7,8-HXCDD											
1,2,3,6,7,8-HXCDF											
1,2,3,7,8,9-HXCDD											
1,2,3,7,8,9-HXCDF											
1,2,3,7,8-PECDD											
1,2,3,7,8-PECDF											
2,3,4,6,7,8-HXCDF											
2,3,4,7,8-PECDF											
2,3,7,8-TCDD											
2,3,7,8-TCDF											
OCDD											
OCDF											
Semivolatile Organics (ug/kg)											
2,4-DINITROTOLUENE	250 U	250 U	250 U	250	250	250	130 J	1300	250 U	15 J	250
2,6-DINITROTOLUENE	260 U	260 U	260 U	260	260	260	260 U	305	150 J	260 U	260
Energetics (ug/kg)											
1,3,5-TRINITROBENZENE	250 U	250 U	250 U	250	250	250	235 J	250 U	95 J	495	250
1,3-DINITROBENZENE	250 U	250 U	250 U	250	250	250	250 U	250 U	250 U	250 U	250
2,4,6-TRINITROTOLUENE	250 U	250 U	250 U	250	250	250	925	161 J	220	55 J	250
2-AMINO-4,6-DINITROTOLUENE	250 U	250 U	250 U	250	250	250	580	250 U	440	250 U	250
4-AMINO-2,6-DINITROTOLUENE	250 U	250 U	250 U	250	250	250	750	120 J	385	135 J	250
HMX	2200 U	2200 U	2200 U	2200	2200	2200	8900	3740	6050	11400	2200
RDX	1000 U	1000 U	1000 U	1000	1000	1000	3580	445 J	10900	480 J	1000
TETRYL	650 U	650 U	650 U	650	650	650	650 U	650 U	650 U	650 U	650

APPENDIX A-2

ANALYTICAL RESULTS FOR SOIL
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03/10-47	03/10-48	03/10-48	03/10-48	03/10-49	03/10-50	03/10-50	03/10-50	03/10-51	03/10-52
MEDIA	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO
SAMPLE	03/10-47-93-1	03/10-48-93-1	03/10-48-93-1-D	03/10-48-93-1-MAX	03/10-49-93-1	03/10-50-93-1	03/10-50-93-1-D	03/10-50-93-1-MAX	03/10-51-93-1	03/10-52-93-1
DUPLICATE	NORMAL	DUP	DUP	MAX	NORMAL	DUP	DUP	MAX	NORMAL	NORMAL
TOP DEPTH (FT)	6	6	6	6	6	6	6	6	6	6
BOTTOM DEPTH (FT)	18	18	18	18	18	18	18	18	18	18
SAMPLE DATE	8/19/1993	8/16/1993	8/17/1993	8/16/1993	8/17/1993	8/19/1993	8/19/1993	8/19/1993	8/19/1993	8/17/1993
Dioxins/Furans (ng/kg)										
1,2,3,4,6,7,8-HPCDD										
1,2,3,4,6,7,8-HPCDF										
1,2,3,4,7,8,9-HPCDF										
1,2,3,4,7,8-HXCDD										
1,2,3,4,7,8-HXCDF										
1,2,3,6,7,8-HXCDD										
1,2,3,6,7,8-HXCDF										
1,2,3,7,8,9-HXCDD										
1,2,3,7,8,9-HXCDF										
1,2,3,7,8-PECDD										
1,2,3,7,8-PECDF										
2,3,4,6,7,8-HXCDF										
2,3,4,7,8-PECDF										
2,3,7,8-TCDD										
2,3,7,8-TCDF										
OCDD										
OCDF										
Semivolatile Organics (ug/kg)										
2,4-DINITROTOLUENE	250 U	115 J	25 J	115 J	1060	250 U	250 U	250 U	250 U	840
2,6-DINITROTOLUENE	260 U	260 U	260 U	260 U	575	260 U	260 U	260 U	260 U	355
Energetics (ug/kg)										
1,3,5-TRINITROBENZENE	250 U	460	55 J	460	250 U	250 U	250 U	250 U	250 U	100 J
1,3-DINITROBENZENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
2,4,6-TRINITROTOLUENE	250 U	18200	705	18200	150 J	425	3220	3220	695	475
2-AMINO-4,6-DINITROTOLUENE	250 U	620	165 J	620	175 J	150 J	245 J	245 J	250 U	270
4-AMINO-2,6-DINITROTOLUENE	250 U	250 U	250	250	260	165 J	225 J	225 J	120 J	505
HMX	2200 U	280 J	25 J	280 J	3160	2200 U	90 J	90 J	290 J	1380 J
RDX	1000 U	19500	670 J	19500	415 J	1000 U	1000 U	1000 U	635 J	820 J
TETRYL	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U

ANALYTICAL RESULTS FOR SOIL
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03/10-53	03/10-54	03/10-54	03/10-54	03/10-55	03/10-56	03/10-57	03/10-58	03/10-59	03/10-60	03/10-61
MEDIA	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO
SAMPLE	03/10-53-93-1	03/10-54-93-1	03/10-54-93-1-D	03/10-54-93-1-MAX	03/10-55-93-1	03/10-56-93-1	03/10-57-93-1	03/10-58-93-1	03/10-59-93-1	03/10-60-93-1	03/10-61-93-1
DUPLICATE	NORMAL	DUP	DUP	MAX	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
TOP DEPTH (FT)	6	6	6	6	6	6	6	6	6	6	6
BOTTOM DEPTH (FT)	18	18	18	18	18	18	18	18	18	18	18
SAMPLE DATE	8/11/1993	8/12/1993	8/12/1993	8/12/1993	8/19/1993	8/19/1993	8/19/1993	8/17/1993	8/11/1993	8/19/1993	8/12/1993
Dioxins/Furans (ng/kg)											
1,2,3,4,6,7,8-HPCDD											
1,2,3,4,6,7,8-HPCDF											
1,2,3,4,7,8,9-HPCDF											
1,2,3,4,7,8-HXCDD											
1,2,3,4,7,8-HXCDF											
1,2,3,6,7,8-HXCDD											
1,2,3,6,7,8-HXCDF											
1,2,3,7,8,9-HXCDD											
1,2,3,7,8,9-HXCDF											
1,2,3,7,8-PECDD											
1,2,3,7,8-PECDF											
2,3,4,6,7,8-HXCDF											
2,3,4,7,8-PECDF											
2,3,7,8-TCDD											
2,3,7,8-TCDF											
OCDD											
OCDF											
Semivolatile Organics (ug/kg)											
2,4-DINITROTOLUENE	250 U	250 U	250 U	250 U	250 U	125 J	250 U	45 J	250 U	250 U	250 U
2,6-DINITROTOLUENE	260 U	260 U	250 U	260 U	260 U	260 U	260 U	100 J	260 U	260 U	260 U
Energetics (ug/kg)											
1,3,5-TRINITROBENZENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	1440
1,3-DINITROBENZENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
2,4,6-TRINITROTOLUENE	250 U	250 U	250 U	250 U	250 U	136000	130 J	45 J	250 U	250 U	19800
2-AMINO-4,6-DINITROTOLUENE	250 U	250 U	250 U	250 U	250 U	475	250 U	30 J	250 U	250 U	5650
4-AMINO-2,6-DINITROTOLUENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U	75 J	250 U	250 U	8200
HMX	2200 U	2200 U	2200 U	2200 U	2200 U	190 J	9200	105 J	2200 U	2200 U	223000
RDX	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	35 J	1000 U	1000 U	1820000
TETRYL	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U	650 U

APPENDIX A-2

ANALYTICAL RESULTS FOR SOIL
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	03/10-62	03/10-63	03/10-64	03/10-65	03/10-66	03/10-67	03/10-68	03/10-69	03/10-70	03/10-71	A06
MEDIA	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO
SAMPLE	03/10-62-93-1	03/10-63-93-1	03/10-64-93-1	03/10-65-93-1	03/10-66-93-1	03/10-67-93-1	03/10-68-93-1	03/10-69-93-1	03/10-70-93-1	03/10-71-93-1	CR95-03SS-A06-01
DUPLICATE	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	DUP
TOP DEPTH (FT)	6	6	6	6	6	6	6	6	6	6	0
BOTTOM DEPTH (FT)	18	18	18	18	18	18	18	18	18	18	0
SAMPLE DATE	8/17/1993	8/11/2013	8/11/1993	8/17/1993	8/18/1993	8/17/1993	8/11/1993	8/11/1993	8/11/1993	8/11/1993	8/29/1995
Dioxins/Furans (ng/kg)											
1,2,3,4,6,7,8-HPCDD											33.6 J
1,2,3,4,6,7,8-HPCDF											8.96 J
1,2,3,4,7,8,9-HPCDF											0.21 U
1,2,3,4,7,8-HXCDD											0.17 U
1,2,3,4,7,8-HXCDF											11 U
1,2,3,6,7,8-HXCDD											1.11
1,2,3,6,7,8-HXCDF											0.61 U
1,2,3,7,8,9-HXCDD											1.86
1,2,3,7,8,9-HXCDF											0.24 U
1,2,3,7,8-PECDD											0.22 U
1,2,3,7,8-PECDF											0.2 U
2,3,4,6,7,8-HXCDF											0.23 U
2,3,4,7,8-PECDF											0.19 U
2,3,7,8-TCDD											0.15 U
2,3,7,8-TCDF											0.14 U
OCDD											1170 J
OCDF											25.4 J
Semivolatile Organics (ug/kg)											
2,4-DINITROTOLUENE	250 U	250 U	250	250 U	250 U	95 J	250 U	250	250	250	
2,6-DINITROTOLUENE	260 U	260 U	260	260 U	260 U	260 U	260 U	260	260	260	
Energetics (ug/kg)											
1,3,5-TRINITROBENZENE	1600	250 U	250	250 U	250 U	195 J	115 J	250	250	250	
1,3-DINITROBENZENE	250 U	250 U	250	250 U	250 U	250 U	250 U	250	250	250	
2,4,6-TRINITROTOLUENE	565	250 U	250	60 J	175 J	1380	100 J	3820	250	250	
2-AMINO-4,6-DINITROTOLUENE	205 J	250 U	250	250 U	250 U	250	250 U	250	250	250	
4-AMINO-2,6-DINITROTOLUENE	340	250 U	105 J	250 U	60 J	440	125 J	760	250	250	
HMX	19200	2200 U	2200	6050	125 J	2880	170 J	64000	1500 J	295 J	
RDX	3020	1000 U	1000	1000 U	1000 U	1360	1000 U	192000	1000	1000	
TETRYL	650 U	650 U	650	650 U	650 U	650 U	650 U	650	650	650	

ANALYTICAL RESULTS FOR SOIL
AMMUNITION BURNING GROUND (ABG) AREA
NSWC CRANE, INDIANA

LOCATION	A06	A06	A07	A08
MEDIA	SO	SO	SO	SO
SAMPLE	CR95-03SS-A06-01-D	CR95-03SS-A06-01-MAX	CR95-03SS-A07-01	CR95-03SS-A08-01
DUPLICATE	DUP	MAX	NORMAL	NORMAL
TOP DEPTH (FT)	0	0	0	0
BOTTOM DEPTH (FT)	0	0	0	0
SAMPLE DATE	8/29/1995	8/29/1995	8/29/1995	8/29/1995
Dioxins/Furans (ng/kg)				
1,2,3,4,6,7,8-HPCDD	42.3 J	42.3 J	30 J	38.7 J
1,2,3,4,6,7,8-HPCDF	4.41 U	8.96 J	11.4 J	7.09 J
1,2,3,4,7,8,9-HPCDF	0.79 U	0.79 U	0.58 U	2.23 U
1,2,3,4,7,8-HXCDD	0.84	0.84	0.18 U	0.2 U
1,2,3,4,7,8-HXCDF	0.16 U	11 U	2.45	1.03 U
1,2,3,6,7,8-HXCDD	0.84 U	1.11	1.04 U	2.39
1,2,3,6,7,8-HXCDF	0.14 U	0.61 U	1.62 U	0.86 U
1,2,3,7,8,9-HXCDD	2.39	2.39	1.9	3.69
1,2,3,7,8,9-HXCDF	0.48 U	0.48 U	0.32 U	1.08 U
1,2,3,7,8-PECDD	0.21 U	0.22 U	0.17 U	0.49 U
1,2,3,7,8-PECDF	0.26 U	0.26 U	0.16 U	0.23 U
2,3,4,6,7,8-HXCDF	0.16 U	0.23 U	0.31 U	1.04 U
2,3,4,7,8-PECDF	0.25 U	0.25 U	0.16 U	0.23 U
2,3,7,8-TCDD	0.11 U	0.15 U	0.16 U	0.22 U
2,3,7,8-TCDF	0.13 U	0.14 U	1.81 J	2.23
OCDD	1510 J	1510 J	824 J	256 J
OCDF	10.3 J	25.4 J	31.1 J	13.4 J
Semivolatile Organics (ug/kg)				
2,4-DINITROTOLUENE				
2,6-DINITROTOLUENE				
Energetics (ug/kg)				
1,3,5-TRINITROBENZENE				
1,3-DINITROBENZENE				
2,4,6-TRINITROTOLUENE				
2-AMINO-4,6-DINITROTOLUENE				
4-AMINO-2,6-DINITROTOLUENE				
HMX				
RDX				
TETRYL				

APPENDIX A-3

ANALYTICAL RESULTS FOR GROUND WATER
JEEP TRAIL AREA
NSWC CRANE, INDIANA

LOCATION	03-07	03-10	03-11	03-12	03-13	03-14	03-15	03-16	03-17	03-18	03-20
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	03-07-GW-94	03-10-GW-94	03-11-GW-94	03-12-GW-94	03-13-GW-94	03-14-GW-94	03-15-GW-94	03-16-GW-94	03-17-GW-94	03-18-GW-94	03-20-GW-94
DUPLICATE	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE	9/14/1994	9/15/1994	9/15/1994	9/14/1994	9/14/1994	9/14/1994	9/14/1994	9/16/1994	9/14/1994	9/14/1994	9/14/1994
Volatile Organics (ug/L)											
1,1,1-TRICHLOROETHANE	250 U	5 U	5 U	5 U	5 U	5 U	1 J	5 U	5 U	5 U	5 U
1,1,2,2-TETRACHLOROETHANE	2100	5 U	5 U	5 U	5 U	5 U	8.4	5 U	5 U	5 U	5 U
1,1,2-TRICHLOROETHANE	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1-DICHLOROETHANE	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1-DICHLOROETHENE	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,2-DICHLOROETHANE	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,2-DICHLOROPROPANE	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
2-BUTANONE	1300 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
2-HEXANONE	1300 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
4-METHYL-2-PENTANONE	1300 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
ACETONE	1300 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
BENZENE	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
BROMODICHLOROMETHANE	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
BROMOFORM	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
BROMOMETHANE	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
CARBON DISULFIDE	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
CARBON TETRACHLORIDE	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
CHLOROBENZENE	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
CHLORODIBROMOMETHANE	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
CHLOROETHANE	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
CHLOROFORM	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
CHLOROMETHANE	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
CIS-1,2-DICHLOROETHENE	1000	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
CIS-1,3-DICHLOROPROPENE	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
ETHYLBENZENE	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
METHYLENE CHLORIDE	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
STYRENE	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
TETRACHLOROETHENE	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
TOLUENE	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
TRANS-1,2-DICHLOROETHENE	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
TRANS-1,3-DICHLOROPROPENE	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
TRICHLOROETHENE	4000	5 U	5 U	4.6 J	5 U	5 U	7.7	5 U	5 U	5 U	5 U
VINYL ACETATE	1300 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
VINYL CHLORIDE	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
XYLENES, TOTAL	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U

APPENDIX A-3

ANALYTICAL RESULTS FOR GROUND WATER
JEEP TRAIL AREA
NSWC CRANE, INDIANA

LOCATION	03-07	03-10	03-11	03-12	03-13	03-14	03-15	03-16	03-17	03-18	03-20
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	03-07-GW-94	03-10-GW-94	03-11-GW-94	03-12-GW-94	03-13-GW-94	03-14-GW-94	03-15-GW-94	03-16-GW-94	03-17-GW-94	03-18-GW-94	03-20-GW-94
DUPLICATE	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE	9/14/1994	9/15/1994	9/15/1994	9/14/1994	9/14/1994	9/14/1994	9/14/1994	9/15/1994	9/14/1994	9/14/1994	9/14/1994
Energetics (ug/L)											
1,3,5-TRINITROBENZENE	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
1,3-DINITROBENZENE	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
2,4,6-TRINITROTOLUENE	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
2,4-DINITROTOLUENE	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
2,6-DINITROTOLUENE	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
2-AMINO-4,6-DINITROTOLUENE	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
4-AMINO-2,6-DINITROTOLUENE	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
HMX	20 U	20 U	20 U	94	93	45	20 U	20 U	13	20 U	20 U
RDX	20 U	13 J	20 U	79	91	14 J	20 U	40	15	20 U	20 U
TETRYL	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Metals (ug/L)											
ALUMINUM	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	646	25 U	25 U
ANTIMONY	3 U	7.2	3 U	5.2	3 U	3 U	3 U	7.4	3 U	6	3 U
ARSENIC	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
BARIUM	44	75	68	47	46	105	48	47	36	45	48
BERYLLIUM	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
CADMIUM	1.9	0.2 U	0.2 U	0.2 U	0.3	0.2 U	0.2 U	0.2 U	0.38	0.2 U	2.87
CALCIUM	258000	99900	104000	57100	76300	113000	82100	56700	59600	63800	63400
CHROMIUM	8 U	8 U	8 U	8 U	8 U	8 U	8 U	8 U	8 U	8 U	8 U
COBALT	15 U	15 U	15 U	15 U	15 U	15 U	15 U	15 U	15 U	15 U	15 U
COPPER	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
IRON	121	25 U	25 U	25 U	25 U	25 U	25 U	25 U	1010	25 U	25 U
LEAD	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	5.2	1 U	1 U
MAGNESIUM	419000	14100	9670	8540	7990	12100	10100	4530	3910	7660	4190
MANGANESE	8610	18	5 U	5 U	5 U	5 U	5 U	5 U	260	5 U	5 U
MERCURY	0.02	0.03	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
NICKEL	16	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
POTASSIUM	68000	2100	3310	3040	2210	3790	3430	1320	1250	1890	1330
SELENIUM	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
SILVER	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
THALLIUM	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
TIN	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
VANADIUM	23	8	9	17	8	9	8	7 U	7 U	11	35
ZINC	10 U	10 U	13	10 U	10 U	10 U	10 U	10	10 U	10 U	10 U
Miscellaneous (mg/L)											

APPENDIX A-3

ANALYTICAL RESULTS FOR GROUND WATER
JEEP TRAIL AREA
NSWC CRANE, INDIANA

LOCATION	03-07	03-10	03-11	03-12	03-13	03-14	03-15	03-16	03-17	03-18	03-20
MEDIA	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
SAMPLE	03-07-GW-94	03-10-GW-94	03-11-GW-94	03-12-GW-94	03-13-GW-94	03-14-GW-94	03-15-GW-94	03-16-GW-94	03-17-GW-94	03-18-GW-94	03-20-GW-94
DUPLICATE	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE	9/14/1994	9/15/1994	9/15/1994	9/14/1994	9/14/1994	9/14/1994	9/14/1994	9/15/1994	9/14/1994	9/14/1994	9/14/1994
NITRATE/NITRITE	0.183	1.32	0.922	0.752	0.527	0.198	0.251	2.99	0.212	0.389	0.918
SODIUM	10.6	3.07	2.85	3.19	6.83	2.73	2.22	4.14	1.95	2.67	1.28

APPENDIX A-3

ANALYTICAL RESULTS FOR GROUND WATER
JEEP TRAIL AREA
NSWC CRANE, INDIANA

LOCATION	03-21	03-22	03-23	03-24	03-25
MEDIA	GW	GW	GW	GW	GW
SAMPLE	03-21-GW-94	03-22-GW-94	03-23-GW-94	03-24-GW-94	03-25-GW-94
DUPLICATE	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE	9/14/1994	9/14/1994	9/14/1994	9/14/1994	9/14/1994
Volatile Organics (ug/L)					
1,1,1-TRICHLOROETHANE	5 U	5 U	5 U	5 U	5 U
1,1,2,2-TETRACHLOROETHANE	5 U	4.2 J	5 U	3.6 J	5 U
1,1,2-TRICHLOROETHANE	5 U	5 U	5 U	5 U	5 U
1,1-DICHLOROETHANE	5 U	5 U	5 U	5 U	5 U
1,1-DICHLOROETHENE	5 U	5 U	5 U	5 U	5 U
1,2-DICHLOROETHANE	5 U	5 U	5 U	5 U	5 U
1,2-DICHLOROPROPANE	5 U	5 U	5 U	5 U	5 U
2-BUTANONE	25 U	25 U	25 U	25 U	25 U
2-HEXANONE	25 U	25 U	25 U	25 U	25 U
4-METHYL-2-PENTANONE	25 U	25 U	25 U	25 U	25 U
ACETONE	25 U	25 U	25 U	25 U	25 U
BENZENE	5 U	5 U	5 U	5 U	5 U
BROMODICHLOROMETHANE	5 U	5 U	5 U	5 U	5 U
BROMOFORM	5 U	5 U	5 U	5 U	5 U
BROMOMETHANE	5 U	5 U	5 U	5 U	5 U
CARBON DISULFIDE	5 U	5 U	5 U	5 U	5 U
CARBON TETRACHLORIDE	5 U	5 U	5 U	5 U	5 U
CHLOROBENZENE	5 U	5 U	5 U	5 U	5 U
CHLORODIBROMOMETHANE	5 U	5 U	5 U	5 U	5 U
CHLOROETHANE	5 U	5 U	5 U	5 U	5 U
CHLOROFORM	5 U	5 U	5 U	5 U	5 U
CHLOROMETHANE	5 U	5 U	5 U	5 U	5 U
CIS-1,2-DICHLOROETHENE	5 U	5 U	5 U	9.3	5 U
CIS-1,3-DICHLOROPROPENE	5 U	5 U	5 U	5 U	5 U
ETHYLBENZENE	5 U	5 U	5 U	5 U	5 U
METHYLENE CHLORIDE	5 U	5 U	5 U	5 U	5 U
STYRENE	5 U	5 U	5 U	5 U	5 U
TETRACHLOROETHENE	5 U	5 U	5 U	5 U	5 U
TOLUENE	5 U	5 U	5 U	5 U	5 U
TRANS-1,2-DICHLOROETHENE	5 U	5 U	5 U	1.2 J	5 U
TRANS-1,3-DICHLOROPROPENE	5 U	5 U	5 U	5 U	5 U
TRICHLOROETHENE	5 U	4 J	5 U	16	0.76 J
VINYL ACETATE	25 U	25 U	25 U	25 U	25 U
VINYL CHLORIDE	5 U	5 U	5 U	5 U	5 U
XYLENES, TOTAL	5 U	5 U	5 U	5 U	5 U

ANALYTICAL RESULTS FOR GROUND WATER
JEEP TRAIL AREA
NSWC CRANE, INDIANA

LOCATION	03-21	03-22	03-23	03-24	03-25
MEDIA	GW	GW	GW	GW	GW
SAMPLE	03-21-GW-94	03-22-GW-94	03-23-GW-94	03-24-GW-94	03-25-GW-94
DUPLICATE	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE	9/14/1994	9/14/1994	9/14/1994	9/14/1994	9/14/1994
Energetics (ug/L)					
1,3,5-TRINITROBENZENE	20 U	20 U	20 U	20 U	20 U
1,3-DINITROBENZENE	20 U	20 U	20 U	20 U	20 U
2,4,6-TRINITROTOLUENE	20 U	20 U	20 U	20 U	20 U
2,4-DINITROTOLUENE	20 U	20 U	20 U	20 U	20 U
2,6-DINITROTOLUENE	20 U	20 U	20 U	20 U	20 U
2-AMINO-4,6-DINITROTOLUENE	20 U	20 U	20 U	20 U	20 U
4-AMINO-2,6-DINITROTOLUENE	20 U	20 U	20 U	20 U	20 U
HMX	134	20 U	25	20 U	20 U
RDX	365	20 U	13 J	20 U	20 U
TETRYL	50 U	50 U	50 U	50 U	50 U
Metals (ug/L)					
ALUMINUM	25 U	25 U	25 U	435	25 U
ANTIMONY	3 U	3.9	3 U	3.6	3.4
ARSENIC	2 U	2 U	2 U	2 U	2 U
BARIUM	104	162	46	46	25 U
BERYLLIUM	1 U	1 U	1 U	1 U	1 U
CADMIUM	0.2 U	0.41	0.2 U	0.53	0.2 U
CALCIUM	98600	139000	99900	95800	27100
CHROMIUM	8 U	8 U	8 U	8 U	8 U
COBALT	15 U	15 U	15 U	15 U	15 U
COPPER	5 U	5 U	5 U	5 U	5 U
IRON	25 U	25 U	25 U	904	25 U
LEAD	1 U	1 U	1.6	4.3	1 U
MAGNESIUM	14400	34500	11000	23100	979
MANGANESE	5 U	16	5 U	193	5 U
MERCURY	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
NICKEL	5 U	5 U	5 U	5 U	5 U
POTASSIUM	3210	12600	1680	1480	877
SELENIUM	2 U	2 U	2 U	2 U	2 U
SILVER	10 U	10 U	10 U	10 U	10 U
THALLIUM	2 U	2 U	2 U	2 U	2 U
TIN	50 U	50 U	50 U	50 U	50 U
VANADIUM	34	33	33	7 U	9
ZINC	10 U	10 U	10 U	24	10 U
Miscellaneous (mg/L)					

APPENDIX A-3

ANALYTICAL RESULTS FOR GROUND WATER
JEEP TRAIL AREA
NSWC CRANE, INDIANA

LOCATION	03-21	03-22	03-23	03-24	03-25
MEDIA	GW	GW	GW	GW	GW
SAMPLE	03-21-GW-94	03-22-GW-94	03-23-GW-94	03-24-GW-94	03-25-GW-94
DUPLICATE	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE	9/14/1994	9/14/1994	9/14/1994	9/14/1994	9/14/1994
NITRATE/NITRITE	1.13	2.2	0.026	0.904	0.311
SODIUM	4.26	2	4.35	10.3	2.97

APPENDIX A-4

ANALYTICAL RESULTS FOR SOIL
JEEP TRAIL AREA
NSWC CRANE, INDIANA
PAGE 1 OF 2

LOCATION	A01	A01	A01	A02	A03	A04	A05
MEDIA	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
SAMPLE	CR95-03SS-A01-01	CR95-03SS-A01-01-D	CR95-03SS-A01-01-MAX	CR95-03SS-A02-01	CR95-03SS-A03-01	CR95-03SS-A04-01	CR95-03SS-A05-01
DUPLICATE	DUP	DUP	MAX	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE	8/29/1995	8/29/1995	8/29/1995	8/29/1995	8/29/1995	8/29/1995	8/29/1995
Semivolatile Organics (ug/kg)							
1,2,4-TRICHLOROBENZENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
1,2-DICHLOROBENZENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
1,3-DICHLOROBENZENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
1,4-DICHLOROBENZENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
2,2'-OXYBIS(1-CHLOROPROPANE)	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
2,4,5-TRICHLOROPHENOL	1100 U	23000 U	23000 U	980 U	1000 U	960 U	920 U
2,4,6-TRICHLOROPHENOL	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
2,4-DICHLOROPHENOL	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
2,4-DIMETHYLPHENOL	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
2,4-DINITROPHENOL	1100 U	23000 U	23000 U	980 U	1000 U	960 U	920 U
2,4-DINITROTOLUENE	130 J	76000	76000 J	99 J	420 U	580	380 U
2,6-DINITROTOLUENE	460 U	4000 J	4000 J	400 U	420 U	39 J	380 U
2-CHLORONAPHTHALENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
2-CHLOROPHENOL	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
2-METHYLNAPHTHALENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
2-METHYLPHENOL	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
2-NITROANILINE	1100 U	23000 U	23000 U	980 U	1000 U	960 U	920 U
2-NITROPHENOL	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
3,3'-DICHLOROBENZIDINE	460 U	9600 UJ	9600 U	400 U	420 U	400 U	380 U
3-NITROANILINE	1100 U	23000 U	23000 U	980 U	1000 U	960 U	920 U
4,6-DINITRO-2-METHYLPHENOL	1100 U	23000 U	23000 U	980 U	1000 U	960 U	920 U
4-BROMOPHENYL PHENYL ETHER	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
4-CHLORO-3-METHYLPHENOL	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
4-CHLOROANILINE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
4-CHLOROPHENYL PHENYL ETHER	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
4-METHYLPHENOL	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
4-NITROANILINE	1100 U	23000 U	23000 U	980 U	1000 U	960 U	920 U
4-NITROPHENOL	1100 U	23000 UJ	23000 U	980 U	1000 U	960 U	920 U
ACENAPHTHENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
ACENAPHTHYLENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
ANTHRACENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
BENZO(A)ANTHRACENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
BENZO(A)PYRENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
BENZO(B)FLUORANTHENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
BENZO(G,H,I)PERYLENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
BENZO(K)FLUORANTHENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
BIS(2-CHLOROETHOXY)METHANE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
BIS(2-CHLOROETHYL)ETHER	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
BIS(2-ETHYLHEXYL)PHTHALATE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
BUTYL BENZYL PHTHALATE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
CARBAZOLE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
CHRYSENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
DI-N-BUTYL PHTHALATE	46 J	56000	56000 J	130 J	50 J	1000	24 J
DI-N-OCTYL PHTHALATE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
DIBENZO(A,H)ANTHRACENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
DIBENZOFURAN	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
DIETHYL PHTHALATE	460 U	9600 U	9600 U	400 U	23 J	400 U	380 U
DIMETHYL PHTHALATE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
FLUORANTHENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
FLUORENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
HEXACHLOROBENZENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
HEXACHLOROBUTADIENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
HEXACHLOROCYCLOPENTADIENE	460 UJ	9600 U	9600 UJ	400 UJ	420 UJ	400 UJ	380 UJ
HEXACHLOROETHANE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U

APPENDIX A-4

ANALYTICAL RESULTS FOR SOIL
JEEP TRAIL AREA
NSWC CRANE, INDIANA

LOCATION	A01	A01	A01	A02	A03	A04	A05
MEDIA	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
SAMPLE	CR95-03SS-A01-01	CR95-03SS-A01-01-D	CR95-03SS-A01-01-MAX	CR95-03SS-A02-01	CR95-03SS-A03-01	CR95-03SS-A04-01	CR95-03SS-A05-01
DUPLICATE	DUP	DUP	MAX	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE	8/29/1995	8/29/1995	8/29/1995	8/29/1995	8/29/1995	8/29/1995	8/29/1995
INDENO(1,2,3-CD)PYRENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
ISOPHORONE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
N-NITROSO-DI-N-PROPYLAMINE	460 U	9600 UJ	9600 U	400 U	420 U	400 U	380 U
N-NITROSODIPHENYLAMINE	460 U	8100 J	8100 J	400 U	420 U	48 J	380 U
NAPHTHALENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
NITROBENZENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
PENTACHLOROPHENOL	1100 U	23000 U	23000 U	980 U	1000 U	960 U	920 U
PHENANTHRENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
PHENOL	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
PYRENE	460 U	9600 U	9600 U	400 U	420 U	400 U	380 U
Energetics (ug/kg)							
1,3,5-TRINITROBENZENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U
1,3-DINITROBENZENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U
2,4,6-TRINITROTOLUENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U
2,4-DINITROTOLUENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U
2,6-DINITROTOLUENE	260 U	260 U	260 U	260 U	260 U	260 U	260 U
2-NITROTOLUENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U
3-NITROTOLUENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U
4-NITROTOLUENE	250 U	250 U	250 U	250 U	250 U	250 U	250 U
HMX	2310	1110 J	2310	2200 U	967 J	449 J	2200 U
NITROBENZENE	260 U	260 U	260 U	260 U	260 U	260 U	260 U
RDX	2070 J	772 J	2070 J	1000 U	1000 U	1000 U	1000 U
TETRYL	650 U	650 U	650 U	650 U	650 U	650 U	650 U
Metals (mg/kg)							
ALUMINUM	6010 J	6480 J	6480 J	3810 J	5340 J	7550 J	9050 J
ANTIMONY	0.77 UJ	0.82 UJ	0.82 UJ	0.75 UJ	1.3 J	0.71 UJ	0.93 J
ARSENIC	7.8	8.7	8.7	6.5	6	8.6	14.3
BARIUM	163	164	164	121	167	340	2720
BERYLLIUM	0.71	0.74	0.74	0.72	0.59	0.55	0.9
CADMIUM	1.8	1.7	1.8	0.99	0.78	1	0.23 U
CALCIUM	7580 J	7720 J	7720 J	9350 J	3760 J	2930 J	7040 J
CHROMIUM	11.2	12.9	12.9	8.5	7.3	13.2	14
COBALT	12.1	10.8	12.1	10.5	11.1	9.9	20 J
COPPER	41.3	46.5	46.5	19.2	54.7	91.6	20.2
CYANIDE	0.42	0.47	0.47	0.29	0.2	0.45	0.43
IRON	16800 J	17000 J	17000 J	12800 J	11100 J	14900 J	30900 J
LEAD	155 UJ	165 UJ	165 UJ	123 UJ	76 UJ	92.2 UJ	32.1 J
MAGNESIUM	1090	1160	1160	1110	753	977	1610
MANGANESE	1070	1040	1070	1040	1000	1040	839
MERCURY	0.13 U	0.14 U	0.14 U	0.13 U	0.13 U	0.12 U	0.12 U
NICKEL	13.6	13.6	13.6	11.5	13.3	12.7	28.2
POTASSIUM	891 U	862 U	891 U	864 U	628 U	911 U	2140
SELENIUM	0.6	0.62	0.62	0.5 U	0.5 U	0.48 U	0.68
SILVER	0.26 U	0.27 U	0.27 U	0.25 U	0.25 U	0.55	0.23 U
SODIUM	36.6 U	38.7 U	38.7 U	35.5 U	35.8 U	33.8 U	33.1 U
THALLIUM	0.52 U	0.55 U	0.55 U	0.5 U	0.5 U	0.48 U	0.57 U
VANADIUM	15.3	15.4	15.4	12.3	10.4	16	19.2 J
ZINC	166	169	169	71.6	130	301	131

APPENDIX B

TABULAR REPRESENTATION OF RBSLs

APPENDIX B-1

TABULAR PRESENTATION OF RBSLs FOR RBTL SELECTION
NSWC CRANE, INDIANA

PARAMETER	CAS	REGION 5 ECO DQLs SURFACE WATER (ug/L)	Footnote	FEDERAL MCLs (ug/L)	Footnote	FEDERAL AWQCs FRESHWATER ACUTE (ug/L)	Footnote	FEDERAL AWQCs FRESHWATER CHRONIC (ug/L)	Footnote	IDEM TIER 1 DEFAULT RESIDENTIAL GW CLOSURE LEVELS (ug/L)	IDEM TIER 1 DEFAULT INDUSTRIAL GW CLOSURE LEVELS (ug/L)	Footnote	Footnote	REGION 9 TAP WATER PRGs (ug/L)	Footnote	MINIMUM CRITERIA VALUE	Footnote
EXPLOSIVES (SW-846 METHOD 8330)																	
1,3,5-Trinitrobenzene	99-35-4											N	N	1100	N	1100	
1,3-Dinitrobenzene	99-65-0	2.36										N	N	3.6	N	2.36	
2,4,6-Trinitrotoluene (TNT)	118-96-7											C	C	2.2	C	2.2	
2,4-Dinitrotoluene	121-14-2	230								1.2 C (15)	4.2 C (15)	N	N	73	N	1.2	
2,6-Dinitrotoluene	606-20-2	42								1.2 C (15)	4.2 C (15)	N	N	36	N	1.2	
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0											N	N	1800	N	1800	
2-Nitrotoluene	88-72-2													61		61	
3-Nitrotoluene	99-08-1											N	sat	61	N	61	
4-Nitrotoluene	99-99-0											N	sat	61	N	61	
4-Amino-2,6-dinitrotoluene	19406-51-0																
2-Amino-4,6-dinitrotoluene	35572-78-2																
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	479-45-8											N	N	360	N	360	
Nitrobenzene	98-95-3	740								4.3	51	N	N	3.4	N	3.4	
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4											C	C	0.61	C	0.61	
APPENDIX IX METALS (ANALYTICAL METHODS TO BE DETERMINED BASED ON LABORATORY CAPABILITIES)												0	0				
Antimony	7440-36-0	31		6						6	41	N	N	15	N	6	
Arsenic	7440-38-2	53		50		340		150		50 C	50 C	C	C	0.045	C	0.045	
Barium	7440-39-3	5000		2000						2000 C	7200	N	max	2600	N	2000	
Beryllium	7440-41-7	7.6		4						4 C	4 C	N	C	73	N	4	
Cadmium	7440-43-9	0.66		5		4.3	1	2.2	1	5	51	N	N	18	N	0.66	
Chromium (total)	7440-47-3	42		100		16	10	11	10	100	510	C	C	110 (10)	N	11	
Cobalt	7440-48-4	5										N	max	2200	N	5	
Copper	7440-50-8	5		1300	2,3	13	1	9	1	1300	3800	N	N	1400	N	5	
Lead	7439-92-1	1.3		15	2	65	1	2.5	1	15	42	N	N			1.3	
Mercury (SW-846 Method 7470A/7471A)	7439-97-6	0.0013		2		1.4		0.77		2	31			11	N	0.0013	
Nickel	7440-02-0	29		100	4	470	1	52	1	100	2000	N	N	730	N	29	
Selenium	7782-49-2	5		50				5		50	510	N	N	180	N	5	
Silver	7440-22-4	1		100	7	3.4	1			180	510	N	N	180	N	1	
Thallium	7440-28-0	0.56		2						2	9			2.9 (11)		0.56	
Tin	7440-31-5	73										N	max	22000	N	73	
Vanadium	7440-62-2	19										N	N	260	N	19	
Zinc	7440-66-6	58.9		5000	7	120	1	120	1	11000	31000	N	max	11000	N	58.9	
MISCELLANEOUS METALS (SW-846 METHOD 6010B)																	
Aluminum	7429-90-5			50-200	1	750		87				N	max	36000	N	87	
Calcium	7440-70-2																
Iron	7439-89-6			300	1			1000				N	max	11000	N	300	
Magnesium	7439-95-4																
Manganese	7439-96-5			50	1							N	N	880	N	50	
Potassium	7440-09-7																
Sodium	7440-23-5																
APPENDIX IX VOLATILE ORGANIC COMPOUNDS (SW-846 METHOD 8260B WITH 25 ML PURGE FOR WATER, 5 GM PURGE FOR SOIL)																	
1,1,1,2-Tetrachloroethane	630-20-6	90.25								6.9 C	110 C	C	C	0.43	C	0.43	
1,1,1-Trichloroethane	71-55-6	88		200						200	9200	N	sat	790	N	88	
1,1,2,2-Tetrachloroethane	79-34-5	13								0.9 C	14 C	C	C	0.055	C	0.055	
1,1,2-Trichloroethane	79-00-5	650		5						5 C	50 C	C	C	0.2	C	0.2	
1,1-Dichloroethane	75-34-3	47								990	10000	N	N	810	N	47	
1,1-Dichloroethene	75-35-4	78		7						7 C	7 C	C	C	0.046	C	0.046	
1,2,3-Trichloropropane	96-18-4	12.11										C	C	0.0016	C	0.0016	
1,2-Dibromo-3-chloropropane	96-12-8	11.2		0.2								C	C	0.048	C	0.048	
1,2-Dibromoethane	106-93-4	22.5		0.05								C	C	0.00076	C	0.00076	
1,2-Dichloroethane	107-06-2	190		5						5 C	31 C	C	C	0.12	C	0.12	
1,2-Dichloropropane	78-87-5	380		5						5 C	42 C	C	C	0.16	C	0.16	
1,4-Dioxane	123-91-1													6.1	C	6.1	
2-Butanone	78-93-3	7100								2500	61000	N	N	1900	N	1900	

APPENDIX B-1

TABULAR PRESENTATION OF RBSLs FOR RBTL SELECTION
NSWC CRANE, INDIANA

PARAMETER	CAS	REGION 5 ECO DQLs SURFACE WATER (ug/L)	Footnote	FEDERAL MCLs (ug/L)	Footnote	FEDERAL AWQCs FRESHWATER ACUTE (ug/L)	Footnote	FEDERAL AWQCs FRESHWATER CHRONIC (ug/L)	Footnote	IDEM TIER 1 DEFAULT RESIDENTIAL GW CLOSURE LEVELS (ug/L)	IDEM TIER 1 DEFAULT INDUSTRIAL GW CLOSURE LEVELS (ug/L)	Footnote	Footnote	REGION 9 TAP WATER PRGs (ug/L)	Footnote	MINIMUM CRITERIA VALUE	Footnote
2-Chloro-1,3-butadiene (chloroprene)	126-99-8											N	N	14	N	14	
2-Hexanone	591-78-6	1710												1500 (13)		1500	
4-Methyl-2-pentanone	108-10-1	3680										N	N	160	N	160	
Acetone	67-64-1	78000								770	10000	N	N	610	N	610	
Acetonitrile	75-05-8													79	N	79	
Acrolein	107-02-8	0.205								0.056	2000	N	N	0.042	N	0.042	
Acrylonitrile	107-13-1	0.89										C	C	0.039	C	0.039	
Allyl chloride (3-chloro-1-propene)	107-05-1											N	N	1800	N	1800	
Benzene	71-43-2	114		5						5 C	99 C	C	C	0.41	C	0.41	
Bromodichloromethane	75-27-4			80	9					100 C	100 C	C	C	0.18	C	0.18	
Bromoform	75-25-2	466		80	9					100 C	360 C	C	C	8.5	C	8.5	
Bromomethane	74-83-9									11	140	N	N	8.7	N	8.7	
Carbon disulfide	75-15-0	84.1								1300	10000	N	sat	1000	N	84.1	
Carbon tetrachloride	56-23-5	5.9		5						5 C	22 C	C	C	0.17	C	0.17	
Chlorobenzene	108-90-7	10		100						100	2000	N	N	110	N	10	
Chloroethane	75-00-3	230000										C	C	4.6	C	4.6	
Chloroform	67-66-3	79		80	9					100 C	470 C	C	C	0.16	C	0.16	
Chloromethane	74-87-3											C	C	1.5	C	1.5	
cis-1,2-Dichloroethene	156-59-2	310	5	70						70	1000	N	N	61	N	61	
cis-1,3-Dichloropropene	10061-01-5	7.9								1.3 C (12)	16 C (12)	C	C	0.081 (12)	C	0.081	
Dibromochloromethane	124-48-1	6400		80	9							C	C	0.13	C	0.13	
Dibromomethane	74-95-3											N	N	61	N	61	
Dichlorodifluoromethane	75-71-8											N	N	390	N	390	
Ethyl methacrylate	97-63-2											sat	sat	550	N	550	
Ethylbenzene	100-41-4	17.2		700						700	10000	sat	sat	1300	N	17.2	
Isobutyl alcohol	78-83-1													1800	N	1800	
Methacrylonitrile	126-98-7											N	N	1	N	1	
Methyl iodide	74-88-4																
Methyl methacrylate	80-62-6	2800										N	sat	1400	N	1400	
Methylene chloride	75-09-2	430		5						5 C	380 C	C	C	4.3	C	4.3	
Proprionitrile	107-12-0	6080														6080	
Styrene	100-42-5	56		100						100	20000	sat	sat	1600	N	56	
Tetrachloroethene	127-18-4	8.9		5						5 C	55 C	C	C	1.1	C	1.1	
Toluene	108-88-3	253		1000						1000	20000	sat	sat	720	N	253	
Total Xylenes	1330-20-7	117		10000						10000	180000	sat	sat	1400	N	117	
trans-1,2-Dichloroethene	156-60-5	310		100						100	2000	N	N	120	N	100	
trans-1,3-Dichloropropene	10061-02-6	7.9								1.3 C (12)	16 C (12)	C	C	0.081 (12)	C	0.081	
trans-1,4-Dichloro-2-butene	110-57-6													0.0012 (2)		0.0012	
Trichloroethene	79-01-6	75		5						5 C	260 C	C	C	1.6	C	1.6	
Trichlorofluoromethane	75-69-4											N	sat	1300	N	1300	
Vinyl acetate	108-05-4	248.03								550	100000	N	N	410	N	248.03	
Vinyl chloride	75-01-4	9.2		2						2 C	2 C	C	C	0.02	C	0.02	

APPENDIX B-1

TABULAR PRESENTATION OF RBSLs FOR RBTL SELECTION
NSWC CRANE, INDIANA

PARAMETER	CAS	REGION 5 ECO DQLs SURFACE WATER (ug/L)	Footnote	FEDERAL MCLs (ug/L)	Footnote	FEDERAL AWQCs FRESHWATER ACUTE (ug/L)	Footnote	FEDERAL AWQCs FRESHWATER CHRONIC (ug/L)	Footnote	IDEM TIER 1 DEFAULT RESIDENTIAL GW CLOSURE LEVELS (ug/L)	IDEM TIER 1 DEFAULT INDUSTRIAL GW CLOSURE LEVELS (ug/L)	Footnote	Footnote	REGION 9 TAP WATER PRGs (ug/L)	Footnote	MINIMUM CRITERIA VALUE	Footnote
APPENDIX IX SEMIVOLATILE ORGANIC COMPOUNDS (SW-846 METHOD 8270C; 8270C SIM OR 8310, BASED ON LABORATORY CAPABILITIES, WHERE NOTED)												0	0				
1,2,4,5-Tetrachlorobenzene	95-94-3	26.24										N	N	11	N	11	
1,2,4-Trichlorobenzene	120-82-1	69.2		70						70	1000	N	sat	190	N	69.2	
1,2-Dichlorobenzene	95-50-1	11		600						600	9200	sat	sat	370	N	11	
1,3-Dichlorobenzene	541-73-1	87								22	3100	N	N	5.5	N	5.5	
1,4-Dichlorobenzene	106-46-7	43		75						75 C	120 C	C	C	0.5	C	0.5	
1,4-Naphthoquinone	130-15-4																
1,4-Phenylenediamine	106-50-3											N	max	6900	N	6900	
1-Naphthylamine	134-32-7	0.67														0.67	
2,3,4,6-Tetrachlorophenol	58-90-2	14.06										N	N	1100	N	14.06	
2,4,5-Trichlorophenol	95-95-4									3600	10000	N	N	3600	N	3600	
2,4,6-Trichlorophenol	88-06-2	2								77 C	26 C	C	C	6.1	C	2	
2,4-Dichlorophenol	120-83-2	18								110	310	N	N	110	N	18	
2,4-Dimethylphenol	105-67-9	100.17								730	2000	N	N	730	N	100.17	
2,4-Dinitrophenol	51-28-5	4.07								73	200	N	N	73	N	4.07	
2,6-Dichlorophenol	87-65-0																
2-Acetylaminofluorene	53-96-3	534.97														534.97	
2-Chloronaphthalene	91-58-7	0.396										N	N	490	N	0.396	
2-Chlorophenol	95-57-8	8.8								38	510	N	N	30	N	8.8	
2-Methylnaphthalene (by SIM)	91-57-6	329.55														329.55	
2-Methylphenol	95-48-7									1800	5100	N	N	1800	N	1800	
2-Naphthylamine	91-59-8																
2-Nitroaniline	88-74-4											N	N	2.1	N	2.1	
2-Nitrophenol	88-75-5	13.5												290 (14)	N	13.5	
2-Picoline	109-06-8	3790														3790	
3,3'-Dichlorobenzidine	91-94-1	99.75								1.9 C	6.4 C	C	C	0.15	C	0.15	
3,3'-Dimethylbenzidine	119-93-7											C	C	0.0073	C	0.0073	
3-Methylcholanthrene	56-49-5	0.0891														0.0891	
3-Methylphenol	108-39-4											N	N	1800	N	1800	
3-Nitroaniline	99-09-2																
4,6-Dinitro-2-methylphenol	534-52-1	2.3														2.3	
4-Aminobiphenyl	92-67-1																
4-Bromophenyl phenyl ether	101-55-3	1.5														1.5	
4-Chloro-3-methylphenol	59-50-7	20														20	
4-Chloroaniline	106-47-8	231.97								150	410	N	N	150	N	150	
4-Chlorophenyl phenyl ether	7005-72-3																
4-Methylphenol	106-44-5											N	N	180	N	180	
4-Nitroaniline	100-01-6																
4-Nitrophenol	100-02-7	35										N	N	290	N	35	
4-Nitroquinoline-1-oxide	56-57-5																
5-Nitro-o-toluidine	99-55-8											C	C	2	C	2	
7,12-Dimethylbenz(a)anthracene	57-97-6																
a,a-Dimethylphenethylamine	122-09-8	300.16										N	N	37	N	37	
Acenaphthene (by SIM)	83-32-9	9.9								460	4200	N	N	370	N	9.9	
Acenaphthylene (by SIM)	208-96-8	4840								460 (19)	460 (19)			370 (19)	N	370	
Acetophenone	98-86-2	687.89										N	N	0.042	N	0.042	
Aniline	62-53-3	0.44										C	C	12	C	0.44	
Anthracene (by SIM)	120-12-7	0.029								43	43	N	max	1800	N	0.029	
Aramite	140-57-8	3.09										C	C	2.7	C	2.7	
Benzo(a)anthracene (by SIM)	56-55-3	0.839								1.2 C	3.9 C	C	C	0.092	C	0.092	
Benzo(a)pyrene (by SIM)	50-32-8	0.014		0.2						0.2 C	0.39 C	C	C	0.0092	C	0.0092	
Benzo(b)fluoranthene (by SIM)	205-99-2	9.07								1.2 C	1.5 C	C	C	0.092	C	0.092	
Benzo(g,h,i)perylene (by SIM)	191-24-2	7.64								8.3 (20)	8.3 (20)			6.2 (20)	N	6.2	
Benzo(k)fluoranthene (by SIM)	207-08-9	0.0056								0.8 C	0.8 C	C	C	0.92	C	0.0056	
Benzyl alcohol	100-51-6	281.24										N	max	11000	N	281.24	

APPENDIX B-1

TABULAR PRESENTATION OF RBSLs FOR RBTL SELECTION
NSWC CRANE, INDIANA

PARAMETER	CAS	REGION 5 ECO DQLs SURFACE WATER (ug/L)	Footnote	FEDERAL MCLs (ug/L)	Footnote	FEDERAL AWQCs FRESHWATER ACUTE (ug/L)	Footnote	FEDERAL AWQCs FRESHWATER CHRONIC (ug/L)	Footnote	IDEM TIER 1 DEFAULT RESIDENTIAL GW CLOSURE LEVELS (ug/L)	IDEM TIER 1 DEFAULT INDUSTRIAL GW CLOSURE LEVELS (ug/L)	Footnote	Footnote	REGION 9 TAP WATER PRGs (ug/L)	Footnote	MINIMUM CRITERIA VALUE	Footnote
Bis(2-chloroethoxy)methane	111-91-1	6400														6400	
Bis(2-chloroethyl)ether	111-44-4	1140								0.15 C	2.6 C	C	C	0.0098	C	0.0098	
Bis(2-chloroisopropyl)ether	39638-32-9											C	C	0.27	C	0.27	
Bis(2-ethylhexyl)phthalate	117-81-7	2.1		6						6 C	200 C	C	C	4.8	C	2.1	
Butyl benzyl phthalate	85-68-7	49								2700	2700	N	max	7300	N	49	
Chlorobenzilate	510-15-6	7.16										C	C	0.25	C	0.25	
Chrysene (by SIM)	218-01-9	0.033								1.6 C	1.6 C	C	C	9.2	C	0.033	
Diallate	2303-16-4	29										C	C	1.1	C	1.1	
Dibenzo(a,h)anthracene (by SIM)	53-70-3	0.0016								0.12 C	0.39 C	C	C	0.0092	C	0.0016	
Dibenzofuran	132-64-9	20										N	N	24	N	20	
Diethyl phthalate	84-66-2	3								29000	82000	N	max	29000	N	3	
Dimethyl phthalate	131-11-3	73										max	max	360000	N	73	
Di-n-butyl phthalate	84-74-2	3								3600	10000	N	N	3600	N	3	
Di-n-octyl phthalate	117-84-0	30								20	20	N	sat	730	N	20	
Diphenylamine	122-39-4	412.51										N	N	910	N	412.51	
Ethyl methane sulfonate	62-50-0																
Ethyl parathion	56-38-2	0.008				0.065		0.013				N	N	220	N	0.008	
Famphur	52-85-7																
Fluoranthene (by SIM)	206-44-0	8.1								210	210	N	N	1500	N	8.1	
Fluorene (by SIM)	86-73-7	3.9								310	2000	N	N	240	N	3.9	
Hexachlorobenzene	118-74-1	0.00024		1						1 C	1.8 C	C	C	0.042	C	0.00024	
Hexachlorobutadiene	87-68-3	0.223								7.3	20	C	C	0.86	C	0.223	
Hexachlorocyclopentadiene	77-47-4	77.04		50						50	720	N	N	260	N	50	
Hexachloroethane	67-72-1	30.5								36	100	C	C	4.8	C	4.8	
Hexachloropropene	1888-71-7	20														20	
Indeno(1,2,3-cd)pyrene (by SIM)	193-39-5	4.31								0.022 C	0.022 C	C	C	0.092	C	0.092	
Isodrin	465-73-6	0.0309														0.0309	
Isophorone	78-59-1	900								900 C	3000 C	C	C	71	C	71	
Isosafrole	120-58-1																
Kepone	143-50-0	0.132										C	C	0.0037	C	0.0037	
Methapyrilene	91-80-5																
Methyl methane sulfonate	66-27-3																
Methyl parathion	298-00-0											N	N	9.1	N	9.1	
Naphthalene (by SIM)	91-20-3	44								8.3	2000	N	N	6.2	N	6.2	
n-Nitrosodiethylamine	55-18-5	767.94										C	C	0.00045	C	0.00045	
n-Nitrosodimethylamine	62-75-9											C	C	0.0013	C	0.0013	
n-Nitrosodi-n-butylamine	924-16-3	1000										C	C	0.002	C	0.002	
n-Nitrosodi-n-propylamine	621-64-7									0.12 C	0.41 C	C	C	0.0096	C	0.0096	
n-Nitrosomethylethylamine	10595-95-6											C	C	0.0031	C	0.0031	
n-Nitrosomorpholine	59-89-2																
n-Nitrosopiperidine	100-75-4																
n-Nitrosopyrrolidine	930-55-2											C	C	0.032	C	0.032	
O,O,O-Triethyl phosphorothioate	126-68-1	58.25														58.25	
o-Toluidine	95-53-4											C	C	0.28	C	0.28	
p-(Dimethylamino)azobenzene	60-11-7																
Pentachlorobenzene	608-93-5	0.47										N	N	29	N	0.47	
Pentachloroethane	76-01-7	56.42														56.42	
Pentachloronitrobenzene	82-68-8	50										C	C	0.26	C	0.26	
Pentachlorophenol	87-86-5	5.23		1		19		15		1 C	24 C	C	C	0.56	C	0.56	
Phenacetin	62-44-2																
Phenanthrene (by SIM)	85-01-8	2.1								8.3 (20)	2000 (20)			6.2 (20)	N	2.1	
Phenol	108-95-2	100								22000	61000	N	max	22000	N	100	
Pronamide	23950-58-5	160										N	N	2700	N	160	
Pyrene (by SIM)	129-00-0	0.3								140	140	N	N	180	N	0.3	
Pyridine	110-86-1	2380										N	N	37	N	37	

APPENDIX B-1

TABULAR PRESENTATION OF RBSLs FOR RBTL SELECTION
NSWC CRANE, INDIANA

PARAMETER	CAS	REGION 5 ECO DQLs SURFACE WATER (ug/L)	Footnote	FEDERAL MCLs (ug/L)	Footnote	FEDERAL AWQCs FRESHWATER ACUTE (ug/L)	Footnote	FEDERAL AWQCs FRESHWATER CHRONIC (ug/L)	Footnote	IDEM TIER 1 DEFAULT RESIDENTIAL GW CLOSURE LEVELS (ug/L)	IDEM TIER 1 DEFAULT INDUSTRIAL GW CLOSURE LEVELS (ug/L)	Footnote	Footnote	REGION 9 TAP WATER PRGs (ug/L)	Footnote	MINIMUM CRITERIA VALUE	Footnote
Safrole	94-59-7	40														40	
APPENDIX IX ORGANOCHLORINE PESTICIDES and PCBs (SW-846 METHOD 8081A and 8082)												0	0				
4,4'-DDD	72-54-8	0.0011								3.6 C	12 C	C	C	0.28	C	0.0011	
4,4'-DDE	72-55-9	0.00000000451								2.5 C	8.4 C	C	C	0.2	C	0.00000000451	
4,4'-DDT	50-29-3	0.001				1.1		0.001		2.5 C	8.4 C	C	C	0.2	C	0.001	
Aldrin	309-00-2	0.0309				3				0.05 C	0.17 C	C	C	0.004	C	0.004	
Alpha-BHC	319-84-6	12.38								0.14 C	0.45 C	C	C	0.011	C	0.011	
Alpha-chlordane	5103-71-9	0.00029	6	2	6	2.4	6	0.0043	6	2 C (6)	8.2 C (6)	C	C	0.19 (6)	C	0.00029	
Aroclor-1016	12674-11-2	0.000029	8	0.5	8			0.014	8	0.5 C (8)	1.4 C (8)	N	C	0.96	C	0.000029	
Aroclor-1221	11104-28-2	0.000029	8	0.5	8			0.014	8	0.5 C (8)	1.4 C (8)	C	C	0.034	C	0.000029	
Aroclor-1232	11141-16-5	0.000029	8	0.5	8			0.014	8	0.5 C (8)	1.4 C (8)	C	C	0.034	C	0.000029	
Aroclor-1242	53469-21-9	0.000029	8	0.5	8			0.014	8	0.5 C (8)	1.4 C (8)	C	C	0.034	C	0.000029	
Aroclor-1248	12672-29-6	0.000029	8	0.5	8			0.014	8	0.5 C (8)	1.4 C (8)	C	C	0.034	C	0.000029	
Aroclor-1254	11097-69-1	0.000029	8	0.5	8			0.014	8	0.5 C (8)	1.4 C (8)	C	C	0.034	C	0.000029	
Aroclor-1260	11096-82-5	0.000029	8	0.5	8			0.014	8	0.5 C (8)	1.4 C (8)	C	C	0.034	C	0.000029	
Beta-BHC	319-85-7	0.495								0.47 C	1.6 C	C	C	0.037	C	0.037	
Delta-BHC	319-86-8	666.67								0.14 C (17)	0.45 C (17)			0.011 (17)		0.011	
Dieldrin	60-57-1	0.000026				0.24		0.056		0.053 C	0.18 C	C	C	0.0042	C	0.000026	
Endosulfan I	959-98-8	0.003				0.22		0.056		0.22 C (16)	0.51 C (16)			220	NC	0.003	
Endosulfan II	33213-65-9	0.003				0.22		0.056		0.22 C (16)	0.51 C (16)			220	NC	0.003	
Endosulfan sulfate	1031-07-8	2.22								0.22 C (16)	0.51 C (16)			220	NC	0.22	
Endrin	72-20-8	0.002		2		0.086		0.036		2	31	N	N	11	N	0.002	
Endrin aldehyde	7421-93-4	0.15								2 (18)	31 (18)			11	N	0.15	
Gamma-BHC (Lindane)	58-89-9	0.01		0.2		0.95				0.2 C	2.2 C	C	C	0.052	C	0.01	
Gamma-chlordane	12789-03-6	0.00029	6	2	6	2.4	6	0.0043	6	2 C (6)	8.2 C (6)	C	C	0.19 (6)	C	0.00029	
Heptachlor	76-44-8	0.00039		0.4		0.52		0.0038		0.4 C	0.64 C	C	C	0.015	C	0.00039	
Heptachlor epoxide	1024-57-3	0.00048		0.2		0.52		0.0038		0.2 C	3.2 C	C	C	0.0074	C	0.00048	
Methoxychlor	72-43-5	0.005		40				0.03		40	45	N	N	180	N	0.005	
Toxaphene	8001-35-2	0.0002		3		0.73		0.0002		3 C	3 C	C	C	0.061	C	0.0002	
APPENDIX IX HERBICIDES (SW-846 METHOD 8151A)												0	0				
2,4-D	94-75-7			70								N	N	360	N	70	
2,4,5-T	93-76-5	686.33										N	N	360	N	360	
2,4,5-TP (Silvex)	93-72-1	326.64		50								N	N	290	N	50	
Dinoseb	88-85-7	0.39		7								N	N	37	N	0.39	
Hexachlorophene	70-30-4	0.228										N	N	11	N	0.228	
MISCELLANEOUS PARAMETERS (ANALYTICAL METHODS TO BE DETERMINED BASED ON LABORATORY CAPABILITIES)												0	0				
Alkalinity	TTNUS001							20000								20000	
Nitrate	14797-55-8			10000										10000	N	10000	
Perchlorate (EPA Method 314.0)	14797-73-0															18	
Nitrite	14797-65-0			1000										1000	N	1000	
pH (SW-846 9045C)	n/a			6.5-8.5	7			6.5-9									
Specific Conductance	n/a																
Temperature	TTNUS047																
Total Organic Carbon (TOC) (EPA 415.1)	7440-44-0																
Total Suspended Solids (EPA 160.1)	n/a																
Turbidity	n/a																

Footnotes:
1 Criteria are hardness dependent.
2 Action level.
3 Secondary MCL for copper is 1,000 ug/L.
4 Value is being remanded.

APPENDIX B-1

TABULAR PRESENTATION OF RBSLs FOR RBTL SELECTION
NSWC CRANE, INDIANA

PARAMETER	CAS	REGION 5 ECO DQLs SURFACE WATER (ug/L)	Footnote	FEDERAL MCLs (ug/L)	Footnote	FEDERAL AWQCs FRESHWATER ACUTE (ug/L)	Footnote	FEDERAL AWQCs FRESHWATER CHRONIC (ug/L)	Footnote	IDEM TIER 1 DEFAULT RESIDENTIAL GW CLOSURE LEVELS (ug/L)	IDEM TIER 1 DEFAULT INDUSTRIAL GW CLOSURE LEVELS (ug/L)	Footnote	Footnote	REGION 9 TAP WATER PRGs (ug/L)	Footnote	MINIMUM CRITERIA VALUE	Footnote

5 trans-1,2-Dichloroethene.
6 Chlordane.
7 Secondary MCL, based on aesthetic drinking water qualities (i.e., color, odor, taste, etc.).
8 Total for all Aroclor congeners.
9 1994 Proposed rule for Disinfectants and Disinfection By-Products: Total for all trihalomethanes combined cannot exceed 80 ug/L.
10 Hexavalent chromium.
11 Thallium carbonate.
12 1,3-Dichloropropene.
13 EPA Region 3 RBC presented.
14 Value for 4-nitrophenol presented.
15 Dinitrotoluene mixture.
16 Endosulfan.
17 Value for alpha-BHC presented.
18 Value for endrin presented.
19 Value for acenahpthene presented.
20 Value for naphthalene presented.
21 Gross alpha particle activity.
22 Beta particle and photon activity.
23 Secondary MCL for sulfate is 250,000 ug/L.

APPENDIX B-2

TABULAR PRESENTATION OF SOIL AND SEDIMENT RBSLs FOR RBTL SELECTION
NSWC CRANE, INDIANA

PARAMETER	CAS	EPA GENERIC SSLs INGESTION (mg/kg)	Footnote	EPA GENERIC SSLs INHALATION (mg/kg)	Footnote	EPA GENERIC SSLs MIGRATION TO GW (mg/kg) DAF = 1	Footnote	REGION 5 ECO DOLs SOIL (mg/kg)	Footnote	REGION 5 ECO DOLs SEDIMENT (mg/kg)	Footnote	IDEM TIER 1 DEFAULT RESIDENTIAL SOIL CLOSURE LEVELS (mg/kg)	Footnote	IDEM TIER 1 DEFAULT INDUSTRIAL SOIL CLOSURE LEVELS (mg/kg)	Footnote	REGION 9 SOIL PRGs FOR RESIDENTIAL LAND USE (mg/kg)	REGION 9 SOIL PRGs FOR INDUSTRIAL LAND USE (mg/kg)	MINIMUM CRITERIA VALUE (SOIL) (mg/kg)	MINIMUM CRITERIA VALUE (SED) (mg/kg)	Footnote	MINIMUM CRITERIA VALUE (SOIL AND SED) (mg/kg)
EXPLOSIVES (SW-846 METHOD 8330)																					
1,3,5-Trinitrobenzene	99-35-4															1800	26000	1800	1800		1800
1,3-Dinitrobenzene	99-65-0							0.6547		0.000924						6.1	88	0.6547	0.000924		0.000924
2,4,6-Trinitrotoluene (TNT)	118-96-7															18	82	18	18		18
2,4-Dinitrotoluene	121-14-2	0.9				0.00004		1.28		0.07513		0.0085 (1)	C	0.026 C (1)	C	120	1800	0.00004	0.00004		0.00004
2,6-Dinitrotoluene	606-20-2	0.9				0.00003		0.03283		0.02062						61	880	0.00003	0.00003		0.00003
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0															3100	44000	3100	3100		3100
2-Nitrotoluene	88-72-2															370	1000	370	370		370
3-Nitrotoluene	99-08-1															370	1000	370	370		370
4-Nitrotoluene	99-99-0															370	1000	370	370		370
4-Amino-2,6-dinitrotoluene	19406-51-0																				
2-Amino-4,6-dinitrotoluene	35572-78-2																				
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	479-45-8															610	8800	610	610		610
Nitrobenzene	98-95-3	39		92		0.007		1.31		0.4876		0.028		0.34		20	110	0.007	0.007		0.007
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4															4.4	22	4.4	4.4		4.4
APPENDIX IX METALS (ANALYTICAL METHODS TO BE DETERMINED BASED ON LABORATORY CAPABILITIES)																					
Antimony	7440-36-0	31				0.3		0.1423				5.4		37		31	820	0.1423	0.3		0.1423
Arsenic	7440-38-2	0.4		750		1		5.7		0.0059		3.9	C	20	C	0.39	2.7	0.39	0.0059		0.0059
Barium	7440-39-3	5500		690000		82		1.04				1500		5900		5400	100000	1.04	82		1.04
Beryllium	7440-41-7	0.1		1300		3		1.06				1.9	C	10	C	150	2200	0.1	0.1		0.1
Cadmium	7440-43-9	78		1800		0.4		0.00222		0.596		7.5		77		3	810	0.00222	0.4		0.00222
Chromium (total)	7440-47-3	390	4	270	4	2	4					38		196		210	450	2	2		2
Cobalt	7440-48-4							0.14033		50						4700	100000	0.14033	50		0.14033
Copper	7440-50-8							2.96		16		580		1700		2900	76000	2.96	16		2.96
Lead	7439-92-1	400	14					0.05373		31		81		227		400	1000	0.05373	31		0.05373
Mercury (SW-846 Method 7470A/7471A)	7439-97-6	23		10		0.1		0.073		0.174		2.1		32				0.073	0.1		0.073
Nickel	7440-02-0	1600		13000		7		13.8		16		130		2700		1600	41000	7	7		7
Selenium	7782-49-2	390				0.3		0.02765				5.2		53		390	10000	0.02765	0.3		0.02765
Silver	7440-22-4	390				2		4.04		0.5		31		87		390	10000	2	0.5		0.5
Thallium	7440-28-0					0.04		0.05692				2.9		13		6.3 (16)	160 (16)	0.04	0.04		0.04
Tin	7440-31-5							7.62								47000	100000	7.62	47000		7.62
Vanadium	7440-62-2	550				300		1.59								550	14000	1.59	300		1.59
Zinc	7440-66-6	23000				620		6.62		120		10000		10000		23000	100000	6.62	120		6.62
MISCELLANEOUS METALS (SW-846 METHOD 6010B)																					
Aluminum	7429-90-5															78000	100000	78000	78000		78000
Calcium	7440-70-2																				
Iron	7439-89-6															23000	100000	23000	23000		23000
Magnesium	7439-95-4																				
Manganese	7439-96-5															1800	32000	1800	1800		1800
Potassium	7440-09-7																				
Sodium	7440-23-5																				
APPENDIX IX VOLATILE ORGANIC COMPOUNDS (SW-846 METHOD 8260B WITH 25 ML PURGE FOR WATER, 5 GM PURGE FOR SOIL)																					
1,1,1,2-Tetrachloroethane	630-20-6							225		0.01089		0.050	C	0.79	C	3	7	0.05	0.01089		0.01089
1,1,1-Trichloroethane	71-55-6			1200		0.1		29.8		0.24885		1.9		89		770	1400	0.1	0.1		0.1
1,1,2,2-Tetrachloroethane	79-34-5	3		0.6		0.0002		0.12722		0.02908		0.007	C	0.11	C	0.38	0.9	0.0002	0.0002		0.0002
1,1,2-Trichloroethane	79-00-5	11		1		0.0009		28.6		0.67351		0.03	C	0.30	C	0.84	1.9	0.0009	0.0009		0.0009
1,1-Dichloroethane	75-34-3	7800		1300		1		20.1		0.000575		5.6		58		590	2100	1	0.000575		0.000575
1,1-Dichloroethene	75-35-4	1		0.07		0.003		8.27		0.02327		0.058	C	0.058	C	0.054	0.12	0.003	0.003		0.003
1,2,3-Trichloropropane	96-18-4							3.36		0.00835						0.0014	0.0031	0.0014	0.0014		0.0014
1,2-Dibromo-3-chloropropane	96-12-8							0.03518		0.01998						0.45	4	0.03518	0.01998		0.01998
1,2-Dibromoethane	106-93-4							1.23		0.01237						0.0069	0.048	0.0069	0.0069		0.0069
1,2-Dichloroethane	107-06-2	7		0.4		0.001		21.2		0.05418		0.024	C	0.15	C	0.35	0.76	0.001	0.001		0.001
1,2-Dichloropropane	78-87-5	9		15		0.001		32.7		0.35181		0.03	C	0.25	C	0.35	0.77	0.001	0.001		0.001
1,4-Dioxane	123-91-1							2.05		0.00000543						44	220	2.05	0.00000543		0.00000543
2-Butanone	78-93-3							89.6		0.13696		10		260		7300	28000	10	0.13696		0.13696
2-Chloro-1,3-butadiene (chloroprene)	126-99-8							0.0029		0.00106						3.8	12	0.0029	0.00106		0.00106
2-Hexanone	591-78-6							12.6		1.01						3100 (6)	62,000 (6)	12.6	1.01		1.01
4-Methyl-2-pentanone	108-10-1							443		0.54437						790	2900	443	0.54437		0.54437
Acetone	67-64-1	7800		100000		0.8		2.5		0.45337		3.1		41		1600	6200	0.8	0.45337		0.45337
Acetonitrile	75-05-8							1.37		0.13905						270	1700	1.37	0.13905		0.13905
Acrolein	107-02-8							5.27		0.0000144		0.00027		0.32		0.1	0.34	0.00027	0.0000144		0.0000144
Acrylonitrile	107-13-1							0.02393		0.0000157						0.21	0.51	0.02393	0.0000157		0.0000157
Allyl chloride (3-chloro-1-propene)	107-05-1							0.01338		0.000266						3000	43000	0.01338	0.000266		0.000266
Benzene	71-43-2	22		0.8		0.002		0.25482		0.14157		0.34	C	0.87	C	0.67	1.5	0.002	0.002		0.002
Bromodichloromethane	75-27-4	10		3000		0.03		0.53978		0.00113		0.63	C	0.63	C	1	2.4	0.03	0.00113		0.00113
Bromoform	75-25-2	81		53		0.04		15.9		0.99627		0.75	C	2.7	C	62	310	0.04	0.04		0.04
Bromomethane	74-83-9	110		10		0.01		0.23516		0.94674		0.052		0.7		3.9	13	0.01	0.01		0.01
Carbon disulfide	75-15-0	7800		720		2		0.09412		0.13397		10		82		360	720	0.09412	0.13397		0.09412
Carbon tetrachloride	56-23-5	5		0.5		0.003		2.98		0.03573		0.066	C	0.29	C	0.24	0.53	0.003	0.003		0.003
Chlorobenzene	108-90-7	1600		130		0.07		13.1		0.06194		1.3		27		1	540	0.07	0.06194		0.06194
Chloroethane	75-00-3									56.6						3	6.5	3	3		3
Chloroform	67-66-3	100		0.3		0.03		1.19		0.027		0.59	C	2.7	C	0.24	0.52	0.03	0.027		0.027
Chloromethane	74-87-3							10.4		0.0000785						1.2	2.7	1.2	0.0000785		0.0000785
cis-1,2-Dichloroethene	156-59-2	780		1200		0.02		0.78373	5	0.20694	5	0.4		5.8		43	150	0.02	0.02		0.02

APPENDIX B-2

TABULAR PRESENTATION OF SOIL AND SEDIMENT RBSLs FOR RBTL SELECTION
NSWC CRANE, INDIANA

PARAMETER	CAS	EPA GENERIC SSLs INGESTION (mg/kg)	Footnote	EPA GENERIC SSLs INHALATION (mg/kg)	Footnote	EPA GENERIC SSLs MIGRATION TO GW (mg/kg) DAF = 1	Footnote	REGION 5 ECO DQLs SOIL (mg/kg)	Footnote	REGION 5 ECO DQLs SEDIMENT (mg/kg)	Footnote	IDEM TIER 1 DEFAULT RESIDENTIAL SOIL CLOSURE LEVELS (mg/kg)	Footnote	IDEM TIER 1 DEFAULT INDUSTRIAL SOIL CLOSURE LEVELS (mg/kg)	Footnote	REGION 9 SOIL PRGs FOR RESIDENTIAL LAND USE (mg/kg)	REGION 9 SOIL PRGs FOR INDUSTRIAL LAND USE (mg/kg)	MINIMUM CRITERIA VALUE (SOIL) (mg/kg)	MINIMUM CRITERIA VALUE (SED) (mg/kg)	Footnote	MINIMUM CRITERIA VALUE (SOIL AND SED) (mg/kg)
cis-1,3-Dichloropropene	10061-01-5	4	11	0.1	11	0.0002	11	0.39786		0.00296		0.0091 (11)	C	0.11 (11)	C	0.082 (11)	0.18 (11)	0.0002	0.0002		0.0002
Dibromochloromethane	124-48-1	8		1300		0.02		2.05		0.26761						1.1	2.7	0.02	0.02		0.02
Dibromomethane	74-95-3							85		0.0000859						67	240	85	0.0000859		0.0000859
Dichlorodifluoromethane	75-71-8							39.5		0.00133						94	310	39.5	0.00133		0.00133
Ethyl methacrylate	97-63-2							30		0.000602						140	140	30	0.000602		0.000602
Ethylbenzene	100-41-4	7800		400		0.7		5.16		0.0001		13		200		230	230	0.7	0.0001		0.0001
Isobutyl alcohol	78-83-1							20.8		3.35						13000	40000	20.8	3.35		3.35
Methacrylonitrile	126-98-7							0.05705		0.0000297						2.1	8.8	0.05705	0.0000297		0.0000297
Methyl iodide	74-88-4																				
Methyl methacrylate	80-62-6							984		0.16756						2200	2700	984	0.16756		0.16756
Methylene chloride	75-09-2	85		13		0.001		4.05		1.26		0.023	C	1.8	C	8.9	21	0.001	0.001		0.001
Propionitrile	107-12-0							0.04983		0.11466								0.04983	0.11466		0.04983
Styrene	100-42-5	16000		1500		0.2		4.69		0.44496		3.5		720		1	1700	0.2	0.2		0.2
Tetrachloroethene	127-18-4	12		11		0.003		9.92		0.19583		0.058	C	0.84	C	5.7	19	0.003	0.003		0.003
Toluene	108-88-3	16000		650		0.6		5.45		52.5		12		240		520	520	0.6	0.6		0.6
Total Xylenes	1330-20-7	160000		410	17	9	17	10		1.88		190		410		210	210	9	1.88		1.88
trans-1,2-Dichloroethene	156-60-5	1600		3100		0.03		0.78373		0.20894		0.68		14		63	210	0.03	0.03		0.03
trans-1,3-Dichloropropene	10061-02-6	4	11	0.1	11	0.0002	11	0.39786		0.00296		0.0091 (11)	C	0.11 (11)	C	0.082 (11)	0.18 (11)	0.0002	0.0002		0.0002
trans-1,4-Dichloro-2-butene	110-57-6									0.00182						0.0079 (9)	0.018 (9)	0.0079 (9)	0.00182		0.00182
Trichloroethene	79-01-6	58		5		0.003		12.4		0.17956		0.057	C	3.0	C	2.8	6.1	0.003	0.003		0.003
Trichlorofluoromethane	75-69-4							16.4		0.00307						390	2000	16.4	0.00307		0.00307
Vinyl acetate	108-05-4	78000		1000		8		12.7		0.01295		2.3		430		430	1400	2.3	0.01295		0.01295
Vinyl chloride	75-01-4	0.3		0.03		0.0007		0.64614		0.002		0.013	C	0.013	C	0.022	0.049	0.0007	0.0007		0.0007
APPENDIX IX SEMIVOLATILE ORGANIC COMPOUNDS (SW-846 METHOD 8270C; 8270C SIM OR 8310, BASED ON LABORATORY CAPABILITIES, WHERE NOTED)																					
1,2,4,5-Tetrachlorobenzene	95-94-3							2.02		20.9						18	260	2.02	18		2.02
1,2,4-Trichlorobenzene	120-82-1	780		3200		0.3		11.1		11.7		5.3		77		6	3000	0.3	0.3		0.3
1,2-Dichlorobenzene	95-50-1	7000		560		0.9		2.98		0.23132		17		260		370	370	0.9	0.23132		0.23132
1,3-Dichlorobenzene	541-73-1							37.7		3.01		0.42		59		13	52	0.42	0.42		0.42
1,4-Dichlorobenzene	106-46-7	27				0.1		0.54559		1.45		2.2	C	3.4	C	3	8.1	0.1	0.1		0.1
1,4-Naphthoquinone	130-15-4																				
1,4-Phenylenediamine	106-50-3							6.16		0.00000568						12000	100000	6.16	0.00000568		0.00000568
1-Naphthylamine	134-32-7																				
2,3,4,6-Tetrachlorophenol	58-90-2							0.19878		1.51						1800	26000	0.19878	1.51		0.19878
2,4,5-Trichlorophenol	95-95-4	7800				14		14.1		0.08556		250		700		6100	88000	14	0.08556		0.08556
2,4,6-Trichlorophenol	88-06-2	58		200		0.008		9.94		0.06484		1.5	C	5.0	C	44	220	0.008	0.008		0.008
2,4-Dichlorophenol	120-83-2	230				0.05		87.5		0.13363		1.1		3		1	2600	0.05	0.05		0.05
2,4-Dimethylphenol	105-67-9	1600				0.4		0.01		0.30453		9		25		1	18000	0.01	0.30453		0.01
2,4-Dinitrophenol	51-28-5	160				0.01		0.08066		0.00133		0.29		0.82		120	1800	0.01	0.00133		0.00133
2,6-Dichlorophenol	87-65-0							1.17		0.00394								1.17	0.00394		0.00394
2-Acetylaminofluorene	53-96-3							0.59634		0.01532								0.59634	0.01532		0.01532
2-Chloronaphthalene	91-58-7							0.01218		0.41723						4900	27000	0.01218	0.41723		0.01218
2-Chlorophenol	95-57-8	390		53000		0.2		0.24266		0.0117		0.75		10		6	240	0.2	0.0117		0.0117
2-Methylnaphthalene (by SIM)	91-57-6							3.24		0.0202								3.24	0.0202		0.0202
2-Methylphenol	95-48-7	3900				0.8		40.4		0.000626		14		39		3100	44000	0.8	0.000626		0.000626
2-Naphthylamine	91-59-8							3.03		0.00174								3.03	0.00174		0.00174
2-Nitroaniline	88-74-4							74.1		0.000222						3.5	50	3.5	0.000222		0.000222
2-Nitrophenol	88-75-5							1.8		0.00777						490 (10)	7000 (10)	1.8	0.00777		0.00777
2-Picoline	109-06-8							9.9		0.75305								9.9	0.75305		0.75305
3,3'-Dichlorobenzidine	91-94-1	1				0.0003		0.64836		0.02822		0.062	C	0.21	C	1.1	5.5	0.0003	0.0003		0.0003
3,3'-Dimethylbenzidine	119-93-7							0.1042		0.002						0.053	0.27	0.053	0.002		0.002
3-Methylcholanthrene	56-49-5							0.07794		8190								0.07794	8190		0.07794
3-Methylphenol	108-39-4							163		0.000808						3100	44000	163	0.000808		0.000808
3-Nitroaniline	99-09-2							3.16		0.000222								3.16	0.000222		0.000222
4,6-Dinitro-2-methylphenol	534-52-1							0.14408		0.01038								0.14408	0.01038		0.01038
4-Aminobiphenyl	92-67-1							0.00305		0.00566								0.00305	0.00566		0.00305
4-Bromophenyl phenyl ether	101-55-3									1.68									1.68		1.68
4-Chloro-3-methylphenol	59-50-7							7.95		0.38818								7.95	0.38818		0.38818
4-Chloroaniline	106-47-8	310				0.03		1.1		0.14608		0.97		2.7		240	3500	0.03	0.03		0.03
4-Chlorophenyl phenyl ether	7005-72-3									0.656112									0.656112		0.656112
4-Methylphenol	106-44-5							3.49		0.000645						310	4400	3.49	0.000645		0.000645
4-Nitroaniline	100-01-6							21.9		0.000222								21.9	0.000222		0.000222
4-Nitrophenol	100-02-7							5.12		0.00778						490	7000	5.12	0.00778		0.00778
4-Nitroquinoline-1-oxide	56-57-5							0.12222		0.00124								0.12222	0.00124		0.00124
5-Nitro-o-toluidine	99-55-8							8.73		0.000645						15	75	8.73	0.000645		0.000645
7,12-Dimethylbenz(a)anthracene	57-97-6																				
a,a-Dimethylphenethylamine	122-09-8															61	880	61	61		61
Acenaphthene (by SIM)	83-32-9	4700				29		682		0.00671		130		1200		3700	38000	29	0.00671		0.00671
Acenaphthylene (by SIM)	208-96-8							682		0.00587		130 (12)		1200 (12)		3700 (12)	38000 (12)	682	0.00587		0.00587
Acetophenone	98-86-2							300		0.248						0.49	1.6	0.49	0.248		0.248
Aniline	62-53-3							0.05678		0.0000338						85	430	0.05678	0.0000338		0.0000338
Anthracene (by SIM)	120-12-7	23000				590		1480		0.0469		51		51		22000	100000	51	0.0469		0.0469
Aramite	140-57-8							166		0.00000111						19	99	19	0.00000111		0.00000111
Benzo(a)anthracene (by SIM)	56-55-3	0.9				0.08		5.21		0.0317		5.0	C	15	C	0.62	2.9	0.08	0.0317		0.0317
Benzo(a)pyrene (by SIM)	50-32-8	0.09				0.4		1.52		0.0319		0.50	C	1.5	C	0.062	0.29	0.062	0.0319		0.0319

APPENDIX B-2

TABULAR PRESENTATION OF SOIL AND SEDIMENT RBSLs FOR RBTL SELECTION
NSWC CRANE, INDIANA
PAGE 3 OF 4

PARAMETER	CAS	EPA GENERIC SSLs INGESTION (mg/kg)	Footnote	EPA GENERIC SSLs INHALATION (mg/kg)	Footnote	EPA GENERIC SSLs MIGRATION TO GW (mg/kg) DAF = 1	Footnote	REGION 5 ECO DQLs SOIL (mg/kg)	Footnote	REGION 5 ECO DQLs SEDIMENT (mg/kg)	Footnote	IDEM TIER 1 DEFAULT RESIDENTIAL SOIL CLOSURE LEVELS (mg/kg)	Footnote	IDEM TIER 1 DEFAULT INDUSTRIAL SOIL CLOSURE LEVELS (mg/kg)	Footnote	REGION 9 SOIL PRGs FOR RESIDENTIAL LAND USE (mg/kg)	REGION 9 SOIL PRGs FOR INDUSTRIAL LAND USE (mg/kg)	MINIMUM CRITERIA VALUE (SOIL) (mg/kg)	MINIMUM CRITERIA VALUE (SED) (mg/kg)	Footnote	MINIMUM CRITERIA VALUE (SOIL AND SED) (mg/kg)
Benzo(b)fluoranthene (by SIM)	205-99-2	0.9				0.2		59.8		10.4		5.0	C	15	C	0.62	2.9	0.2	0.2		0.2
Benzo(g,h,i)perylene (by SIM)	191-24-2							119		0.17		0.7 (15)		170 (15)		56 (15)	190 (15)	119	0.17		0.17
Benzo(k)fluoranthene (by SIM)	207-08-9	9				2		1480		0.24		39	C	39	C	6.2	29	2	0.24		0.24
Benzyl alcohol	100-51-6							65.8		0.03394						18000	100000	65.8	0.03394		0.03394
Bis(2-chloroethoxy)methane	111-91-1							0.30209		0.34971								0.30209	0.34971		0.30209
Bis(2-chloroethyl)ether	111-44-4	0.6		0.2		0.00002		23.7		0.21196		0.0007	C	0.012	C	0.21	0.82	0.00002	0.00002		0.00002
Bis(2-chloroisopropyl)ether	39638-32-9											0.027	C			2.5	7.4	0.027	0.027		0.027
Bis(2-ethylhexyl)phthalate	117-81-7	46		31000		180		0.92594		0.182		300	C	980	C	35	180	0.92594	0.182		0.182
Butyl benzyl phthalate	85-68-7	16000		930		810		0.23889		4.19		930		930		12000	100000	0.23889	4.19		0.23889
Chlorobenzilate	510-15-6							5.05		0.86029						1.8	9.1	1.8	0.86029		0.86029
Chrysene (by SIM)	218-01-9	88				8		4.73		0.0571		26	C	26	C	62	290	4.73	0.0571		0.0571
Diallate	2303-16-4							0.45214		0.00151						8	40	0.45214	0.00151		0.00151
Dibenzo(a,h)anthracene (by SIM)	53-70-3	0.09				0.06		18.4		0.00622		0.5	C	1.5	C	0.062	0.29	0.062	0.00622		0.00622
Dibenzofuran	132-64-9									1.52						290	5100	290	1.52		1.52
Diethyl phthalate	84-66-2	63000		2000		23		24.8		0.00804		450		1300		49000	100000	23	0.00804		0.00804
Dimethoate	60-51-5							0.21802		0.19015						12	180	0.21802	0.19015		0.19015
Dimethyl phthalate	131-11-3							734		0.02495						100000	100000	734	0.02495		0.02495
Di-n-butyl phthalate	84-74-2	7800		2300		270		0.14979		0.1105		2300		2000		6100	88000	0.14979	0.1105		0.1105
Di-n-octyl phthalate	117-84-0	1600		10000		10000		709		40.6		2000		2000		1200	10000	709	40.6		40.6
Diphenylamine	122-39-4							1.01		0.0346						1500	22000	1.01	0.0346		0.0346
Ethyl methane sulfonate	62-50-0																				
Ethyl parathion	56-38-2							0.00034		0.00034						370	5300	0.00034	0.00034		0.00034
Fluoranthene (by SIM)	206-44-0	3100				210		122		0.1113		880		880		2300	30000	122	0.1113		0.1113
Fluorene (by SIM)	86-73-7	3100				28		122		0.0212		170		1100		2600	33000	28	0.0212		0.0212
Hexachlorobenzene	118-74-1	0.4		1		0.1		0.19878		0.02		2.2	C	3.9	C	3	1.5	0.1	0.02		0.02
Hexachlorobutadiene	87-68-3	8		8		0.1		0.03976		1.38		16	C	44	C	6	32	0.03976	0.1		0.03976
Hexachlorocyclopentadiene	77-47-4	550		10		20		0.75537		0.90074		400		2000		420	5900	0.75537	0.90074		0.75537
Hexachloroethane	67-72-1	46		55		0.02		0.59634		2.23		2.8	C	7.7	C	35	180	0.02	0.02		0.02
Hexachloropropene	1888-71-7									0.0002									0.0002		0.0002
Indeno(1,2,3-cd)pyrene (by SIM)	193-39-5	0.9				0.7		109		0.2		3.0	C	3.0	C	0.62	2.9	0.62	0.2		0.2
Isodrin	465-73-6							0.00332		0.05516								0.00332	0.05516		0.00332
Isophorone	78-59-1	670		4600		0.03		139		0.4223		5.3	C	18	C	510	2600	0.03	0.03		0.03
Isosafrole	120-58-1							9.94		0.00412								9.94	0.00412		0.00412
Kepone	143-50-0							0.03272		0.00331						0.027	0.14	0.027	0.00331		0.00331
Methapyrilene	91-80-5							2.78		0.0000144								2.78	0.0000144		0.0000144
Methyl methane sulfonate	66-27-3																				
Methyl parathion	298-00-0							0.000292		0.000755						15	220	0.000292	0.000755		0.000292
Naphthalene (by SIM)	91-20-3	3100				4		0.09939		0.0346		0.7		170		56	190	0.09939	0.0346		0.0346
n-Nitrosodiethylamine	55-18-5							0.08933		0.02277						0.0032	0.016	0.0032	0.0032		0.0032
n-Nitrosodimethylamine	62-75-9							0.0000321		0.00000275						0.0095	0.048	0.0000321	0.00000275		0.00000275
n-Nitrosodi-n-butylamine	924-16-3							0.26707		0.77204						0.024	0.081	0.024	0.024		0.024
n-Nitrosodi-n-propylamine	621-64-7	0.09				0.000002		0.54368		0.000217		0.0006	C	0.002	C	0.069	0.35	0.000002	0.000002		0.000002
n-Nitrosomethylethylamine	10595-95-6							0.00166		0.00000485						0.022	0.11	0.00166	0.00000485		0.00000485
n-Nitrosomorpholine	59-89-2							0.07057		0.0000037								0.07057	0.0000037		0.0000037
n-Nitrosopiperidine	100-75-4							0.00665		0.0000226								0.00665	0.0000226		0.0000226
n-Nitrosopyrrolidine	930-55-2							0.01258		0.000000908						0.23	1.2	0.01258	0.000000908		0.000000908
O,O,O-Triethyl phosphorothioate	126-68-1																				
o-Toluidine	95-53-4							2.97		0.000199						2	10	2	0.000199		0.000199
p-(Dimethylamino)azobenzene	60-11-7																				
Pentachlorobenzene	608-93-5							0.49695		1.26						49	700	0.49695	1.26		0.49695
Pentachloroethane	76-01-7							10.7		0.68918								10.7	0.68918		0.68918
Pentachloronitrobenzene	82-68-8							7.09		18.2						1.9	9.5	1.9	1.9		1.9
Pentachlorophenol	87-86-5	3				0.001		0.11927		30.1		0.028	C	0.86	C	3	11	0.001	0.001		0.001
Phenacetin	62-44-2							11.7		0.00225								11.7	0.00225		0.00225
Phenanthrene (by SIM)	85-01-8							45.7		0.0419		0.7 (15)		170 (15)		56 (15)	190 (15)	45.7	0.0419		0.0419
Phenol	108-95-2	47000				5		120		0.02726		110		320		37000	100000	5	0.02726		0.02726
Pronamide	23950-58-5							0.0136		0.0016						4600	66000	0.0136	0.0016		0.0016
Pyrene (by SIM)	129-00-0	2300				210		78.5		0.053		570		570		2300	54000	78.5	0.053		0.053
Pyridine	110-86-1							1.03		0.10617						61	880	1.03	0.10617		0.10617
Safrole	94-59-7							0.40398		0.16486								0.40398	0.16486		0.16486
APPENDIX IX ORGANOCHLORINE PESTICIDES and PCBs (SW-846 METHOD 8081A and 8082)																					
4,4'-DDD	72-54-8	3				0.6		0.75815		0.00553		28	C	121	C	2.4	17	0.75815	0.00553		0.00553
4,4'-DDE	72-55-9	2				3		0.59587		0.00142		20	C	86	C	1.7	12	0.59587	0.00142		0.00142
4,4'-DDT	50-29-3	2				2		0.0175		0.00119		20	C	86	C	1.7	12	0.0175	0.00119		0.00119
Aldrin	309-00-2	0.04		3		0.02		0.00332		0.002		0.25	C	0.80	C	0.029	0.15	0.00332	0.002		0.002
Alpha-BHC	319-84-6	0.1		0.8		0.00003		0.09939		0.006		0.0072	C	0.024	C	0.09	0.59	0.00003	0.00003		0.00003
Alpha-chlordane	5103-71-9	0.5	7	20	7	0.5	7	0.224	7	0.0045	7	9.6 (7)		39 (7)		1.6 (7)	11 (7)	0.224	0.0045		0.0045
Aroclor-1016	12674-11-2	1	8					0.67971	8	0.0341	8	1.8 (8)	C	5.3 (18)	C	3.9	29	0.67971	0.0341		0.0341
Aroclor-1221	11104-28-2	1	8					0.67971	8	0.0341	8	1.8 (8)	C	5.3 (18)	C	0.22	1	0.22	0.0341		0.0341
Aroclor-1232	11141-16-5	1	8					0.67971	8	0.0341	8	1.8 (8)	C	5.3 (18)	C	0.22	1	0.22	0.0341		0.0341
Aroclor-1242	53469-21-9	1	8					0.67971	8	0.0341	8	1.8 (8)	C	5.3 (18)	C	0.22	1	0.22	0.0341		0.0341
Aroclor-1248	12672-29-6	1	8					0.67971	8	0.0341	8	1.8 (8)	C	5.3 (18)	C	0.22	1	0.22	0.0341		0.0341
Aroclor-1254	11097-69-1	1	8					0.67971	8	0.0341	8	1.8 (8)	C	5.3 (18)	C	0.22	1	0.22	0.0341		0.0341
Aroclor-1260	11096-82-5	1	8					0.67971	8	0.0341	8	1.8 (8)	C	5.3 (18)	C	0.22	1	0.22	0.0341		0.0341

APPENDIX B-2

TABULAR PRESENTATION OF SOIL AND SEDIMENT RBSLs FOR RBTL SELECTION
NSWC CRANE, INDIANA

PARAMETER	CAS	EPA GENERIC SSLs INGESTION (mg/kg)	Footnote	EPA GENERIC SSLs INHALATION (mg/kg)	Footnote	EPA GENERIC SSLs MIGRATION TO GW (mg/kg) DAF = 1	Footnote	REGION 5 ECO DQLs SOIL (mg/kg)	Footnote	REGION 5 ECO DQLs SEDIMENT (mg/kg)	Footnote	IDEM TIER 1 DEFAULT RESIDENTIAL SOIL CLOSURE LEVELS (mg/kg)	Footnote	IDEM TIER 1 DEFAULT INDUSTRIAL SOIL CLOSURE LEVELS (mg/kg)	Footnote	REGION 9 SOIL PRGs FOR RESIDENTIAL LAND USE (mg/kg)	REGION 9 SOIL PRGs FOR INDUSTRIAL LAND USE (mg/kg)	MINIMUM CRITERIA VALUE (SOIL) (mg/kg)	MINIMUM CRITERIA VALUE (SED) (mg/kg)	Footnote	MINIMUM CRITERIA VALUE (SOIL AND SED) (mg/kg)
Beta-BHC	319-85-7	0.4				0.0001		0.00398		0.005		0.026	C	0.088	C	0.32	2.1	0.0001	0.0001		0.0001
Delta-BHC	319-86-8							9.94		71.5		0.0072 (18)	C	0.024 (18)	C	0.09 (18)	0.59 (18)	0.0072	71.5		0.0072
Dieldrin	60-57-1	0.04		1		0.0002		0.00238		0.002		0.046	C	0.15	C	0.03	0.15	0.0002	0.0002		0.0002
Endosulfan I	959-98-8	470	13			0.9	13	0.11927		0.000175		20 (13)		46 (13)		370 (13)	5300 (13)	0.11927	0.000175		0.000175
Endosulfan II	33213-65-9	470	13			0.9	13	0.11927		0.000104		20 (13)		46 (13)		370 (13)	5300 (13)	0.11927	0.000104		0.000104
Endosulfan sulfate	1031-07-8							0.03578		0.0346		20 (13)		46 (13)		370 (13)	5300 (13)	0.03578	0.0346		0.0346
Endrin	72-20-8	23				0.05		0.0101		0.00267		0.99		15		18	260	0.0101	0.00267		0.00267
Endrin aldehyde	7421-93-4							0.0105		3.2		0.99 (19)		15 (19)		18 (19)	260 (19)	0.0105	3.2		0.0105
Gamma-BHC (Lindane)	58-89-9	0.5				0.0005		0.005		0.00094		0.0094	C	0.10	C	0.44	2.9	0.0005	0.0005		0.0005
Gamma-chlordane	12789-03-6	0.5	7	20	7	0.5	7	0.224	7	0.0045	7	9.6 (7)		39 (7)		1.6 (7)	11 (7)	0.224	0.0045		0.0045
Heptachlor	76-44-8	0.1		0.1		1		0.00598		0.0006		0.56	C	1.2	C	0.11	0.55	0.00598	0.0006		0.0006
Heptachlor epoxide	1024-57-3	0.07		5		0.03		0.15188		0.0006		0.46	C	1.0	C	0.053	0.27	0.03	0.0006		0.0006
Methoxychlor	72-43-5	390				8		0.01988		0.00359		160		180		310	4400	0.01988	0.00359		0.00359
Toxaphene	8001-35-2	0.6		89		2		0.11927		0.000109		3.9	C	12	C	0.44	2.2	0.11927	0.000109		0.000109
APPENDIX IX HERBICIDES (SW-846 METHOD 8151A)																					
2,4-D	94-75-7							0.02725		0.00579						690	12000	0.02725	0.00579		0.00579
2,4,5-T	93-76-5							0.59634		58.7						610	8800	0.59634	58.7		0.59634
2,4,5-TP (Silvex)	93-72-1							0.1088		7.35						490	7000	0.1088	7.35		0.1088
Dinoseb	88-85-7							0.0218		0.01178						61	880	0.0218	0.01178		0.01178
Hexachlorophene	70-30-4							0.19878		231						18	260	0.19878	18		0.19878
DIOXINS/FURANS (SW-846 METHOD 8290)																					
2,3,7,8-Tetrachlorodibenzodioxin (2,3,7,8-TCDD)	1746-01-6	4.26E-06	20	4.30E+01	22	2.87E-07	20									3.90E-06		2.87E-07			2.87E-07
1,2,3,7,8-Pentachlorodibenzodioxin (1,2,3,7,8-PeCDD)	40321-76-4	4.26E-06	21	4.30E+01	21	2.87E-07	21									3.90E-06		2.87E-07			2.87E-07
1,2,3,6,7,8-Hexachlorodibenzodioxin (1,2,3,6,7,8-HxCDD)	67853-65-7	4.26E-05	21	4.30E+02	21	2.87E-06	21									3.90E-05		2.87E-06			2.87E-06
1,2,3,4,7,8-Hexachlorodibenzodioxin (1,2,3,4,7,8-HxCDD)	39227-28-6	4.26E-05	21	4.30E+02	21	2.87E-06	21									3.90E-05		2.87E-06			2.87E-06
1,2,3,7,8,9-Hexachlorodibenzodioxin (1,2,3,7,8,9-HxCDD)	72918-21-9	4.26E-05	21	4.30E+02	21	2.87E-06	21									3.90E-05		2.87E-06			2.87E-06
1,2,3,4,6,7,8-Heptachlorodibenzodioxin (1,2,3,4,6,7,8-HpCDD)	67562-39-4	4.26E-04	21	4.30E+03	21	2.87E-05	21									3.90E-04		2.87E-05			2.87E-05
1,2,3,4,6,7,8,9-Octachlorodibenzodioxin (OCDD)	3268-87-9	4.26E-02	21	4.30E+05	21	2.87E-03	21									3.90E-02		2.87E-03			2.87E-03
2,3,7,8-Tetrachlorodibenzofuran (2,3,7,8-TCDF)	1746-01-6	4.26E-05	21	4.30E+02	21	2.87E-06	21									3.90E-05		2.87E-06			2.87E-06
1,2,3,7,8-Pentachlorodibenzofuran (1,2,3,7,8-PeCDF)	57117-41-6	8.52E-05	21	8.60E+02	21	5.74E-06	21									7.80E-05		5.74E-06			5.74E-06
2,3,4,7,8-Pentachlorodibenzofuran (2,3,4,7,8-PeCDF)	57117-31-4	8.52E-06	21	8.60E+01	21	5.74E-07	21									7.80E-06		5.74E-07			5.74E-07
1,2,3,6,7,8-Hexachlorodibenzofuran (1,2,3,6,7,8-HxCDF)	57117-44-9	4.26E-05	21	4.30E+02	21	2.87E-06	21									3.90E-05		2.87E-06			2.87E-06
1,2,3,7,8,9-Hexachlorodibenzofuran (1,2,3,7,8,9-HxCDF)	19408-74-3	4.26E-05	21	4.30E+02	21	2.87E-06	21									3.90E-05		2.87E-06			2.87E-06
1,2,3,4,7,8-Hexachlorodibenzofuran (1,2,3,4,7,8-HxCDF)	70648-26-9	4.26E-05	21	4.30E+02	21	2.87E-06	21									3.90E-05		2.87E-06			2.87E-06
2,3,4,6,7,8- Hexachlorodibenzofuran (2,3,4,6,7,8-HxCDF)	60851-34-5	4.26E-05	21	4.30E+02	21	2.87E-06	21									3.90E-05		2.87E-06			2.87E-06
1,2,3,4,6,7,8-Heptachlorodibenzofuran (1,2,3,4,6,7,8-HpCDF)	67562-39-4	4.26E-04	21	4.30E+03	21	2.87E-05	21									3.90E-04		2.87E-05			2.87E-05
1,2,3,4,7,8,9- Heptachlorodibenzofuran (1,2,3,4,7,8,9-HpCDF)	55673-89-7	4.26E-03	21	4.30E+04	21	2.87E-04	21									3.90E-03		2.87E-04			2.87E-04
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	39001-02-00	4.26E-02	21	4.30E+05	21	2.87E-03	21									3.90E-02		2.87E-03			2.87E-03
Total Tetrachlorodibenzodioxin (Total TCDD)		4.26E-06		4.30E+01		2.87E-07										3.90E-06		2.87E-07			2.87E-07
Total Pentachlorodibenzodioxin (Total PCDD)		4.26E-06		4.30E+01		2.87E-07										3.90E-06		2.87E-07			2.87E-07
Total Hexachlorodibenzodioxin (Total HxCDD)		4.26E-05		4.30E+02		2.87E-06										3.90E-05		2.87E-06			2.87E-06
Total Heptachlorodibenzodioxin (Total HpCDD)		4.26E-04		4.30E+03		2.87E-05										3.90E-04		2.87E-05			2.87E-05
Total Tetrachlorodibenzofuran (Total TCDF)		4.26E-05		4.30E+02		2.87E-06										3.90E-05		2.87E-06			2.87E-06
Total Pentachlorodibenzofuran (Total PCDF)		8.52E-05		8.60E+01		5.74E-06										7.80E-05		5.74E-06			5.74E-06
Total Hexachlorodibenzofuran (Total HxCDF)		4.26E-05		4.30E+02		2.87E-06										3.90E-05		2.87E-06			2.87E-06
Total Heptachlorodibenzofuran (Total HpCDF)		4.26E-03		4.30E+03		2.87E-03										3.90E-04		2.87E-03			2.87E-03
MISCELLANEOUS PARAMETERS																					
Nitrate (SW-846 Method 9056)	14797-55-8																				
Nitrite (SW-846 Method 9056)	14797-65-0																				

Footnotes:
1 Dinitrotoluene mixture.
2 Interim value based on TLV.
3 Interim value based on LD50
4 Assume hexavalent chromium.
5 trans-1,2-Dichloroethene.
6 EPA Region 3 risk-based concentration.
7 Chlordane.
8 Total for all Aroclor congeners
9 Value for 1,4-dichloro-2-butene presented.
10 Value for 4-nitrophenol presented
11 1,3-Dichloropropene.
12 Value for acenphthene presented
13 Endosulfan.
14 OSWER soil screening level for residential land use (USEPA, July 1994).
15 Value for naphthalene presented.
16 Thallium carbonate.
17 o-Xylene.
18 Value for alpha-BHC presented.
19 Value for endrin presented.
20 Value from EPA Superfund Risk Assessment website
21 Value obtained by applying WHO TEFs (12-98) to TCDD value
22 Value is for volatilization from soil.

APPENDIX C

HUMAN HEALTH RISK ASSESSMENT METHODOLOGY

APPENDIX C

HUMAN HEALTH RISK ASSESSMENT METHODOLOGY

This section of the QAPP outlines the general methodologies and procedures that will be used to conduct the Baseline Human Health Risk Assessment for the Jeep Trail and Little Sulphur Creek at NSWC Crane. The objective of the risk assessment is to determine whether detected concentrations of chemicals within the study areas pose a significant threat to potential human receptors under current and/or future land use. The potential risks to human receptors will be estimated based on the assumption that no actions are taken to control contaminant releases.

The following current United States Environmental Protection Agency (U.S. EPA) and the State of Indiana Department of Environmental Management (IDEM) risk assessment guidance were used to develop the framework for the Baseline Human Health Risk Assessment:

- 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. OSWER Directive 9285.6-03 (U.S. EPA, 1991a)

- Dermal Exposure Assessment: Principles and Applications. Interim Report. Office of Research and Development, Washington, D.C. EPA/600/8-91/011B (U.S. EPA 1992a).

- Supplemental Guidance to RAGS: Calculating the Concentration Term. OSWER Publication No. 9285.7-081 (U.S. EPA, 1992c)

- Distribution of Preliminary Review Draft: Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure. Office of Solid Waste and Emergency Response, Washington, D.C. (U.S. EPA 1993a).

- Soil Screening Guidance: Technical Background Document. Office of Solid Waste and Emergency Response, Washington, D.C. EPA/540/R-95/128 (U.S. EPA 1996a).

- Exposure Factors Handbook. Office of Health and Environmental Assessment, Washington, D.C. EPA/600/P-95/002Fa (U.S. EPA 1997a).

- Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Interim Guidance (Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C. 20460, UNDATED, Received courtesy of U.S. EPA Region I, June 2000)

- RISC (Risk-Integrated System of Cleanups). An Agency-Wide Manual, Public Draft. Indiana Department of Environmental Management, Office of Environmental Response (IDEM 1997).

- RISC (Risk Integrated System of Closure). Technical Resource Guidance Document. Indiana Department of Environmental Management, Office of Environmental Response (IDEM, 1999).

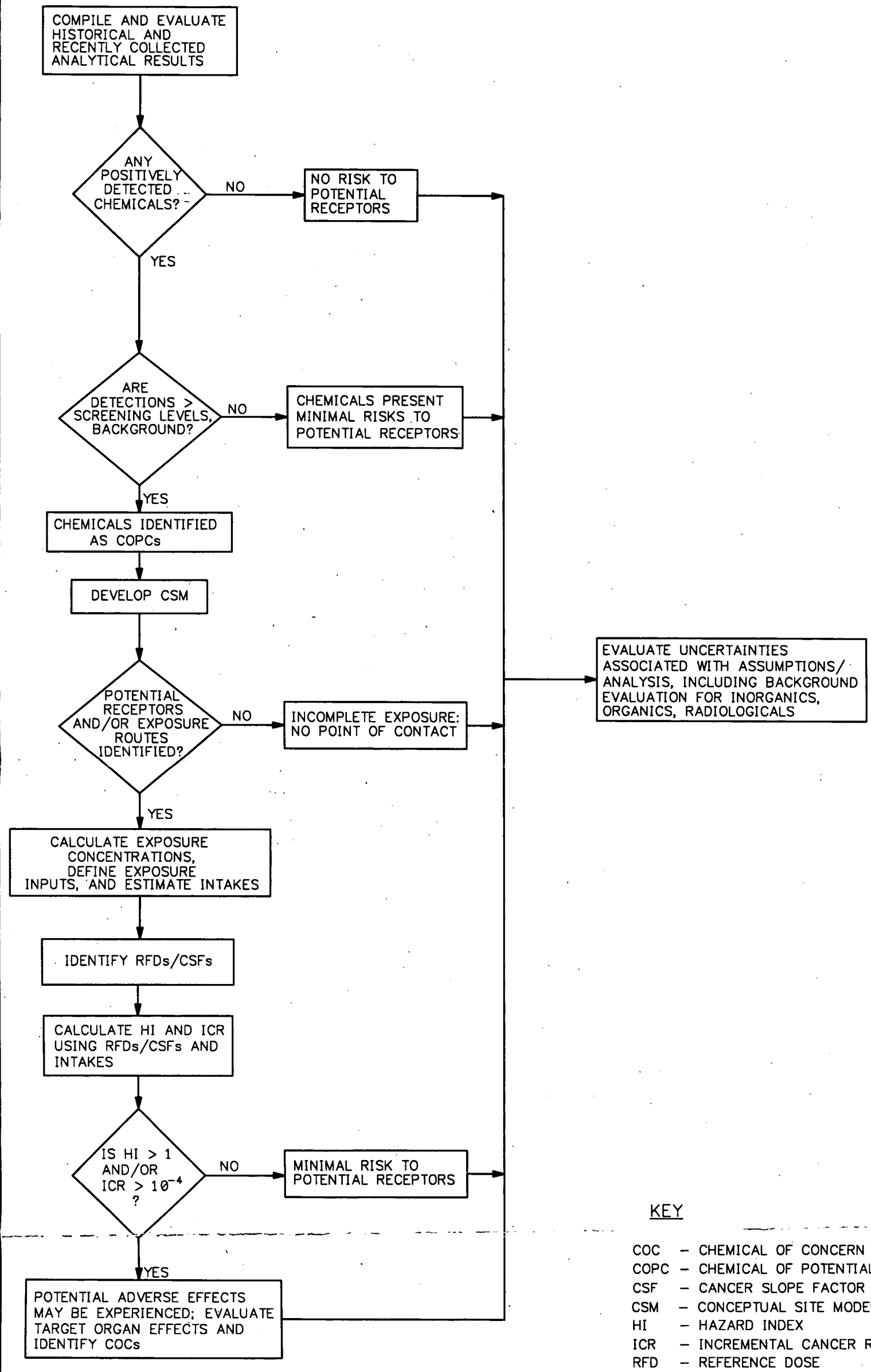
- 1998 Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments) (U.S. EPA 1998a).

A Baseline Human Health Risk Assessment consists of five components: (1) Data Evaluation; (2) Exposure Assessment; (3) Toxicity Assessment; (4) Risk Characterization; and (5) Uncertainty Analysis. Section 1 of this QAPP contains discussions of the methodologies to be followed for the five components of the risk assessment. A schematic diagram of the general risk assessment process is provided as Figure C-1 in this appendix.

Three major aspects of chemical contamination and environmental fate and transport must be 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; and (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 is absent for a site, the exposure route is regarded as incomplete, and no potential risks will be considered to exist for human receptors.

C.1 DATA EVALUATION

Data evaluation, the first component of a Baseline Human Health Risk Assessment, is a media-specific task involving the compilation and evaluation of analytical data. The main objective of the data evaluation is to develop a media-specific list of Chemicals of Potential Concern (COPCs), which will be used to quantitatively determine potential human health risks for site media.



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

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CHECKED BY DATE			APPROVED BY DATE
COST/SCHED-AREA			APPROVED BY DATE
SCALE NOT TO SCALE			DRAWING NO. FIGURE C-1 REV. 0

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

C.1.1 Data Usability

Data from samples collected for the proposed field investigations, which are described in Section 4(Ralph ??) of this QAPP, will be used to assess risks to potential human receptors. All analytical data used in the quantitative estimation of potential risks will be subjected to data validation. A discussion of data validation protocol to be followed is provided in the *Section 9* of this QAPP. A *Data Evaluation* (see Sections 9 and 12) will be generated for the proposed field investigation data. Precision, accuracy, representativeness, completeness, and comparability will be evaluated and a brief summary of the results of the data validation will be documented. Additionally, the "data useability" evaluation worksheet suggested by USEPA RAGS Part D will be completed as a part of the data evaluation.

Fixed-based analytical results only from the target analyte lists for the proposed field investigations and EPA approved historic data will be used in the quantitative risk evaluation. Typically, unfiltered results for ground water and surface water are used to assess risks associated with these media. Filtered groundwater results will be used for the risk assessment if the associated unfiltered groundwater samples are found to be turbid. Field measurements, data regarded as unreliable (i.e., qualified as "R" during the data validation process), historic data considered not acceptable by the U.S. EPA, and results of Tentatively Identified Compound (TIC) analyses will not be used in the quantitative risk assessment. However, these data may be used to substantiate the conclusions of the quantitative risk analysis.

Because of uncertainties associated with data quality, some of the historical data collected for the Jeep Trail and Little Sulphur Creek will not be used to quantitatively assess potential risks. As discussed in Section 1.3.5, the quality associated with some of the historical data has not been adequately documented, and some of the data do not seem to have been validated. The data packages for some of the data (including the raw data) cannot be obtained to ascertain the level of quality associated with the data or to independently validate the data. However, these data may be used in a qualitative fashion to support the conclusions of the quantitative risk analysis. The proposed field investigations were developed to be comprehensive (i.e., locations sampled historically, as well as data gap locations, were included), thus, the uncertainty associated with the elimination of the historical data from the quantitative risk assessment will not be significant.

C.1.2 Selection of 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 Baseline Human Health Risk Assessment to those site-related constituents that dominate overall potential risks. Screening by risk-based concentrations and

Basewide background levels will be used to focus the risk assessment on meaningful chemicals and exposure routes.

In general, a chemical will be selected as a COPC and retained for further quantitative risk evaluation if: 1) the maximum detection in a sampled medium exceeds the lowest risk-based concentration and 2) the chemical is determined to be present at concentrations exceeding background (only naturally occurring inorganics and radiologicals are eliminated as COPCs based on background comparisons.) Chemicals eliminated from further evaluation at this time are assumed to present minimal risks to potential human receptors.

C.1.2.1 COPC Screening Levels

Several types of screening levels will be used to identify COPCs for the Jeep Trail and Little Sulphur Creek. Risk-based screening concentrations based on U.S. EPA Region IX (referred to as Preliminary Remediation Goals [PRGs]) (U.S. EPA, Region IX, 1999) will be used, as well as other IDEM and U.S. EPA criteria (U.S. EPA 1991b). The risk-based U.S. EPA Region IX screening concentrations will correspond to a systemic hazard quotient of 0.1 (for noncarcinogens) or a lifetime cancer risk of 1E-6 (for carcinogens). It should be noted that the EPA Region IX PRGs for noncarcinogens are based on a hazard index of 1. The Region IX PRG values for noncarcinogens will be multiplied by 0.1 so that the screening concentrations will correspond to a hazard index of 0.1. The screening levels to be used for each media in the risk assessment are briefly discussed below.

<u>Soil/Sediment</u>

The following criteria will be used to select COPC for soil (surface and subsurface soil):

- U.S. EPA Region IX PRGs for Residential Soil (U.S. EPA Region IX, 1999);
- U.S. EPA Generic SSLs (Soil Screening Levels) for Migration to Ground Water (U.S. EPA, 1996a);
- U.S. EPA Generic SSLs for Transfers from Soil to Air (U.S. EPA, 1996a);
- IDEM Tier I Cleanup Levels for Surface Soil (IDEM, 1999); and
- IDEM Tier I Cleanup Levels for Subsurface Soil (IDEM, 1999).

If the maximum concentration of a constituent exceeds any of these criteria (and the constituent is considered to be present at concentrations greater than Basewide background levels), the chemical will be selected as a COPC for soil and carried through to the quantitative risk assessment. Given the anticipated size of the background and site-specific data-sets, it is anticipated that background

comparisons will be accomplished by statistical analyses that compare background and site-specific soil data sets (see Figure 1-14). The background comparisons for purposes of COPC selection will be limited to naturally occurring inorganics only.

Because of the different exposure scenarios for potential human receptors, COPCs will be identified for surface and subsurface soil. Surface soil will be defined as soil collected from 0 to 2 feet bgs. Subsurface soil will be defined as soil collected from depths greater than 2 feet bgs.

The comparison of site soil data to U.S. EPA Generic SSLs for transfers from soil to air will be used to identify whether a quantitative analysis of the inhalation of particulates/vapors from soil exposure pathway is warranted. If the maximum soil concentration of a chemical exceeds the SSL, a quantitative evaluation of potential risks from inhalation will be performed, as described in Section C.2.4. Otherwise, the risks associated with the inhalation pathway will be considered insignificant, and the exposure pathway will be eliminated from further evaluation.

No specific screening levels exist for human exposure to sediment. COPCs will be selected for sediment by comparing detected site concentrations to the following:

- U.S. EPA Region IX PRGs for Residential Soil (U.S. EPA Region IX, 1999) and
- IDEM Tier I Cleanup Levels for Surface Soil (IDEM, 1999).

A chemical detected in sediments will be selected as a COPC for sediments if the maximum detected concentration exceeds the preceding screening values and upstream/background concentrations (see Figure 1-13). The background comparisons for purposes of COPC selection will be limited to naturally occurring inorganics only. U.S. EPA Generic SSLs for transfers from soil to air and for migration to ground water are not considered to be appropriate for sediment screening because of the high moisture content associated with sediment matrices. The use of soil screening levels for sediment COPC identification is regarded as a conservative approach because exposure to sediment anticipated to be is less than exposure to soil.

Ground Water/Surface Water

The same screening levels will be used to select COPCs for ground water and surface water. The following criteria will be used:

- U.S. EPA Region IX PRGs for Tap Water (U.S. EPA, Region IX, 1999);
- IDEM Tier I Cleanup Levels for Residential Ground Water (IDEM, 1999); and
- U.S. EPA Maximum Contaminant Levels (MCLs) (U.S. EPA, 1996b).

If the maximum concentration of a constituent exceeds any of these criteria (and the constituent is considered to be present at concentrations greater than Basewide background levels), the chemical will be selected as a COPC and carried through to the quantitative risk assessment. Given the anticipated size of the background and site-specific data-sets, it is anticipated that background comparisons will be accomplished by statistical analyses that compare background and site-specific groundwater data sets (see Figures 1-13 and 1-15). The background comparisons for purposes of COPC selection will be limited to naturally occurring inorganics only.

Risk-based COPC screening levels for tap water ingestion, which are based on daily, residential exposure assumptions, will be 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 Jeep Trail and Little Suphur Creek because ground water at the site is not used as a potable drinking water source. However, off-site residents downgradient of the study area may use the groundwater and surface water of Little Sulphur Creek as potable water supplies. Potential human exposure to the surface water of Little Sulphur Creek within the study area is expected to be limited to incidental exposures (such as that which occurs during trespassing [i.e., exposure to seeps] or shallow subsurface soil excavations by construction workers), which is significantly less than the daily exposure assumed during the development of the aforementioned ground water screening criteria.

Federal Ambient Water Quality Criteria (AWQC) will not be used to select COPCs for surface water. AWQC applicable to the protection of human health assuming routine consumption of water will not be used because the conservative U.S. EPA Region IX PRGs for Tap Water, the IDEM Tier I Cleanup Levels for Residential Ground Water, and the U.S. EPA MCLs will be used to select COPCs for groundwater and surface water. In addition, the surface water bodies present within and downgradient of the study area do not support game fish populations because of their size and the intermittent nature of the surface water resource along much of Sulphur Creek

C.1.2.2 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 since the U.S. EPA has not derived toxicity values for lead. However,

recommended screening levels are available for lead in soil which 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) recommend 400 mg/kg as the lowest screening level for lead-contaminated soil in a residential setting, where children are frequently present (U.S. EPA, 1994a). 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 will be used as the screening level for soil and sediment.

Guidance for the USEPA Technical Review Workgroup for Lead (TRW) indicates 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/b). This value will not be used for COPC selection, but may be used in the qualitative evaluation of lead.

The Safe Drinking Water Act Action Level of 15 µg/L (micrograms per liter) will used as the screening level for lead in ground water and surface water.

C.1.2.3 Essential Nutrients and Chemicals without Toxicity Criteria

The essential nutrients calcium, magnesium, potassium, and sodium will not be identified as COPCs for the Jeep Trail and Little Sulphur Creek. 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 chemicals (e.g., benzo(g,h,i)perylene, phenanthrene). These chemicals will not be selected as COPCs as they can not be addressed during the quantitative risk assessment. However, these chemicals will be mentioned in the data evaluation section, after the identification of COPCs, and qualitatively addressed in the uncertainty section of the risk assessment.

C.1.2.4 Determination of Site-Related Chemicals

Chemicals found at concentrations indicative of background levels are not considered to be site-related contaminants and will not be retained as COPCs for the quantitative risk assessment. The use of Basewide background soil data and site-specific background groundwater, surface water, and sediment data will determine if detected chemicals are present at naturally occurring or non-site related anthropogenic levels. To the extent possible, conventional statistical methods (e.g., Bartlett's T-test,

Wilcoxin Rank Sum, etc.) will be employed to compare site concentrations for the Jeep Trail and Little Sulphur Creek to background concentrations. If conventional statistical methods are not possible due to limited sample size or other constraints, the background comparison will be conducted as a simple maximum site concentration to maximum background concentration comparison.

The elimination of detected chemicals based on background data for soil will be limited to inorganics only. Although some organic compounds [primarily PAHs (Polycyclic Aromatic Hydrocarbons), pesticides, dioxins, and PCBs (polychlorinated biphenyls)] are found at low-level concentrations in background samples, the concentrations detected are most likely reflective of non-site related, anthropogenic sources of contamination (e.g., automobile exhausts). All detected organic compounds will be regarded as site-related for purposes of COPC selection. However, historical information for a site, the results of the analysis of soil samples collected in the reference area discussed in Section 1, and the results of the analysis of background samples will be reviewed in the baseline risk assessment to determine if the organics present in the site samples are attributable to site-related activities or anthropogenic sources.

C.1.3 COPC Summary Screening Tables

Media-specific tables summarizing the selection of COPCs will be included in the risk assessment. The tables will be prepared according to the guidelines established for preparation of Standard Table 2 of the RAGS Part D guidance. An example format of a typical COPC selection table is provided as Table C-1.

C.2 EXPOSURE ASSESSMENT

This portion of the risk assessment defines and evaluates, quantitatively or qualitatively, the type and magnitude of human exposure to the chemicals present at or migrating from a site. The exposure assessment is 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/radiological intakes under the identified exposure scenarios.

Actual or potential exposures at the Jeep Trail and Little Sulphur Creek at NSWC Crane will be 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: (1) a source of chemicals that can be released to the environment; (2) a route of contaminant transport through an environmental medium; and (3) an exposure or contact point for a human receptor.

TABLE C-1

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
JEEP TRAIL AND LITTLE SULPHUR CREEK
NSWS CRANE, CRANE, INDIANA

Scenario Timeframe:
Medium:
Exposure Medium:
Exposure Point:

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value (2)	Screening Toxicity Value (3)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection (4)

1 Minimum/maximum defected concentration.

2 N/A - Refer to supporting information for background discussion.
Background values derived from statistical analysis. Follow Regional guidance and provide supporting information.

3 Provide reference for screening toxicity value.

4 Rationale Codes Selection Reason: Infrequent Detection but Associated Historically (HIST).
Frequent Detection (FD)
Toxicity Information Available (TX0
Above Screening Levels (ASL)
Deletion Reason: Infrequent Detection (IFD)
Background Levels (BKG)
No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

Definitions: N/A = Not Applicable
SQL = Sample Quantitation Limit
COPC = Chemical of Potential Concern
ARAC/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
MCL = Federal Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
J = Estimated Value
C = Carcinogenic
N = Non-Carcinogenic

TABLE C-1

C.2.1 Conceptual Site Model

The development of a CSM is an essential component of the exposure assessment. The CSM will integrate information regarding the physical characteristics of the site, exposed populations, sources of contamination, and contaminant mobility (fate and transport) to identify potential exposure routes and receptors to be evaluated in the risk assessment. A well-defined CSM will allow for a better understanding of the risks at a site and will aid the risk managers in the identification of the potential need for remediation. The site-specific CSM for the Jeep Trail and Little Sulphur Creek is presented in this section and illustrated in Figure C-2. The model was used to develop the proposed field investigations to ensure that the data collected meet the needs of the risk assessment. Sources of contamination, contaminant release mechanisms, transport/migration pathways, exposure routes, and potential receptors are defined. The CSM will be refined during the risk assessment process using the data and information collected as part of the proposed field investigations. Table C-2 provides a site-specific summary of the potential receptors to be evaluated for the Jeep Trail and Little Sulphur Creek. A summary of the exposure routes that will be addressed quantitatively for each human receptor is also provided in Table C-2. A summary discussion of the CSMs for the Jeep Trail and Little Sulphur Creek is provided in Section 1 of this QAPP.

Site Sources of Environmental Contamination

Based on historical site data and sampling, the following parameters are among the site-related chemical contaminants known to be present or potentially present in environmental media within the study area:

- Explosives (e.g., 2,4,6-trinitrotoluene [TNT] and HMX) and their degradation products (e.g., 2-amino-4,6-dinitrotoluene)
- Metals (e.g., lead)
- Chlorinated volatile organic chemicals (VOCs) including but not limited to 1,1,2,2-trichloroethane, 1,2-dichloroethene, trichloroethene, and vinyl chloride)

Potential Contaminant Release Mechanisms and Transport/Migration Pathways

Based on available historical information 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 at the ABG and the Jeep Trail. For example, TNT and 2,4-dinitrotoluene concentrations in the surface soils of the ABG and the Jeep Trail exceed 1,500 mg/kg and 35 mg/kg, respectively. TNT has also been detected in groundwater underlying and downgradient of the ABG and the Jeep Trail. The existing historical ground water data for the ABG indicates the presence of several halogenated VOCs at

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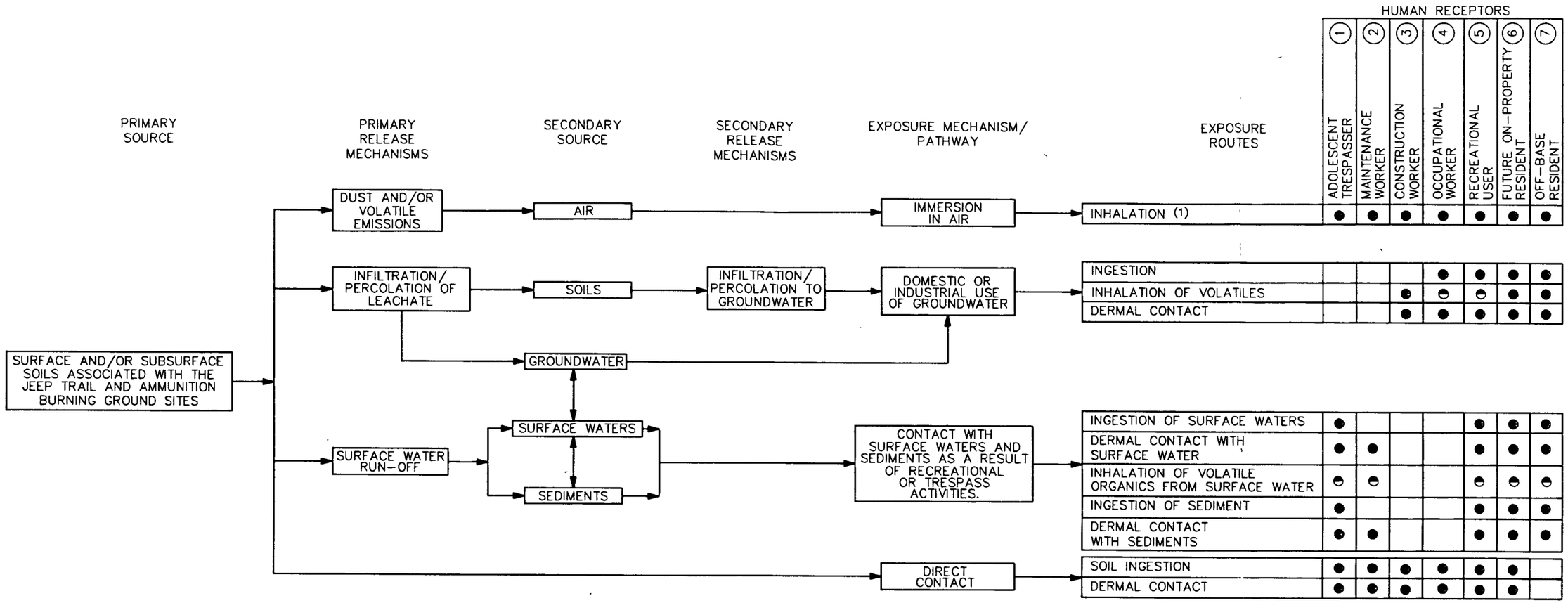

LEGEND:

● EXPOSURE PATHWAY TO BE EVALUATED IN RISK ASSESSMENT

◐ THE CONTRIBUTION TO EXPOSURE FROM THIS EXPOSURE PATHWAY IS ANTICIPATED TO BE NEGLIGIBLE

A BLANK SPACE INDICATES THAT THE EXPOSURE ROUTE IS NOT COMPLETE FOR THIS RECEPTOR

KEY

1. POTENTIAL RECEPTOR UNDER CURRENT AND FUTURE LAND USE. ACCESS TO THE SITE IS NOT LIMITED ONCE INSIDE THE FACILITY.
2. MAINTENANCE WORKERS NOT CURRENTLY ASSIGNED TO JEEP TRAIL OR LITTLE SULFER CREEK.
3. POTENTIAL RECEPTOR UNDER FUTURE LAND USE. A SHORT-TERM PROJECT (e.g., UTILITY INSTALLATION) MAY OCCUR.
4. PLAUSIBLE FUTURE RECEPTOR. HOWEVER, JEEP TRAIL SITE IS NOT 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.
7. OFF BASE RESIDENTS CURRENTLY EXIST (AND USE GROUNDWATER RESOURCE) DOWNGRADIENT OF JEEP TRAIL & LITTLE SULFER CREEK.

NOTE:

1) EXPOSURE IS EVALUATED QUANTATIVELY BY A COMPARISON OF MAXIMUM CONCENTRATIONS WITH SSL's FOR TRANSFERS FROM SOIL TO AIR.

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 8/18/00
CHECKED BY DATE
COST/SCHED-AREA
SCALE NOT TO SCALE

CONCEPTUAL SITE MODEL
JEEP TRAIL AND LITTLE SULPHER CREEK
NSWC CRANE, INDIANA

CONTRACT NO 0514
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE C-2 REV. 1

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TABLE C-2

EXPOSURE ROUTES FOR QUANTITATIVE EVALUATION
JEEP TRAIL AND LITTLE SULPHUR CREEK
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) • Surface Water/Sediment Dermal Contact • Surface Water/Sediment Ingestion
Maintenance Workers (future land use)	• Soil Dermal Contact (surface) • Soil Ingestion (surface) • Inhalation of Air/Dust/Emissions (surface) • Surface Water/Sediment Dermal Contact
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 of Volatile Organics (during excavation)
Small Child (0 to 6 yrs.) and Adult Recreational Users (future land use)	• Soil Dermal Contact (surface) • Soil Ingestion (surface) • Inhalation of Air/Dust/Emissions (surface) • Surface Water/Sediment Dermal Contact • Surface Water/Sediment Ingestion • Ground Water Dermal Contact • Direct Ingestion of Ground Water
On-Base 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) • Surface Water/Sediment Dermal Contact • Surface Water/Sediment Ingestion
Occupational Worker	• Soil Dermal Contact (surface) • Soil Ingestion (surface) • Inhalation of Air/Dust/Emissions (surface) • Direct Ingestion of Ground Water • Ground Water Dermal Contact
Off-Base Residents (Adults/Children	• Direct Ingestion of Ground Water • Ground Water Dermal Contact • Inhalation of Volatiles in Ground Water • Surface Water/Sediment Ingestion • Surface Water/Sediment Dermal Contact

concentrations exceeding 100 to 1,000 µg/L. VOC concentrations in monitoring wells at the Jeep Trail are typically less than 100 µg/L. Explosives such as 2,4-dinitrotoluene have been detected in the surface waters and sediments of Little Sulphur Creek. HMX has been detected in the surface waters and sediments of Little Sulphur Creek at maximum concentrations of 45 µg/L and 10 mg/kg, respectively. These data indicate that VOCs, explosives, and other contaminants have been disposed of within source areas within the study area (i.e., the ABG, the Jeep Trail) and have migrated to the ground water and Little Sulphur Creek via contaminant transport mechanisms such as infiltration and percolation and surface water run-off. Depth to ground water at the ABG and Jeep Trail is less than 10 feet bgs in the valley bottom and increases along the valley slopes. Consequently, the shallower water depths may facilitate transport of chemicals from soils to ground water. Because the shallow water table aquifer is in communication with deeper aquifers (e.g., Beech Creek Aquifer) transport of contaminants has also occurred from one aquifer to another.

Given that surface and subsurface soil contamination has occurred as a result of waste disposal at the ABG and the Jeep Trail and that contaminants have migrated to ground water and Little Sulphur Creek, plausible contaminant release and migration mechanisms include the following:

- Transport of surface soil contaminants to the subsurface soils and groundwater (and from one aquifer to another) via infiltration, percolation, and migration within the groundwater aquifer.

- Recharge of groundwater via surface waters. The study area in the vicinity and immediately downgradient of the ABG is a ground water recharge area. Little Sulphur Creek is a "losing stream" just below the ABG.

- Discharge of ground water to surface water and sediments as noted at Spring C located downstream of the source areas. Little Sulphur Creek becomes a "gaining stream" downstream of the Jeep Trail in the vicinity of Spring C which feeds Little Sulphur Creek.

- Overland run-off of surface waters and sediments from the ABG and the Jeep Trail toward and into Little Sulphur Creek. (On-site surface soil contaminants at the Jeep Trail may also migrate to off-site soils as a result of overland flow of surface waters.)

- Migration of contaminants in ground water (i.e., lateral migration) to potential receptor locations downgradient of the ABG and Jeep Trail source areas and beyond the NSWC Crane boundary.

- Migration of fugitive dusts and VOCs from surface soils (and subsurface soils if construction/excavation activities occur).

Potential Current and Future Receptors of Concern and Exposure Pathways

NSWC Crane is an active naval base and will remain active for the foreseeable future. The ABG is an active and RCRA-permitted open burning ordinance treatment unit and there are no plans to close the unit. In contrast, the Jeep Trail is no longer used as a treatment area and is likely to be used for military (non-disposal) or recreational purposes in the future. However, for purposes of completeness, the baseline risk assessment will consider 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 within the study area:

- Trespassers – A plausible receptor under current or future land use. Although access to the base is controlled, once inside the base access to the study area is not limited by any physical constraints (this is particularly true for the Jeep Trail). In addition, hunting activities are permitted at the base. Because the study area is relatively remote and surrounded by forested areas, hunters (particularly adolescents) may trespass within the study area. This receptor may be exposed to potentially contaminated surface soil (0 to 2 feet bgs) (incidental ingestion; dermal contact), air (inhalation), surface water (incidental ingestion; dermal contact), and sediments (incidental ingestion; dermal contact) in the intermittent streams. However, because of the intermittent nature of surface water in some portions of Little Sulphur Creek, exposure to surface water is likely to be very limited for those portions (e.g., the section adjoining the Jeep Trail). Direct contact with ground water (except where groundwater has discharged to Little Sulphur Creek) or subsurface soils is not anticipated for this receptor.

- Maintenance Workers – A plausible receptor under future land use. This includes adult military or civilian personnel assigned duties on a infrequent basis within the study area (e.g., groundskeeping activities, storm sewer/drainage maintenance). This receptor could be exposed to surface soils (incidental ingestion; dermal contact), surface water (dermal contact), sediments (incidental ingestion; dermal contact), and air (inhalation). Direct contact with ground water or subsurface soils is not anticipated for this receptor. There are currently no maintenance workers assigned to the Jeep Trail or to Little Sulphur Creek.

- Construction Workers – A plausible receptor under future land use. No construction activities are currently planned for the study area. Additionally, the shallow depth to ground water in some sections of the study area would likely preclude excavation and construction. However, excavation and

construction is plausible in other sections of the study area. Consequently, this receptor could be exposed to surface and subsurface soils (to an estimated maximum depth of 10 feet bgs) (incidental ingestion; dermal contact), ground water (dermal contact), and air (inhalation). Routine exposure to surface water and sediments is not expected for the construction worker.

- Occupational Worker – A plausible receptor under future land use for the Jeep Trail. (It should be noted that Base workers are currently assigned to the ABG.) This includes adult military or civilian personnel assigned to routine daily work tasks. This receptor could be exposed to surface soil (incidental ingestion; dermal contact), and air (inhalation). It is anticipated that this receptor would not be routinely exposed to subsurface soils, surface waters, or sediments. Conservatively, it will be assumed that the occupational worker may be exposed to groundwater (ingestion; dermal contact). (It should be noted that a public water supply is not currently available within the study area.) This receptor is expected to be exposed on a more frequent basis than the maintenance or construction worker. (It should be noted that bottled water is currently provided as a drinking water supply for Base workers at the ABG.)

- Recreational Users – A plausible receptor under future land use. If NSWC Crane were to close, the most likely scenario is that the property would be converted to a 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 (incidental ingestion; dermal contact) and sediments (incidental ingestion; dermal contact) in Sulphur Creek. Conservatively, it will be assumed that the recreational user may be exposed to groundwater (ingestion; dermal contact). (A public water supply is not currently available within the study area.) It should be noted that surface water in the vicinity of the Jeep Trail is intermittent and exposure is expected to be very limited. Direct contact with subsurface soils is not anticipated for this receptor. NSWC Crane is not expected to close because principal Base operations, the demilitarization of munitions, are critical to the support of the U.S. Naval fleet.

- On-Base Residents – An unlikely receptor under future land use. 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 soils (incidental ingestion; dermal contract), ground water (ingestion, dermal contact), surface water (ingestion; dermal contact), air (inhalation), and sediment (incidental ingestion; dermal contact).

- Off-Base Residents – Off-base residents do exist downgradient of the study area. It is assumed that an off-base resident may be exposed to ground water (ingestion, dermal contact), surface water (ingestion; dermal contact), air (inhalation), and sediment (incidental ingestion; dermal contact).

These receptors have been previously defined in recent planning documents for SWMUs 4, 5, 9, 10, and/or 01/12 (the Mustard Gas Burial Ground), and/or are similar to the following receptors evaluated in the *Current Contamination Conditions Risk Assessment* [TtNUS, February 1999]):

- Base personnel and families (current land use)
- SWMU workers (current land use)
- Park employees (future land use)
- Park visitors (future land use)
- On-SWMU residents (future land use)
- Off-facility residents (current land use)

Details regarding the assumed receptor characteristics (e.g., intake rate, frequency, duration of exposure) are defined in this section which presents the methodologies for human health risk assessment.

C.2.2 Central Tendency Exposure vs. Reasonable Maximum Exposure

Traditionally, exposures evaluated in the human health risk assessment 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, December 1989). However, recent risk assessment guidance (U.S. EPA, 1992b) 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 will be evaluated in the site-specific risk assessment for the Jeep Trail and Little Sulphur Creek at NSWC Crane. The available guidance (U.S. EPA, 1993a) concerning the evaluation of CTE is limited and at times vague. Therefore, professional judgment may be exercised when defining CTE conditions for a particular receptor at a site.

C.2.3 Exposure Point Concentrations

The exposure point concentration (EPC), which is calculated for COPCs only, is an estimate of the chemical concentration within an exposure unit that is likely to be contacted over time by a receptor and is used to estimate exposure intakes. The 95 percent upper confidence limit (UCL), which is based on the distribution of a data set, is often considered to be the best estimate of the exposure point concentration

for data sets with 10 or more samples (U.S. EPA, 1992c). The 95 percent UCL will be used as the exposure concentration to assess RME and CTE risks (U.S. EPA, 1993a). For data sets with less than 10 samples, the UCL is considered to be a poor estimate of the mean, and the exposure point concentration is usually defined using an alternative descriptive statistic (e.g., the maximum detected concentration).

Conventional statistical methods (e.g., the Shapiro-Wilk W-Test) will be used to determine the distribution and UCL of a particular data set (Gilbert, 1987; U.S. EPA, 1992c). Detailed sample calculations, as well as general methodology for the statistical evaluation, will be presented in the site-specific risk assessment. Sample and duplicate analytical results will be averaged for statistical use. Nondetected data points will be utilized; in general, one-half the sample-specific detection limit will be employed for these analytical results.

The following paragraphs discuss the exposure units to be evaluated and the guidelines used to calculate the media-specific exposure point concentration.

The Jeep Trail EU will include the two treatment sub-units (the "burn pit" and the "burn area"; each treatment unit is approximately 100 feet by 30 feet separated by 30 feet) and the area immediately beyond (i.e., within 10 feet of) the presumed extent of contamination. The entire study area (approximately 1-acre) will be considered the EU for soils. Surface soils will extend to a depth of 2 feet; subsurface soil will be all soil from a depth of 2 feet to 10 feet or bedrock, whichever is shallower. A 1-acre EU area is considered a reasonable size based on the current and 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 inclusion (i.e., sampling) of the area immediately beyond the presumed perimeter of the unit facilitates the assessment of the extent of contamination, but does not extend so far into expected uncontaminated regions that the EU concentrations are artificially reduced. Additional EUs may be defined if, based on the first soil sampling event, significant soil contamination is noted beyond the presumed extent of the Jeep Trail study area. For example, contaminated surface soils may exist between (i.e., downslope of) the source areas and the creek as a result of surface water run-off. Additionally, the Jeep Trail EU may be subdivided to gain perspective on risk estimates if significant contaminant "hot spots" exist within the EU (e.g., contamination in the "burn area" or "burn pit" are distinctive).

As detailed below, the EPC for a receptor hypothetically using or otherwise exposed to ground water underlying the Jeep Trail study area will be the arithmetic average of wells in the most highly concentrated area of the plume potentially underlying the Jeep Trail study area. If it is determined that a ground water contaminant plume at the Jeep Trail is or may be moving beyond the study area boundaries, EPCs for

ground water at receptor locations beyond the Jeep Trail study area may be determined via actual groundwater monitoring data for wells at or near the facility boundary or by using modeling techniques. The locations will be selected, if necessary, based on the concentrations detected within the Jeep Trail study area (i.e., the observed or potential contaminant loading to or within the ground water aquifer), the aquifer characteristics (e.g., flow, direction), and the chemical and physical nature of contaminants detected in the ground water.

Based on anticipated receptor activity, the entire proposed Little Sulphur Creek study area (i.e., upgradient of the ABG to the confluence with Johnson Hollow Creek) is the most plausible EU for surface water and sediment exposure. However, subdivision of the creek may be warranted in light of contaminant profiles and receptor exposure scenarios. The EU for surface waters and sediments will include sediments in flood plains adjoining Little Sulphur Creek and Springs A, B, and C that feed Little Sulphur Creek. Additionally, the Jeep Trail EU may be subdivided to gain perspective on risk estimates at various exposure points/sub-units along Little Sulphur Creek. Exposure points/sub-units evaluated may include the ABG, the Jeep Trail, and Springs A, B, and C. An evaluation of these exposure points/sub-units may be necessary to understand the relative contribution of risk from contaminant sources and because of the variable nature of surface water in Little Sulphur Creek. For example, the surface water flow in Little Sulphur Creek below the ABG, but above Spring C is intermittent and, consequently, can not be evaluated as a reliable domestic water supply resource. In contrast, there is year-around groundwater-to-surface water flow at Springs A, B, and C. Additional EUs (below the confluence with Johnson Hollow) may be defined if, based on the first surface water and sediment sampling event, significant surface water and sediment contamination is suspected beyond the initially defined Little Sulphur Creek study area.

The following guidelines will be used to calculate the EPCs:

- If a soil, surface water, or sediment data set for an EU contains fewer than 10 samples, the EPC for the reasonable maximum exposure (RME) and central tendency exposure (CTE) case will be defined as the maximum detected concentration.

- If a soil, surface water, or sediment data set for an EU contains 10 or more samples, the 95 percent upper confidence limit (UCL) on the arithmetic mean, which will be based on the distribution of the data set, will be selected as the EPC for the RME and CTE case. Conventional statistical methods (e.g., the Shapiro-Wilk W-Test, the *t*- and *H*-statistic based UCL calculation) will be used to determine the distribution and UCL. The "best fit" distribution (normal or lognormal) will be assumed if the data set distribution is undefined. However, the EPCs calculated assuming a lognormal distribution will be reviewed and re-calculated (if necessary) as recommended in a recent EPA reference to assure that

the *H*-statistic based UCL is not an over-prediction of the EPC (U.S. EPA, 1997b). If the calculated 95 percent UCL exceeds the maximum detected concentration, the maximum concentration will be used as the EPC. If enough data are available and a qualified statistician judges bootstrapping to present a more realistic estimation of risk, the bootstrapping technique described in the U.S. EPA 1997 reference will be used.

- Assuming that multiple rounds of ground water samples may be collected from site monitoring wells, and that no temporal concentration trend is obvious, the EPC for a ground water receptor will be the arithmetic average of wells in the highly concentrated area of the plume. If a temporal trend is noted, the EPC will be based on the most recent ground water sampling event only.

Sample and duplicate analytical results will be averaged for statistical use. Data values less than sample-specific detection limits will be substituted with one-half the detection limit. It should be noted that EPCs for ground water may also be developed for specific receptor locations (e.g., the facility boundary), as necessary, using actual groundwater modeling data or ground water modeling techniques.

C.2.4 Chemical Intake Estimation

The methodologies and techniques used to estimate exposure intakes are presented in this section of the QAPP. Intakes for the identified potential receptor groups will be calculated using current U.S. EPA risk assessment guidance (e.g., U.S. EPA, 1998b, 1998a, and 1991b) and presented in the risk assessment spreadsheets. Risk assessment spreadsheets will be appended to the site-specific risk assessments as support documentation. All quantitative risk assessment results will be presented in RAGS Part D format tables.

Noncarcinogenic intakes will be estimated using the concept of an average annual exposure. Carcinogenic intakes will be calculated as an incremental lifetime exposure, which will assume a life expectancy of 70 years. Assumptions regarding exposure are presented in Table C-3.

TABLE C-3

SUMMARY OF EXPOSURE ASSUMPTIONS
JEEP TRAIL AND LITTLE SULPHUR CREEK
NSWC CRANE, CRANE, INDIANA
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Receptor	Exposure Assumptions			Rationale/Reference
	Input Parameter	RME	CTE	
Adolescent Trespasser (6 to 17 Years)	EF (days/yr)	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 (yrs)	11	11	Adolescents from age 6 to 17 evaluated.
	ET (hours/day) and t_{event} (hr/event)	4	2	Professional judgement.
	BW (kg)	43	43	Average age-specific value (USEPA, May 1989).
	SA (cm^2/day) and A (cm^2)1	3,820	3,100	25 percent of the total body surface area will be assumed to be available for soil, sediment, and surface water contact. CTE and RME areas represent 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 (USEPA, August 1997).
	CR (L/hr)	0.05	0.05	Intake rates for exposure to surface water during swimming (USEPA, November 1995).
	IR_s/IR_{sed} (mg/day)	100	50	Assumed similar to adult exposure (USEPA, May 1993).
	IR_a (m^3/hour)	1.9	1.9	Recommended short-term heavy activities rate for children (USEPA, August 1997; Table 5-23).
Maintenance/ Occupational Worker	EF (days/yr)	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 (USEPA, May 1993).
	ED (yrs)	25	9	Convention for RME (USEPA, March 1991) and CTE (USEPA, May 1993).
	ET (hours)	8 (air) (occupational worker) 4 (air) (maintenance worker) 2 (surface water) (maintenance worker) 0.25 (ground water) (occupational worker)	8 (air) (occupational worker) 4 (air) (maintenance worker) 1.5 (surface water) (maintenance worker) 0.167 (ground water) (occupational worker)	Standard default for occupational worker exposed to air. (USEPA, March 1991). Professional judgement for all other parameters.
	BW (kg)	70	70	USEPA, May 1993.

TABLE C-3

SUMMARY OF EXPOSURE ASSUMPTIONS
JEEP TRAIL AND LITTLE SULPHUR CREEK
NSWC CRANE, CRANE, INDIANA
PAGE 2 OF 4

Receptor	Exposure Assumptions			Rationale/Reference
	Input Parameter	RME	CTE	
Maintenance/ Occupational Worker (Continued)	SA (cm^2/day)	2,830	2,300	Surface area of the hands and forearms measured in men assumed to be available for soil/sediment/surface water contact. The RME and CTE values represent the 95th and 50th percentile areas of the hands and forearms (USEPA, August 1997, Table 6-2). (Similar to recommended SA for industrial worker Table 3.5, RAGS Part E.)
	IR_{sed}/IR_s (mg/day)	100	50	USEPA, May 1993.
	IR_a (m^3/hour)	2.5 (maintenance) 0.6 (occupational)	2.5 (maintenance) 0.6 (occupational)	For maintenance workers, recommended short-term heavy activities rate for outdoor workers (USEPA, August 1997; Table 5-23). For occupational workers, adult daily inhalation rate (USEPA, December 1989 and page 5-24 of USEPA, August 1997).
	IR_w (L/day)	1 (occupational worker)	1 (occupational worker)	Professional judgement.
Construction Worker	EF (days/yr)	150	150	Professional judgement. Ground assumed to be frozen or snow covered for 22 weeks/yr.
	ED (yrs)	1	1	Estimated length of construction project (professional judgement).
	ET (hours)	8 (air) 2 (ground water)	8 (air) 1.5 (ground water)	For air, standard default (USEPA, March 1991). Professional judgement for dermal exposure to ground water.
	BW (kg)	70	70	USEPA, May 1993.
	SA (cm^2/day)	5,800	5,000	Recommended values for adult skin surface area assumed to be available for soil contact (USEPA, August 1997; Table 6-16). Valued also assumed for dermal contact with ground water.
	IR_s (mg/day)	480	240	Convention for the RME (USEPA, March 1991). CTE is 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 (USEPA, August 1997; Table 5-23).
	EV (events/day)	1	1	Professional judgement.
Small Child and Adult Recreational User	EF (days/yr)	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 (yrs)	24(1) 6(3)	7(1) 2(3)	USEPA, May 1993. Assumed length of residence for an adult living near the facility.
	ET (hours/day) and t_{event} (hr/event)	4	2	Professional judgement.

TABLE C-3

SUMMARY OF EXPOSURE ASSUMPTIONS
JEEP TRAIL AND LITTLE SULPHUR CREEK
NSWC CRANE, CRANE, INDIANA
PAGE 3 OF 4

Receptor	Exposure Assumptions			Rationale/Reference
	Input Parameter	RME	CTE	
Small Child and Adult Recreational User (Continued)	BW (kg)	70[1] 15[3]	70[1] 15[3]	USEPA, May 1993.
	SA (cm^2/day)	9,190 (adult) 4,000 (child)	7,770 (adult) 3,500 (child)	Feet, lower legs, hands, and arms of adult male assumed to be available for soil, surface water, and sediment contact. The RME and CTE values represent the 95th and 50th percentile areas of the feet, lower legs, hands and arms (USEPA, August 1997, Table 6-2). Fifty-percent of the total body surface area for child will be assumed to be available for soil, sediment, and surface water contact. CTE and RME represent the mean of the 50th and 95th for ages 0 to 6 as provided in Table 6-6 of the Exposure Factors Handbook (August 1997).
	IR_{sed}/IR_S (mg/day)	200[3] 100[1]	100[3] 50[1]	Based on USEPA, May 1993.
	IR_a (m^3/hour)	1.2[3] 1.6[1]	1.2[3] 1.6[1]	Recommended short-term moderate activities rate for adults and children (USEPA, August 1997 page 5-24 and Table 5-23).
	IR_w (l/DAY)	1	1	Professional judgment.
	CR (L/hr)	0.05[1] 0.01[2]	0.05[1] 0.01[2]	Intake rates for exposure to surface water during swimming (USEPA, November 1995).
	FI	0.5	0.5	Professional judgment.
Resident (Adult/Small Child)	EF (days/yr or showers/yr)	350	234	USEPA, May 1993. One shower assumed to be taken per day.
	ED (yrs)	24[1] 6[3]	7[1] 2[3]	USEPA, May 1993.
	t_{event} (hr/event) (showering)	0.25	0.167	15 min/event for RME and 10 min/event for CTE (USEPA, January 1992).
	BW (kg)	70[1] 15[3]	70[1] 15[3]	USEPA, May 1993.
	SA (cm^2/day)	5,800[1] [5] 2,000[3] [5] 18,000[1] [4] 6,600[1] [4]	5,000[1] [5] 1,745[3] [5] 18,000[1] [4] 6,600[1] [4]	Recommended values for adult skin surface area assumed to be available for soil or sediment contact (USEPA, August 1997). [Child CTE and RME areas represent 25% of the total body area, as provided in Table 6-6 of the Exposure Factors Handbook (USEPA, August 1997)]. Recommended values for domestic use of ground water or surface water based on Exhibit 3.2 (RAGS Part E2000).

TABLE C-3

SUMMARY OF EXPOSURE ASSUMPTIONS
JEEP TRAIL AND LITTLE SULPHUR CREEK
NSWC CRANE, CRANE, INDIANA
PAGE 4 OF 4

Receptor	Exposure Assumptions			Rationale/Reference
	Input Parameter	RME	CTE	
Resident (Adult/Small Child) (Continued)	IR_S (mg/day) [IR_{sed} (mg/day)]	100(1) [50(1)] 200(3) [100]	50(1) [25(1)] 100(3) [50]	Values for soil based on USEPA, May 1993. Values for sediment based on professional judgement.
	IR_a (m^3/day) (transfers from soil to air)	20(1) 8.3(3)	20(1) 8.3(3)	Adult daily inhalation rate (USEPA, December 1989) Child daily inhalation rate – Recommended long-term rate for children, 3-5 years of age (USEPA, August 1997; Table 5-23).
	IR_a (m^3/hr) (showering)	0.6	0.6	For all age groups while showering (USEPA, December 1989).
	IR_w (L/day)	2(1) 1.5(3)	1.4(1) 0.66(3)	USEPA, May 1993 for adult exposure. USEPA, August 1997, 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
CR = Contact Rate - Surface Water
Irw = Ingestion Rate - Groundwater
FI = Fraction soil/sediment ingested from source
IR_{sed} = Ingestion Rate - Sediment

1 Exposure assumption for adult receptor.
2 Exposure assumption for adolescent receptor.
3 Exposure assumption for small children (0 to 6 years of age).
4 Assumes domestic use of a ground water or surface water supply.
5 Assumes typical residential exposure to surface soils/sediments.

C.2.4.1 Inhalation of Air and Fugitive Dust/Volatile Emissions from Soils

The amount of a chemical that a receptor takes in as a result of respiration is determined using the concentration of the contaminant in air. Intakes of both particulates and vapors/gases from soil will be calculated using the same equation, as follows (U.S. EPA, 1989b):

$$\text{(chemical)} \quad Intake_{ai} = (C_{ai})(IR_a)(ET)(EF)(ED)\,/(BW)(AT)$$

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)
ET	=	exposure time (hours/day)
EF	=	exposure frequency (days/yr)
ED	=	exposure duration (yr)
BW	=	body weight (kg)
AT	=	averaging time (days);
		for noncarcinogens, AT = ED x 365 days/yr;
		for carcinogens, AT = 70 yrs x 365 days/yr

The concentration of a chemical in air will be developed using modeling techniques, measured soil concentrations, and additional site-specific information.

As mentioned previously in Section C.1.2.1, a qualitative evaluation of exposure (i.e., comparison of maximum site soil concentrations to U.S. EPA Generic SSLs for transfers from soil to air) will be used to identify whether a quantitative analysis of this exposure pathway is warranted. If it is determined that a quantitative evaluation is not required, the potential risks associated with the inhalation pathway will be regarded as minimal and no further evaluation will be performed.

C.2.4.2 Dermal Contact with Soil/Sediment

Direct physical contact with soil (and sediment) may result in the dermal absorption of chemicals. Exposures associated with the dermal route are estimated in the following manner (U.S. EPA 2000; U.S. EPA, 1998b; 1992a):

$$Intake_{si} = (C_{si})(SA)(AF)(ABS)(CF)(EF)(ED)\,/(BW)(AT)$$

where: $Intake_{si}$ = amount of chemical "i" absorbed during contact with soil/sediment (mg/kg/day)

C_{si} = concentration of chemical "i" in soil/sediment (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 (1E-6 kg/mg)

EF = exposure frequency (days/yr)

ED = exposure duration (yr)

BW = body weight (kg)

AT = averaging time (days);
for noncarcinogens, AT = ED x 365 days/yr;
for carcinogens, AT = 70 yrs x 365 days/yr

Exposed surface areas of body available for dermal contact are determined on a receptor-specific basis since they correspond with assumed human activities and clothing worn during exposure events. Current guidance (U.S. EPA, 2000; U.S. EPA, 1992a; U.S. EPA, 1997a; U.S. EPA, 1998b) were 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 maintenance and occupational workers exposed to surface soil, the surface area available for soil contact is assumed to be the hands and forearms of an adult male. The skin surface area is 2,300 cm^2 for the CTE and is 2,830 cm^2 for the RME. These values represent the 50th and 95th percentile areas for the hands and forearms, respectively (U.S. EPA, 1997a). It should be noted that the proposed adult skin surface areas for the RME and CTE case are similar to those proposed in RAGS Part E (U.S. EPA, 2000) assuming an industrial land use (3,300 cm^2 for both the RME and CTE case). The proposed adult skin surface areas are selected because the values are those presented in planning documents for other recent NSWC Crane projects (TtNUS, October 1999; TtNUS, July 2000) and because the RAGS Part E has not been finalized at this time.

- 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, 1997a). These values represent 25 percent of the total body surface area of an adult male.

- For adolescent trespassers, 25 percent of the total body surface area for an adolescent (aged 6 to 16) will be assumed to be available for surface soil and/or sediment contact. The RME value (3,820 cm^2) is derived from the 95th percentile surface area data and the CTE value (3,100 cm^2) is derived from the 50th percentile data, as provided in Table 6-6 of the Exposure Factors Handbook (U.S. EPA, 1997a).

- For adult recreational users assumed to be exposed to surface soil and sediment, the exposed surface area available for contact will be the sum of the feet, lowerlegs, hands, and arms of an adult male. This skin surface area is 7,770 cm^2 for the CTE and is 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, 1997a). For a small child recreational user (0 to 6 years old), it will be assumed that 50 percent of the body surface area will be exposed to surface soil and sediment (i.e., 4,000 and 3500 cm^2, respectively) (These values represent the 95th and 50th percentile areas presented in Table 6-6 of the Exposure Factors Handbook) (U.S. EPA, 1997a).

- For adult residents exposed to surface soil/sediment, the exposed surface areas available for contact will be the U.S. EPA recommended values for adult skin surface area for exposure to soil (RME = 5,800 cm^2 and CTE = 5,000 cm^2 –(Table 6-14, U.S. EPA, 1997a). For child residents assumed to be exposed to surface soil/sediment, the CTE and RME areas will represent 25 percent of the 50th and 95th percentile total surface area of children ages 2 to 6, respectively, as provided in Table 6-6 of the Exposure Factors Handbook (U.S. EPA, 1997a). It should be noted that the proposed adult skin surface areas for the RME and CTE case are similar to those proposed in RAGS Part E (U.S. EPA, 2000) assuming a residential land use (5,700 cm^2 for both the RME and CTE case). However, the skin surface areas proposed for the small child (RME = 2,000 cm^2 and CTE = 1,745 cm^2 (Table 6-6, U.S. EPA, 1997a) are less than those proposed in RAGS Part E assuming residential land use (i.e., 2,800 for both the RME and CTE case). The skin surface areas selected are those values presented in planning documents for other recent NSWC Crane projects (TtNUS, October 1999; TtNUS, July 2000) and because the RAGS Part E has not been finalized at this time.

The published range for the recommended soil adherence factors for the typical residential and industrial land use scenarios in RAGS Part E (U.S. EPA, 2000) are as follows:

	Central Tendency Case		Reasonable Maximum Case	
	Residential (mg/cm^2)	**Industrial (mg/cm^2)**	**Residential (mg/cm^2)**	**Industrial (mg/cm^2)**
Adult Receptor	0.01	0.02	0.07	0.2
Child Receptor	0.04	NA	0.2	NA

NA – Not applicable

It should be noted that the adherence factors suggested for the residential land use scenario will be used to evaluate recreational and trespass exposure scenarios. Adherence factors suggested for the industrial land use scenario will be used to evaluate all types of workers considered (i.e., maintenance worker, occupational worker, and construction worker).

Current U.S. EPA guidance (U.S. EPA, 2000) will be used to determine chemical-specific dermal absorption factors.

C.2.4.3 Incidental Ingestion of Soil/Sediment

Incidental ingestion of soil (and sediment) by potential receptors coincides with dermal exposure. Exposures associated with incidental ingestion are estimated in the following manner (U.S. EPA, 1989):

$$\text{(chemicals)} \quad Intake_{Si} = (C_{Si})(IR_S)(FI)(EF)(ED)(CF)\,/(BW)(AT)$$

where: $Intake_{si}$ = intake of contaminant "i" from soil or sediment (mg/kg/day, chem) (pCi, rad)

C_{si} = concentration of contaminant "i" in soil or sediment (mg/kg, chem)

IR_s = ingestion rate (mg/day)

FI = fraction ingested from contaminated source (dimensionless)

EF = exposure frequency (days/yr)

ED = exposure duration (yr)

CF = conversion factor (1E-6 kg/mg)

BW = body weight (kg)

AT = averaging time (days);
for noncarcinogens, AT = ED x 365 days/yr;
for carcinogens, AT = 70 yrs x 365 days/yr

The same exposure frequencies and durations used in the estimation of dermal intakes will be used to estimate exposure via incidental ingestion. Default values of 1.0 (RME) and 0.5 (CTE) will be used for the fraction of soil ingested from the source. Sediment ingestion rates will be the same as those assumed for soil ingestion except that, for the resident, the proposed sediment ingestion rate will be 50 percent of the proposed soil ingestion rate.

C.2.4.4 Dermal Contact with Ground Water/Surface Water

The same equation is used to estimate intakes for dermal contact with ground water and surface water. Direct contact with ground water at the Jeep Trail and Little Sulphur Creek is limited to exposure that would occur under a residential, recreational, typical industrial (occupational) and construction scenarios. Hypothetical future on-base residential receptors are assumed to use ground water for domestic purposes (i.e., bathing, showering, washing dishes), that can result in a dermal exposure. It is also assumed that off-base residents may use the groundwater resource for domestic purposes. Short-term dermal exposure is assumed to occur for the construction worker during excavation activities, and for hypothetical recreational user or occupational worker receptors that may occasionally use rest-room facilities (supplied by groundwater pumped from the underlying aquifer) while working or recreating. (It should be noted that neither facilities nor groundwater supply wells exist at the Jeep Trail or Little Sulphur Creek at this time. Such facilities currently exist at the ABG.) Dermal contact with surface water may also occur while receptors are involved in certain activities, such as landscaping (maintenance worker), trespassing or recreational sport (hiking, biking, etc.) or if off-base residents use off-site springs feeding Little Sulfur Creek as a domestic water supply.

The following equation will be used to assess exposures resulting from dermal contact with water (U.S. EPA, 1992a; U.S. EPA, 2000):

$$DAD_{wi} = (DA_{event})(EV)(ED)(EF)(A) / (BW)(AT)$$

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 (yr)
EF	=	exposure frequency (days/yr)
A	=	skin surface area available for contact (cm^2)
BW	=	body weight (kg)

AT = averaging time (days);
for noncarcinogens, AT = ED x 365 days/yr;
for carcinogens, AT = 70 yrs x 365 days/yr

Ground water or surface water exposure for hypothetical future on-base or off-base residential receptors using the groundwater/surface water as a domestic water supply is assumed to occur on a daily basis. Exposure to ground water for construction workers, recreational users or typical occupational workers and exposure to surface water for maintenance workers, trespassers, and recreational users are also assumed to occur each day the receptor visits the study area. Dermal intakes for residents will assume total body exposure. For construction workers, trespassers, occupational workers, maintenance workers, and recreational users, the exposed surface area of the body available for contact was based on assumed activities and is similar to the assumptions outlined for dermal contact with soil and sediment. Table C-3 summarizes recommendations for exposure parameters that will be evaluated in the Baseline risk assessment.

The absorbed dose per event (DA_{event}) will be estimated using a nonsteady-state approach for organic compounds and a traditional steady-state approach for inorganics. For organics, the following equations apply:

$$\text{If } t_{event} < t^*, \text{ then: } DA_{event} = (2K_p)\,FA(C_{wi})\,(CF)\left[\frac{\sqrt{6\,T\,t_{event}}}{\pi}\right]$$

$$\text{If } t_{event} > t^*, \text{ then: } DA_{event} = (K_p)\,FA(C_{wi})\,(CF)\left[\frac{t_{event}}{1+B} + 2T\left[\frac{1+3B+3B^2}{(1+B)^2}\right]\right]$$

where:
- t_{event} = duration of event (hr/event)
- t^* = time it takes to reach steady-state conditions (hr)
- K_p = permeability coefficient from water through skin (cm/hr)
- C_{wi} = concentration of chemical "i" in water (mg/L)
- T = lag time (hr)
- π = constant (dimensionless; equal to 3.141592654)
- CF = conversion factor (1E-3 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_{event}, t^*, K_p, T, FA, and B) will be obtained from RAGS Part E the current dermal guidance (U.S. EPA, 2000 and updates). If no published values are available for a particular compound; they will be calculated using equations provided in the cited guidance.

The following nonsteady-state equation will be used to estimate DA_{event} for inorganics:

$$DA_{event} = (K_p)\ (C_{wi})\ (t_{event})$$

In general, the recommended default value of 1E-3 will be 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.

C.2.4.5 Incidental/Direct Ingestion of Ground Water/Surface Water

Residents may be exposed to ground water or surface water via direct ingestion. Intakes associated with ingestion of water will be evaluated using the following equations (U.S. EPA, 1989):

$$\text{(chemical)}\ \ Intake_{wi} = (C_{wi})(IR_w)(EF)(ED)/(BW)(AT)$$

where:	$Intake_{wi}$	=	intake of chemical "i" from water (mg/kg/day, chem)
	C_{wi}	=	concentration of chemical "i" in water (mg/L, chem)
	IR_w	=	ingestion rate for ground water (L/day)
	IR_w	=	ingestion rate for surface water (L/day) = (CR)(ET)
	CR	=	contact rate for surface water (L/hr)
	ET	=	exposure time for surface water (hr/day)
	EF	=	exposure frequency (days/yr)
	ED	=	exposure duration (yr)
	BW	=	body weight (kg)
	AT	=	averaging time (days);
			for noncarcinogens, AT = ED x 365 days/yr;
			for carcinogens, AT = 70 yrs x 365 days/yr

The same exposure times, frequencies, and durations used to assess dermal exposure to water will be used to estimate intakes for ingestion of water.

C.2.4.6 Inhalation of Volatiles in Ground Water

Ground water or surface water exposure may also result in an inhalation exposure if the water resource is used as a domestic water supply. This exposure route will be evaluated for residential receptors only who may be exposed while showering, bathing, washing dishes, etc. Inhalation exposures will be 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 is as follows (U.S. EPA, 1989; Foster and Chrostowski, 1987):

$$Intake_{si} = (S)(IR_{sh})(K)(EF)(ED) / (BW)(AT)(R_a)(CF)$$

$$K = D_s + \frac{\exp(R_a \times D_t)}{R_a} - \frac{\exp R_a \times (D_s - D_t)}{R_a}$$

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/yr)
ED	=	exposure duration (yrs)
BW	=	body weight (kg)
AT	=	averaging time or period of exposure (days)
R_a	=	air exchange rate (min^{-1})
CF	=	conversion factor (1E+6 µg-L/mg-m^3)
D_s	=	shower duration (min)
D_t	=	total time in bathroom (min)

The volatile chemical generation rate will be 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. Calculations of the shower model will be provided in the appendices to the site-specific risk assessments. For most metals anticipated at the Jeep Trail and Little Sulphur Creek, volatilization is not a significant pathway because these substances do not vaporize at room temperature

C.2.4.7 Summary of Exposure Parameters

A summary of the exposure input parameters for all exposure pathways are presented in Table C-3 for the identified potential receptor groups at the Jeep Trail and Little Sulphur Creek. In general, standard default parameters (e.g., U.S. EPA, 1991a; Exposure Factors Handbook, U.S. EPA 1997a), which combine mid-range and upper-end exposure factors, will be used to assess RME conditions. CTE will be assessed primarily by the use of mid-range exposure factors presented in current risk assessment guidance (U.S. EPA, 1989 and 1993a). These input parameters may be updated according to new risk assessment guidance, as it becomes available.

C.2.5 Exposure to Lead

The equations and methodology presented in the previous section cannot be used to evaluate exposure to lead because of the absence of published dose-response parameters. Exposure to lead will be assessed using the following models:

- The latest version of the U.S. EPA's Integrated Exposure Uptake Biokinetic (IEUBK) Model for lead (U.S. EPA, 1994a). This model is typically used to evaluate lead exposure assuming a residential land use scenario.

The U.S. EPA's Technical Review Workgroup (TRW) Model for Lead (U.S. EPA, 1996c). This model is typically used to evaluate lead exposure assuming a non-residential land use scenario.

The IEUBK Model for lead (U.S. EPA, 1994a) is designed to estimate blood levels of lead in children (under 7 years of age) based on either default or site-specific input values for air, drinking water, diet, dust, and soil exposure. Studies indicate that infants and young children are extremely susceptible to adverse effects from exposure to lead. Considerable behavioral and developmental impairments have been noted in children with elevated blood lead levels. The threshold for toxic effects from this chemical is believed to be in the range of 10 µg/dL to 15 µg/dL. Blood lead levels greater than 10 µg/dL are considered to be a "concern".

For the Jeep Trail and Little Sulphur Creek, the IEUBK Model for lead will be used to address exposure to lead in children when detected ground water and surface water concentrations exceed the 15 µg/L Federal Action Level promulgated under the Safe Drinking Water Act and when detected soil and sediment concentrations exceed the OSWER soil screening level of 400 mg/kg for residential land use (U.S. EPA, 1994b). Average chemical concentrations, as well as default parameters for some input

parameters, will be employed. Estimated blood lead levels and probability density histograms will be presented as support documentation for this analysis and appended to the site-specific risk assessment.

Non-residential adult exposure to lead in soil will be evaluated using the U.S. EPA's Technical Review Workgroup for Model Lead (U.S. EPA, 1996c). In this model, adult exposure to lead in soil is addressed by an evaluation of the relationship between the site soil lead concentration and the blood lead concentration in the developing fetuses of adult women. The adult lead model will generate a spreadsheet for each exposure scenario evaluated (i.e., industrial, recreational). The out-put of the spreadsheet will be the probability that the blood lead concentrations in the fetus exceeds 10 µg/L. The probability that the fetal blood lead level will exceed 10 µg/L will be calculated per the following EPA guidelines:

- Use of the TRW Interim Adult Lead Methodology in Risk Assessment, Memorandum from Pat Van Leeuwen (Region 5 Superfund Program) and Paul White (ORD/NCEA) to Mark Maddaloni, Chair, TRW Adult Lead Subgroup, April 7, 1999.

- Frequently Asked Questions (FAQs) on the Adult Lead Model, Technical Review Workgroup for Lead, Guidance Document, April 1999, Rev. 0.

No models are currently available to evaluate the periodic exposure of adolescent trespassers to lead. Therefore, the results of the IEUBK Model for children will be used to qualitatively assess exposure of this receptor. Essentially, the qualitative discussion will cite that potential adverse effects from exposure to lead are expected to be of a lesser magnitude for adolescent trespassers than for children.

C.3 TOXICITY ASSESSMENT

The objective of the toxicity assessment is 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 will be defined for the identified COPCs. Quantitative toxicity values determined during this component of the risk assessment will be 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 is the Reference Dose (RfD). Carcinogenic effects are quantified using the Cancer Slope Factor (CSF).

C.3.1 Toxicity Criteria

Oral and inhalation RfDs and CSFs to be used in the site-specific risk assessments for the Jeep Trail and Little Sulphur Creek will be obtained from the following primary literature sources:

- Integrated Risk Information System (IRIS)
- Annual Health Effects Assessment Summary Tables (HEAST)
- 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 is 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 IX PRG Tables and Region III RBC Tables will also be used as a source of toxicity criteria when toxicity criteria are not available from the aforementioned references

C.3.1.1 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 from administered to absorbed dose will be made using chemical-specific absorption efficiencies published in available guidance (i.e., U.S. EPA 1998b [the primary reference]; IRIS; Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profiles, etc.) 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

Absorption efficiencies used in the risk assessments will reflect the U.S. EPA's current dermal assessment guidance (U.S. EPA, 2000).

C.3.1.2 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 known 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 will be 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 and inhalation CSF for these chemicals is derived by multiplying the CSF for benzo(a)pyrene by the order of potential potency.

C.3.1.3 Toxicity Criteria for Carcinogenic Effects of Dioxins/Furans

Similar to the concept of estimated orders of potential potency for PAHs, chlorinated dibenzo-p-dioxins (CDDs) and -dibenzofurans (CDFs) will be evaluated using Toxicity Equivalence Factors (TEFs) relative to the toxicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) (Environmental Health Perspectives, December 1998; U.S. EPA, March 1989). Based on a variety of approaches that generate toxicities relative to 2,3,7,8-TCDD, the U.S. EPA and others have developed TEFs for other dioxins/furans from structure-activity relationships and the available toxicological information. An equivalent oral CSF for these chemicals may be derived by multiplying the CSF for 2,3,7,8-TCDD by the TEF. However, the TEFs are more typically used to derive a toxicity equivalent concentration (TEQ) representing all of the significant dioxin/furans in a sample. An EPC based on the TEQs for a dataset is then evaluated using the CSF for 2,3,7,8-TCDD.

C.3.1.4 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 support the conclusion that hexavalent chromium is present at the sites, speciation analyses will not be completed for the Jeep Trail and Little Sulphur Creek. Risks associated with this chemical will be assessed by assuming that 10 percent of the reported total chromium result is attributable to hexavalent chromium, while 90 percent of the total chromium result is comprised of trivalent chromium. This assumption is based on published toxicological information (ATSDR, 1991).

C.3.2 Toxicity Profiles

Toxicological profiles for each COPC will be presented as an appendix to the risk assessment. These brief profiles present a summary of the current available literature on the carcinogenic and noncarcinogenic health effects associated with human exposure to COPCs.

C.4 RISK CHARACTERIZATION

Potential risks (noncarcinogenic and carcinogenic) for human receptors resulting from the exposures outlined in the exposure assessment are quantitatively determined during the risk characterization component of the Baseline Human Health Risk Assessment.

A summary and interpretive discussion of the quantitative risk estimates will be provided in the text of the site-specific risk assessments. During the interpretive risk discussion, COPCs which contribute significantly to elevated risks will be identified as "risk drivers" or Chemicals of Concern (COCs). All the numeric estimates of risk will be contained in the risk assessment spreadsheets, which will appended to the assessment as support documentation.

C.4.1 Quantitative Analysis

Quantitative estimates of risk will be calculated according to risk assessment methods outlined in U.S. EPA guidance (U.S. EPA, 1989). Lifetime cancer risks will be expressed in the form of dimensionless probabilities, referred to as incremental cancer risks (ICRs), based on CSFs. Noncarcinogenic risk estimates will be presented in the form of Hazard Quotients (HQs) that are determined through a comparison of intakes with published RfDs.

ICR estimates are generated for each COPC using estimated exposure intakes and published CSFs, as follows:

$$ICR = (\text{Estimated Exposure Intake})(CSF)$$

If the above equation results in an ICR greater than 0.01, the following equation will be used:

$$ICR = 1-[\exp(-\text{Estimated Exposure Intake})(CSF)]$$

An ICR of 1E-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 will be assessed using the concept of HQs and Hazard Indices (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 will be 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.

C.4.1.1 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 will be compared to typical benchmarks. Calculated ICRs will be interpreted using the U.S. EPA's "target range" (1E-4 to 1E-6), while HIs will be evaluated using a value of 1.0.

The U.S. EPA has defined the range of 1E-4 to 1E-6 as the ICR "target range" for most hazardous waste facilities addressed under CERCLA and RCRA. Individual or cumulative ICRs greater than 1E-4 will typically not be considered as protective of human health, while ICRs less than 1E-6 will typically be regarded as protective. (Risk management decisions are necessary when the ICR is within the 1E-4 to 1E-6 cancer risk range.)

An HI exceeding unity (1.0) indicates that there may be potential noncarcinogenic health risks associated with exposure. If an HI exceeds unity, a segregation of target organs effects associated with exposure to COPCs will be performed. Only those chemicals which affect the same target organ(s) or exhibit similar critical effect(s) will be 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.

As a *general* guideline, a "no further action" recommendation will be forwarded to the Navy, the State of Indiana, and the EPA, if the cancer risk estimates and total HIs (developed on a target organ/target effect basis) for receptors of concern do not exceed 1×10^{-4} and 1, respectively. Otherwise the need for remedial

action (including institutional controls) will be evaluated in the Corrective Measures Study (CMS). However, as indicated in EPA RAGS Part D, the upper boundary of the acceptable risk range is not a discrete line at $1x\ 10^{-4}$. "Risks slightly greater than $1x10^{-4}$ may be considered to be acceptable (i.e., protective) if justified based on site-specific conditions, including any uncertainties about the nature and extent of contamination and associated risks." Consequently, a "no further action" recommendation may forwarded even when the $1x\ 10^{-4}$ risk benchmark is exceeded. The following factors will be considered in this determination:

- The magnitude of the *media-specific* risk estimates.

- Significant uncertainties in the baseline human health risk assessment that would tend to overestimate baseline risk assessment results. Uncertainties in the baseline human health risk assessment intake estimates (and their impact on the risk estimates) could be evaluated using "probabilistic risk assessment" techniques. Uncertainties associated with the toxicity criteria would be evaluated qualitatively.

- Significant uncertainties in the EPC estimates that would tend to overestimate baseline risk assessment results.

C.4.2 Qualitative Analysis

As mentioned previously, a qualitative evaluation of risk will be made for several exposure situations.

- The soil inhalation pathway (Section B.2.4) will be initially evaluated by a comparison of maximum site soil concentrations to U.S. EPA Generic SSLs for transfers from soil to air. If the maximum site concentration exceeds the SSL for a chemical, a quantitative analysis of this exposure pathway will be performed.

- The potential for the migration of soil contaminants to groundwater will be assessed by a comparison on maximum and average soil concentrations to U.S. EPA Generic SSLs for transfers from soils to groundwater. SSLs based on a dilution and attenuation factors (DAFs) of 1 and 20 will be used in the evaluation.

C.5 UNCERTAINTY ANALYSIS

The goal of the uncertainty analysis is to identify important uncertainties and limitations associated with the Baseline Human Health Risk Assessment. Uncertainties related to each component of the

assessment (i.e., data evaluation, exposure assessment, toxicity assessment, and risk characterization) will be presented. In addition, the effect of a particular uncertainty on the outcome of the assessment (i.e., risk estimates) will also be indicated, where possible. The following subsections present an overview of uncertainties which may be addressed in the risk assessment uncertainty section.

C.5.1 Uncertainty in Data Evaluation

This section may discuss uncertainties in the risk assessment associated with the analytical data and data quality. This may also involve a discussion of uncertainty in the COPC selection process, the inclusion or exclusion of COPCs in the risk assessment on the basis of background concentrations, the uncertainty in COPC screening levels, and the omission of constituents for which health criteria are not available. The discussion presented will be based, in part, on the evaluation presented in the "Data Useability Worksheet" as suggested U.S. EPA RAGS Part D.

C.5.2 Uncertainty in the Exposure Assessment

This section will include a discussion of the following: assumptions related to current and future land use; the uncertainty in exposure point concentrations, for example, the use of maximum concentrations to estimate risks; uncertainty in the selection of potential receptors and exposure scenarios; and uncertainty in the selection of exposure parameters (RME vs. CTE). If predictive models are used in the risk estimation, the uncertainty associated with the model and modeling parameters will be evaluated.

C.5.3 Uncertainty in the Toxicity Assessment

The uncertainties inherent in RfDs and CSFs and use of available criteria will be discussed. A discussion of the uncertainty in hazard assessment, which deals 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, will be provided. This section will also discuss uncertainty in the dose-response evaluations for the COPCs which relates to the determination of a CSF for the carcinogenic assessment and derivation of an RfD or Reference Concentration (RfC) for the noncarcinogenic assessment. In addition, a discussion of the uncertainty in the toxicity of specific constituents, such as PAHs, arsenic, chromium, aluminum, iron, and copper, will be presented, if applicable.

C.5.4 Uncertainty in the Risk Characterization

This section will discuss the uncertainty in risk characterization, which results primarily from assumptions made regarding additivity/synergism of effects from exposure to multiple COPCs affecting different target

organs across various exposure routes. The risk assessment will discuss the uncertainty inherent in summing risks for several substances across different exposure pathways. It should be noted that probabilistic risk assessment techniques may also be used to further define the uncertainty attached to the risk characterization results. However, the exposure assumptions (e.g., probability distributions) used to prepare the probabilistic risk assessment will be reviewed with the regulatory reviewers before they are incorporated into the uncertainty section of the baseline risk assessment.

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APPENDIX D

ECOLOGICAL RISK ASSESSMENT METHODOLOGY

APPENDIX D
ECOLOGICAL RISK ASSESSMENT METHODOLOGY

D.1 INTRODUCTION

As discussed in Section 1.4.3 of this Quality Assurance Project Plan (QAPP), an environmental risk assessment for contaminants at the ABG and the Jeep Trail was presented in the Current Contamination Conditions Risk Assessment (TtNUS, February 1999). The assessment included biota sampling (vegetation, mammals, aquatic vertebrates and invertebrates), an identification of threatened and endangered wildlife and plant species which exist or may exist within the study area, population studies, and an evaluation of the potential for adverse affects on ecological receptors. The conclusions of the assessment were as follows:

> "The majority of ecological risk posed by contaminants of potential ecological concern (COPECs) at the ABG/Jeep Trail, appear to be limited to the aquatic habitats at this SWMU. Elevated levels of barium, lead and zinc in the sediments at the site may have slight adverse effects to wildlife; however, population studies and tissue samples for fish and macroinvertebrates did not show any evidence of adverse effects. Elevated levels of various compounds in the surface water may have a potential adverse impact to wildlife at this site; however, impacts as a result of these COPECs would be very localized and unlikely to impact the viability of any one species at the site given the availability of similar habitat in close proximity to these locations. Populations studies at this SWMU support this conclusion as animal, fish, macroinvertebrate and vegetation species are diverse and abundant, and are similar to what would be expected to occur in a non-impacted area."

The goal of this follow-up Screening-Level Ecological Risk Assessment (SERA) will be to identify the chemicals detected at concentrations that exceed the COPC screening levels, the locations of these exceedances, and the need for further investigation and/or remedial action at the Jeep Trail and Little Sulphur Creek, at NSWC Crane. More specifically, the objectives of this follow-up assessment are to:

- Update and augment the evaluation presented in the Current Contamination Risk Assessment (TtNUS, February 1999).
- Evaluate the potential effects of rainfall events (i.e., flooding) on surface water/sediment quality (and consequently, ecological receptors) downstream of the ABG.

This SERA will provide information to scientists and managers that will enable them to conclude either that ecological risks for the study area are most likely negligible, or that further information is necessary to better evaluate potential ecological risks for the study area. A phased approach to the SERA will be used that relies first on existing and new environmental chemistry data and field observations for the preliminary assessments. Biological sampling or testing may be conducted if further work is needed. However, such sampling and testing is not proposed at this time. Any recommendations for biological sampling or population studies will consider the biological sampling and environmental field work already conducted within the study area and Navy sponsored biological sampling (i.e., insect tissue study) anticipated to occur Summer 2001. The SERA methodology used at NSWC Crane will follow the guidance presented in the Final Guidelines for Ecological Risk Assessment (U.S. EPA, 1998a) and the Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (U.S. EPA, June 1997).

This SERA will consist of the first two of eight steps required by the Environmental Protection Agency (EPA) guidance (EPA, 1997 and 1998) and the Navy Policy for Conducting Ecological Risk Assessments. Figure D-1 presents the Navy's Ecological Risk Assessment Tiered Approach. The first two steps are the screening-level assessment. Step 3a is the first step of the BERA and consists of refining the list of COPCs that were retained following the SERA further refines the screening level risk assessment. Steps 3b through 7 are conducted if additional evaluations or investigations are necessary. Finally, Step 8, Risk Management, is incorporated throughout the ERA process, in cooperation with Region 5 Regulators.

The first phase in the ERA process is the screening-level risk assessment. In this phase, conservative exposure estimates are made for grouped or individual ecological receptors, and these exposures are compared to screening-levels and threshold toxicity values. The SERA includes the following considerations:

- Screening-level problem formulation
- Screening-level ecological effects evaluation
- Screening-level exposure estimate
- Screening-level risk calculation

These sections are discussed in detail throughout the QAPP and this appendix.

D.2 SCREENING-LEVEL PROBLEM FORMULATION

The screening-level problem formulation includes identification of potential receptor groups, contaminants of potential concern (COPCs), and the mechanisms for fate/transport and toxicity. Determination of the complete exposure pathways that exist at a site is accomplished at this point to facilitate receptor selection. As part of receptor identification, site habitats and potential ecological receptors are described.

D.2.1 Environmental Setting

D.2.1.1 Site Specific Environmental Setting

The Jeep Trail and Little Sulphur Creek AOCs are located in the eastern portion of NSWC Crane. These AOCs lie within the Sulphur Creek Complex Drainage Basin, which is one of 5 drainage basins that carry surface water off the installation. Little Sulphur Creek is approximately 4.6 miles long from its northernmost headwaters to its intersection with Sulphur Creek south of the installation (Figure 1-3). The creek consists of a north and a south fork from the headwaters to approximately the center of the ABG Treatment Area (Figures 1-4 and 1-5). From the ABG, a single channel meanders south a distance of approximately 0.5 miles past the Jeep Trail (located approximately 100 feet east of the channel, see Figure 1-6), and continues another 0.6 miles until reaching the southern installation boundary. Several tributaries discharge into Little Sulphur Creek including the Johnson Hollow tributary, which intersects with Little Sulphur Creek at the southern NSWC Crane boundary. The surface waters of Little Sulphur Creek eventually drain into the East Fork of the White River and then to the Wabash River to the Southwest (Figures 1-2 and 1-3).

The Jeep Trail AOC is approximately 1 acre in size. It is located approximately 100 feet east of Little Sulphur Creek and approximately 0.5 miles downstream of the ABG. The AOC straddles the Jeep Trail, a dirt and gravel road leading south from the ABG to the southern boundary of the installation. The potential contaminant source areas within the AOC (i.e., the "burn pit" and "burn area" described in Section 1) are on the berm of the Jeep Trail road and, consequently, are almost denuded of vegetation. However, the distinctly off-road areas adjoining these contaminant source areas on either side of the Jeep Trail are heavily vegetated with grass, underbrush, and deciduous trees. The terrain slopes (approximately 20 feet) from the Jeep Trail contaminant source areas to Little Sulphur Creek. Consequently, Little Sulphur Creek does receive surface water run-off from the Jeep Trail AOC.

However, surface water flow in Little Sulphur Creek in the vicinity of the Jeep Trail AOC is intermittent. (Little Sulphur Creek becomes a losing stream upstream of the Jeep Trail AOC and just below the ABG.) According to installation personnel, surface water is present only during significant rain events. The Little

Sulphur Creek bed in the vicinity of the Jeep Trail is heavily scoured; sediment accumulation only occurring is isolated areas. The exposed creek bed substrate is rock, gravel, and pebbles.

At this time, the Little Sulphur Creek AOC extends from the north and south fork tributaries upstream of the ABG to just downstream of the installation boundary, including Springs A, B, and C. As evidenced during a site visit conducted in May 2000, Little Sulphur Creek surface water flows through the ABG treatment area, while continually seeping into the underlying leaking Big Clifty sandstone and Beech Creek limestone formations. Ultimately, surface water flow diminishes (i.e., infiltrates into, and becomes groundwater), leaving a dry creek bed further downstream of the ABG Treatment Unit. The width of the dry creek bed in the vicinity of the Jeep Trail AOC is approximately 10 feet. Surface water flow returns to Little Sulphur Creek further downstream of the Jeep Trail AOC in the form of springs (A, B, and C) caused by groundwater discharge.

D.2.1.2 Basewide Environmental Setting

A biological characterization of NSWC Crane, including a listing of plants and animals found at the facility, is presented in the Installation Assessment (IA; Army, 1978) and the Initial Assessment Study (IAS; NEESA, 1983), and is summarized in the Environmental Monitoring Reports (EMR; Halliburton NUS August and November, 1992). A list of the species which 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 summarized in the RCRA Facility Permit (U.S. EPA, July 1995). The following paragraphs briefly summarize the environmental setting at the Base.

Eighty percent of NSWC Crane's 63,000 acres is 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. Wetter sites 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) mammals such as white-tailed deer, beaver, coyote, hawks, red fox, rabbits, raccoons, mice; birds such as ducks, geese, wild turkey, bobwhite quail, red-tailed hawks, and American robins; and various amphibians, reptiles, fish, and invertebrates.

The bird population includes a number of State or Federal Threatened, Endangered, or Species of Special Concern that use the site 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 (B&R Environmental, 1997). Also, the Indiana bat, a Federal endangered species, is known to forage along Little Sulphur Creek within the bounds of the investigation area. As part of an ecological risk assessment in support of the RCRA Subpart X permit, a single male Indiana bat was captured along Little Sulphur Creek south of the Ammunition Burning Grounds during a mist net survey in June 1996 [Current Contamination Conditions Risk Assessment, (TtNUS, February 1999)]. Because streams and associated flood plain forests are preferred foraging habitats for Indiana bats, Little Sulphur Creek provides suitable habitat for both pregnant/lactating females, and male Indiana bats. 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.

There are six main creeks that 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 (Lake Greenwood). Lake Greenwood 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.

D.2.2 Contaminants Ecotoxicity and Fate and Transport

Based on historical site data and sampling, the following parameters are among the site-related chemical contaminants known to be present or potentially present in environmental media within the study area:

- Explosives (e.g., 2,4,6-trinitrotoluene [TNT] and HMX) and their degradation products (e.g., 2-amino-4,6-dinitrotoluene)
- Metals (e.g., lead)
- Chlorinated volatile organic chemicals (VOCs) including but not limited to 1,1,2,2-trichloroethane, 1,2-dichloroethene, trichloroethene, and vinyl chloride
- Polycyclic Aromatic Hydrocarbons (PAHs) including, but not limited to, benzo(a)pyrene, fluoranthene, and pyrene

The following sections present a brief discussion regarding the toxicity, potential food chain and trophic transfer, and fate and transport properties of each class of contaminants potentially present within the study area.

D.2.2.1 Physical and Chemical Characteristics

Physical and chemical characteristics of contaminants may affect their mobility, transport, and bioavailability in the environment. These characteristics include bioaccumulation factors (BAFs), organic carbon partition coefficients, and octanol water partition coefficients. The following paragraphs discuss the significance of each factor.

The SERA will use plant and invertebrate bioaccumulation factors to predict contaminant loading in plants and invertebrates. The following list presents the source of the bioaccumulation factors that will be used in the SERA.

- Plant Bioaccumulation Factors - Organics: Toxicity and Chemical-Specific Factors Database (ORNL, 1998a)
- Plant Bioaccumulation Factors - Inorganics: Empirical Models for the Uptake of Inorganic Chemicals from Soil by Plants (ORNL, 1998b)
- Soil Invertebrate Bioaccumulation Factors - PCBs and Inorganics: Development and Validation of Bioaccumulation Models for Earthworms (Sample et al., 1998a)

Some of the BAFs presented in the documents listed previously estimate the tissue concentrations in dry weight. These values must be converted to wet weight for use in exposure estimation in the foodchain models by multiplying the BAF by the proportion of dry matter content of the organism (Sample, et al., 1997). The following table presents the proportion of dry matter that will be used to adjust the BAFs, if necessary (Sample et al., 1997).

Food Type	Percent Water Content	Percent Dry Weight
Terrestrial Invertebrates (earthworms)	84	16
Terrestrial Plants (monocots-young grass)	70	30

Other plant, invertebrate, and small mammal bioaccumulation factors obtained from the literature also may be used for contaminants that are not listed in the above reference sources. Contaminants that do not have bioaccumulation factors will be assigned a default value of 1.

The organic carbon partition coefficient (K_{oc}) measures the tendency for a chemical to partition between soil or sediment particles containing organic carbon and water. This coefficient is important in the environment because it determines how strongly an organic chemical will bind to the organic carbon in the sediment.

The octanol/water partition coefficient (K_{ow}) is the ratio of a chemical concentration in octanol divided by the concentration in water. The octanol/water partition coefficient has been shown to correlate well with bioconcentration factors in aquatic organisms and with adsorption to soil or sediment.

The BAFs, K_{oc}s, and K_{ow}s for all of the contaminants detected in the soil will be included in the SERA.

D.2.2.2 Metals

Many metals are found naturally in the surface water, sediment, and/or soil at various concentrations due primarily to chemical weathering and fallout from volcanoes. Most metals are toxic to aquatic (i.e., fish, invertebrates) and terrestrial (i.e., plants, invertebrates, vertebrates) ecological receptors at certain concentrations, with some metals being toxic at lower concentrations than others. Also, different chemical forms of the metals may be more toxic than other forms. For example, hexavalent chromium is typically more toxic than trivalent chromium, and methylmercury is more toxic than inorganic mercury. In addition, the toxicity of several metals (cadmium, chromium, copper, lead, nickel, silver, and zinc) to aquatic receptors in freshwater systems decreases with increasing water hardness.

Only a portion of the total bulk concentration of metals in soils is bioavailable to ecological receptors. The uptake and accumulation of trace elements by plants are affected by several soil factors such as pH, Eh, clay content, organic matter content, cation exchange capacity, nutrient balance, concentration of other trace elements in soil, soil moisture, and temperature (Tarradellas et al., 1996). The bioavailability of the metals, however, is not known because there are other soil factors that influence uptake.

Many of these same factors also will influence the bioavailability of metals to invertebrates in sediment. One way to estimate the bioavailable portion of certain divalent metals (cadmium, copper, lead, nickel, and zinc) in sediment is to measure the amount of acid volatile sulfides (AVS) and simultaneously extracted metals (SEM) in a sediment sample. If the molar concentration of AVS is higher than the molar

concentration of SEM, than all the SEM metals are expected to be unavailable to aquatic invertebrates and, therefore, nontoxic. AVS plays little or no role in determining interstitial water concentrations of metals in aerobic systems or those with low productivity (i.e., where the absence of organic carbon limits sulfate reduction) (Ankley et al., 1996), or when ingestion of sediments is the primary exposure route (Lee at al., 2000).

Of the 29 elements essential for plant growth, seven are micronutrients, including copper, iron, manganese, and zinc (Tarradellas et al., 1996). Also, the following metals may stimulate plant growth but are only essential for some plant species: aluminum, cobalt, nickel, sodium, selenium, and vanadium (Tarradellas et al., 1996). Finally, some elements such as lead, cadmium, and mercury are toxic elements with no known function in plant metabolism (Tarradellas et al., 1996).

ORNL (1998b) has calculated soil-to-plant uptake factors for several metals based on a compilation of various studies. Cadmium, mercury, selenium, and zinc were the only metals (except for calcium and potassium) with mean uptake factors greater than one (1.02 to 2.25). None of the metals (except for calcium and potassium) have median uptake factors greater than one. Arsenic, cadmium, mercury, nickel, selenium, and zinc were the only metals (except for calcium, magnesium, and potassium) with upper 90th percentile uptake factors greater than one (1.1 to 5) (ORNL, 1998b). This indicates that most metals will not biomagnify in plants. Finally, it is reported that, for arsenic, copper, nickel, and zinc, the plant-based food chain may be protected because the toxic concentrations of these metals in plants are higher than those for animals, while cadmium and selenium are not toxic to plants at high concentrations and may be accumulated in plants at levels that may be toxic to animals (Cockerham and Shane, 1994). Other metals such as lead, cobalt and mercury can enter the food chain via plant uptake, but to a lesser extent (Cockerham and Shane, 1994).

Cadmium appears to accumulate in most species of earthworms at greater levels than any other metal (Satchell, 1983). This is supported by the high mean soil-to-plant uptake factor of 17 for cadmium, compared to mean uptake factors of 5.7 (zinc), 5.2 (mercury), 4.5 (silver), and 3.3 (lead) (Sample et al., 1998). The remaining metals (except potassium, sodium, and some radionuclides) had mean uptake factors of 1.8 or less (Sample et al., 1998). Cadmium, mercury, nickel, silver, and zinc are the only metals with median uptake factors greater than one (Sample et al., 1998). The upper 90th percentile uptake factors were 40.7, 20.6, 15.3, and 12.9 for cadmium, mercury, silver, and zinc (Sample et al., 1998). The remaining metals had upper 90th percentile uptake factors of 4.7 or less (Sample et al., 1998).

D.2.2.3 Semivolatile Organic Compounds

The most common semivolatile organic compounds that are found at naval facilities include polyaromatic hydrocarbons (PAHs) and phthalates. PAHs are a diverse group of compounds consisting of two or more substituted and unsubstituted polycyclic aromatic rings formed by the incomplete combustion of carbonaceous materials. PAHs are ubiquitous in the modern environment and commonly are constituents of coal tar, soot, vehicle exhaust, cigarette smoke, certain petroleum products, road tar, mineral oils, creosote, and many cooked foods. PAHs also are released to the environment through natural sources such as volcano and forest fire emissions. However, most of the emissions result from anthropogenic sources, largely wood burning for homes. Vehicular emissions are another primary source of PAHs. Hazardous waste sites can be a concentrated source on a local scale. Examples of such sites include former manufactured gas sites (i.e., sources of coal tar) and abandoned wood treatment plants (i.e., sources of creosote) [Agency for Toxic Substances and Disease Registry (ATSDR), 1989a].

PAHs are transferred from surface water by volatilization and sorption to settling particles. The compounds are transformed in surface water by photooxidation, chemical oxidation, and microbial metabolism (ATSDR, 1989a). In soil and sediments, microbial metabolism is the major process for degradation of PAHs (ATSDR, 1989a). Although PAHs accumulate in terrestrial and aquatic plants, many organisms are able to metabolize and eliminate these compounds. Vertebrates can readily metabolize PAHs, but lower forms (insects and worms) cannot metabolize PAHs as quickly. Food chain uptake does not appear to be a major exposure source to PAHs for aquatic animals (ATSDR, 1989a).

Plants and vegetables can absorb PAHs from soils through their roots and translocate them to other plant parts such as developing shoots (Eisler, 1987). In general, however, PAHs are not readily taken up by plants because these compounds are strongly adsorbed onto soil organic particles and root uptake is very inefficient (Donker, et al., 1994). As such, lower molecular weight PAHs (which would be more water soluble) are absorbed by plants more readily than higher molecular weight PAHs. This is indicated by the low soil-to-plant uptake factors, which were calculated using the K_{ow} for the contaminants. Finally, many higher plants can catabolize benzo(a)pyrene and possibly other PAHs (Eisler, 1987).

PAHs vary substantially in their toxicity to aquatic organisms. In general, toxicity increases as molecular weight increases, with the exception of some high molecular weight PAHs that have low acute toxicity. Most species of aquatic organisms rapidly accumulate PAHs from low concentrations in the ambient medium. However, uptake of PAHs is highly species specific, it is higher in algae, mollusks, and other species that are incapable of metabolizing PAHs (Eisler, 1987). The ability of fish to metabolize PAHs

may explain why benzo(a)pyrene is frequently not detected or is found at only very low levels in fish from environments heavily contaminated with PAHs (ATSDR, 1989a).

Phthalates are compounds that are used in production of plastics (ATSDR, 1993). Most phthalates are expected to sorb to soil or sediment particles after their release because of their high Log K_{oc} values (Howard, 1989). Some phthalates may bioconcentrate in aquatic organisms [Spectrum Laboratories, 1999; Howard, 1989; ATSDR, 1989a].

D.2.2.4 Pesticides

Pesticides are used to control pestiferous invertebrates and, therefore, they are toxic to many soil and aquatic invertebrates. In addition, many pesticides are toxic to higher trophic level ecological receptors such as mammals and birds. For example, DDT compounds have been linked to eggshell thinning and subsequent decreased survival of several birds of prey (such as eagles and falcons). Other pesticides such as chlordanes, dieldrin, aldrin, endrin, and heptachlor also are very toxic to mammals and birds (Newell et al., 1987).

Organochlorine insecticides such as DDT, chlordane, aldrin, dieldrin, heptachlor, endosulfan, and endrin and their associated breakdown products generally degrade very slowly and tend to be soluble in lipids, which results in bioaccumulation and possible increases in concentrations through food webs (Newman, 1998). Pesticides have high Log K_{oc} values so they are expected to sorb strongly to soil and sediment particles when released to the environment. Consequently, these compounds are not easily displaced from their site of application, whether by runoff or leaching to groundwater. As a result, these compounds typically will not be taken up by plants.

DDT, DDE and DDD are highly lipid soluble, which, combined with an extremely long half-life, results in bioaccumulation (ATSDR, 1989b). When present in ambient water, DDT and its metabolites are concentrated in freshwater and marine plankton, insects, mollusks, and other invertebrates and fish (ATSDR, 1989b). As these organisms are part of the food chain, a progressive accumulation of residues may result in high levels of residues in organisms at the top of the food chain (ATSDR, 1989b). Moderate to significant bioconcentration in aquatic species has been reported for dieldrin, with bioconcentration factors (BCFs) ranging from 100 to 10,000 (Howard, 1991). Heptachlor also has been reported to bioconcentrate in aquatic species, with bioconcentration factors in fish up to approximately 20,000 (Howard, 1991).

Chlordane will bioconcentrate in both marine and freshwater species (ATSDR, 1989c). In living organisms, chlordane concentrations are usually highest in samples collected near areas where chlordane was used to control termites or other pests, in predatory species, and in tissues with high lipid content (Eisler, 1990). Food chain biomagnification is low except in certain marine mammals (Eisler, 1990).

D.2.2.5 PCBs

The term polychlorinated biphenyls (PCBs) commonly refers to a variety of mixtures of individual biphenyl isomers, each consisting of two joined benzene rings and up to 10 chlorine atoms. Mixtures of these isomers are known by their commercial designation of Aroclor. This trade name is followed by a four-digit number; the first two numbers indicate the type of isomer mixture and the last two numbers indicate the approximate weight percent of chlorine in the mixture (EPA, 1985).

PCBs released into water adsorb to sediments and other organic matter. Typically, PCB concentrations are greater in the sediment and suspended material than in the water column. Substantial quantities of PCBs in aquatic sediments can act as an environmental reservoir from which PCBs may be released slowly over a long period of time (ATSDR, 1989d). For PCBs that exist in the dissolved state in water, volatilization becomes the primary fate process. PCBs have the capability to bioaccumulate and biomagnify (EPA, 1985).

Degradation of PCBs in the environment is dependent upon the degree of chlorination. Generally, the more chlorinated the PCB molecule, the more persistent it will be in the environment. Factors that determine biodegradability include the amount of chlorination, concentration, type of microbial population, available nutrients, and the temperature (ATSDR, 1989d).

PCBs are expected to be highly immobile in the soil due to rapid and strong sorption (ATSDR, 1989d). Some data indicate that plants are capable of taking up PCBs and transferring them into polar metabolites or insoluble molecules (Donker et al., 1994). However, it is not very probable that uptake and transformation of these compounds occur to any great extent, because a large part (greater than 95 percent) will adsorb to the root surface (Donker et al., 1994). The transfer of vapor-phase PCBs from air to aerial plant parts may be the main source of vegetation contamination (ATSDR, 1989d).

Because PCBs are highly lipophilic, they can bioaccumulate in the lipid portions of animals. Bioconcentration factors in the thousands have been reported for various aquatic species (Eisler, 1986a). PCBs also can accumulate in upper trophic level animals such as piscivorous birds and mammals that

feed on contaminated prey items (Eisler, 1986a). Finally, Sample et al. (1998) calculated mean, median, and 90th percentile reported soil-to-earthworm bioaccumulation factors (BAF) of 8.9, 6.7 and 15.9, respectively, indicating the PCBs can accumulate in soil invertebrates.

Adverse effects of PCBs on terrestrial wildlife include increased mortality, reproductive effects, and behavioral effects (USEPA, 1985). As a group, birds are more resistant to acutely toxic effects of PCBs than mammals (Eisler, 1986a). Among sensitive avian species, PCBs disrupt the normal pattern of growth, reproduction, metabolism, and behavior (Eisler, 1986a). Of the mammals, the mink is the most sensitive wildlife species tested for which data are available (Eisler, 1986). Impacts to mink include anorexia, weight loss, lethargy, reproductive effects, and death (Eisler, 1986).

D.2.2.6 Volatile Organic Compounds

VOCs are usually very mobile in the environment because they are poorly adsorbed to soil and sediment particles. Also, because they are very volatile, they typically are only detected in surface waters and surface soils at low concentrations.

Most VOCs have very little potential to bioaccumulate in ecological receptors; therefore, biomagnification through the food chain does not appear to be significant. VOCs are not expected to biomagnify in plants and are typically only toxic to ecological receptors only at relatively high concentrations.

D.2.2.7 Explosives

Some of the more common explosives include nitroaromatic compounds such as 2,4,6-trinitrotoluene, hexahydro-1,3,5-trinitro-1,3,5-triazine, octahydro-1,3,5,7-tetranitro-1,3,5-tetrazocine, N-methyl-N,2,4,6-tetranitroaniline, and associated by-products and degradation products that may have been released to the environment during manufacturing and load, assembly, and pack processes at military facilities (Talmage et al., 1999). These explosives are moderately to highly toxic to freshwater organisms, with chronic screening values less than 1 mg/L, although some of the screening values are low because of the conservative methods used to develop them based on an absence of data (Talmage et al., 1999). Available data indicate that none of the compounds are expected to bioconcentrate (Talmage et al., 1999). Most of the explosives do not appear to be highly toxic to mammals. Terrestrial reference values (TRVs) are greater than 1 mg/kg-day.

Explosives have little to moderate potential to adsorb to soil and sediment (Talmage et al., 1999). Therefore, explosives will have moderate to high mobility in soils and sediment, and most of the explosives will be found in the water column (Talmage et al., 1999).

D.2.3 Potential Exposure Pathways

Based on the historical site operations, the primary source of contaminants is the soil. From the soil, the contaminants may migrate to ground water after the contaminants leach from the soil. In addition, contaminants from the site can enter surface water bodies via overland runoff/erosion, or through ground water discharge. A potential for overland runoff and soil erosion was noted at the ABG during the April 2000 site visits by TtNUS and Navy personnel. Finally, contaminants can enter the air via the emission of volatile organic compounds or through wind erosion/dust. The following paragraphs discuss each of these exposure pathways in more detail. Figure D-2 presents the conceptual site model.

D.2.3.1 Ground Water

Currently, several discharge points for ground water potentially contaminated with site-related contaminants have been identified (e.g., Springs A, B, and C). As noted previously, Little Sulphur is a "losing stream" in the vicinity of and just downgradient of the ABG. It reverts to a "gaining stream" in the vicinity of Spring C. Although ecological receptors are not directly exposed to ground water (prior to it discharging from a spring or as surface water), ecological receptors can be exposed to ground water contaminants after the water discharges to Little Sulphur Creek.

D.2.3.2 Springs/Surface Water

Contaminants in the ground water discharge to surface water. Contaminants in the soil may also enter the Little Sulphur Creek via overland flow. Based on the surrounding habitat, and the presence of mammals and birds, it is probable that these species use the springs and Little Sulphur Creek as a source of drinking water.

Portions of Little Sulphur Creek within the study area are intermittent and would not support fish or a benthic macroinvertebrate community. However, other portions of Little Sulphur Creek (e.g., the portion below Spring C) could support a healthy benthic macroinvertebrate and fish population. These receptors could be exposed to the contaminants in the water by direct contact.

D.2.3.3 Surface Soil/Sediment

Several groups of terrestrial ecological receptors can be exposed to contaminants in the surface soil or sediments that are not sub-merged routinely. Invertebrates such as earthworms are exposed to the contaminants as they move through the soil, and ingest soil particles while searching for food. Plants are exposed to the contaminants via direct contact as contaminants are absorbed through the roots and then translocated to different parts of the plants (i.e., leaves, seeds). Because most, it not all, of the food consumed by target receptors selected for this SERA will primarily be exposed to contaminants in the surface soil (0 to 2 feet below ground surface) exposure to subsurface soils will not be evaluated in the ecological risk assessment.

Visual inspection of Little Sulphur Creek revealed a well-scoured creek bed with little accumulation of sediments. Mammals such as raccoons may be exposed to contaminants in the soil/sediments (albeit limited) via several exposure routes. They may be exposed by direct contact as they search for food or burrow into the soil/sediment. 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 (note that this may not be true for amphibians). Therefore, the dermal pathway will not be evaluated in the SERA. Mammals may also be exposed to contaminants in the soil/sediments via incidental ingestion of soil and ingestion of plants or invertebrates that have accumulated contaminants from the soil. These pathways will be evaluated in the SERA. Note that because large sections of Little Sulphur Creek are typically dry except during rain events, some sediment samples collected in the creek also may be evaluated as if they were surface soil samples.

Larger, predatory species such as the red fox and red-tailed hawk can be exposed to site contaminants in the soil/sediments by ingesting small mammals that have accumulated contaminants. Because of the relatively small size of the Jeep Trail site (approximately 1 acre) the Jeep Trail would only represent 1 or 2 percent of the predators' home range. Therefore, these species will not be evaluated as part of this SERA. However, risks to piscivorous wildlife will be evaluated in the SERA.

As noted previously, visual inspection of the Little Sulphur Creek during the May 2000 site reconnaissance revealed a well-scoured creek bed with accumulation of sediments in isolated areas only. The sediment depths in the creek channel or along the banks would not be expected to exceed approximately 12 inches. Because the contaminant concentration profiles should vary the most within the 0-foot to 1-foot interval and the maximum depth is expected to be 1 foot or less, samples of Little Sulphur Creek sediments will be acquired over two depth intervals – 0.0 to 0.5 feet and 0.5 to 1.0 feet.

D.2.3.4 Air

The inhalation pathway will not be evaluated because air concentrations are expected to be minimal given the size of the Jeep Trail source area and the fact that volatile organics associated with surface water/sediments would dissipate rapidly. Also, inhalation pathways typically are not evaluated in SERAs because of the uncertainty in exposures and effects concentrations.

D.2.4 Endpoints

D.2.4.1 Assessment Endpoints

Assessment endpoints are an explicit expression of the environmental value that is to be protected (EPA 1997a). The selection of these endpoints is based on the habitats present, the migration pathways of probable contaminants, and the routes that contaminants may take to enter receptors.

As already discussed in D.2.1.1, the habitat at and adjacent to the Jeep Trail and Little Sulphur Creek consists of forested areas, open fields with grasses, and potential aquatic habitats. For this SERA, the assessment endpoints are for the protection of the following groups of receptors from adverse effects of contaminants on their growth, survival, and reproduction:

- Soil invertebrates
- Terrestrial Vegetation
- Herbivorous mammals
- Herbivorous birds
- Soil invertebrate-eating birds
- Soil/sediment invertebrate-eating mammals (including bats)
- Carnivorous birds
- Carnivorous mammals
- Piscivorous mammals
- Piscivorous birds
- Omnivorous mammals
- Omnivorous birds
- Benthic invertebrates
- Fish
- Amphibians and Reptiles

The following paragraphs discuss why the above assessment endpoints were selected for this SERA.

Soil Invertebrates: soil invertebrates are expected to be present in the soil at the site. They aid in the formation of soil, redistribution and decomposition of organic matter in the soil and serve as a food source for higher trophic level organisms. They also can accumulate some contaminants that can then be transferred to the higher trophic level organisms that consume invertebrates.

Terrestrial Vegetation: Terrestrial vegetation at the site consists of grasses, shrubs, and trees. They serve as a food source and provide shade and cover for many organisms, and help prevent soil erosion, among other important functions. They also can accumulate some contaminants that can then be transferred to the higher trophic level organisms that consume plants.

Herbivorous Birds and Mammals: Herbivorous birds and mammals (animals that consume only plant tissue) may be present at the site because of the vegetative habitats (i.e., forested,). Their role in the community is essential because without them, higher trophic level could not exist (Smith, 1966). They may be exposed to, and accumulate contaminants that are present in the plants they consume.

Carnivorous Birds and Mammals: Carnivorous birds and mammals consist of birds and mammals that consume invertebrates, fish, and other mammals and birds. Soil invertebrate-eating birds and mammals are present throughout the Base in different terrestrial habitats (i.e., forested, open field). These are considered first-level carnivores and they serve as a food source for higher trophic level carnivores. Piscivorous birds and mammals may be present along Little Sulfur Creek based on the presence of fish in the creek (in the spring-feed portion of the creek below the Jeep Trail). Finally, 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 of the carnivores may be exposed to and accumulate contaminants that are present in the food items they consume.

Omnivorous Birds and Mammals: Omnivorous birds and mammals (that consume both plant and animal tissue) are present throughout the Base in the different terrestrial habitats (i.e., forested, open field). They may be exposed to, and accumulate contaminants that are present in the plants and animals they consume.

Benthic Macroinvertebrates: Benthic macroinvertebrates are similar to the soil invertebrates in that they serve as a food source for higher trophic level organisms (i.e., fish, amphibians, birds, mammals). They

also can accumulate some contaminants that can then be transferred to the higher trophic level organisms that consume invertebrates. They are most likely present in the portions of Little Sulphur Creek fed by Springs A, B, and C and in the continuously running surface waters of Little Sulphur Creek at and an immediately downgradient of the ABG. Their presence in the portions for Little Sulphur Creek that are an intermittent water body to the north will be ephemeral because of a lack of suitable habitat and water flow.

Fish: Fish are likely to be present in those portions of Little Sulphur Creek that run continuously. In particular, they are likely to present in those portions of Little Sulphur Creek that are fed by Springs A, B, and C. Fish are exposed to and can accumulate contaminants from the food items they consume, or from the surface water in which they live.

Amphibians and Reptiles: Amphibians are expected to inhabit water bodies and the surrounding areas, while reptiles can inhabit both aquatic environments and terrestrial habitats. Amphibians and reptiles feed primarily on invertebrates, plants, fish, and/or small mammals. They are exposed to, and can accumulate, contaminants from the food items they consume, or from the surface water/sediment/surface soil in which they live.

D.2.4.2 Measurement Endpoints

Measurement endpoints are estimates of biological impacts (e.g., mortality, growth and reproduction) that are used to evaluate the assessment endpoints. The following measures of effects will be used to evaluate the assessment endpoints in this ERA, where applicable.

- Soil screening values – Mortality, growth, and reproduction of plants and soil invertebrates will be evaluated by comparing the measured concentrations (maximum) of chemicals in the surface soil to screening values designed to be protective of ecological receptors.

- No observed adverse effects levels (NOAELs) for surrogate wildlife species - Mortality, reproductive, and/or developmental effects of birds and mammals will be evaluated by comparing the estimated ingested dose (based on conservative and average assumptions) from contaminants in the surface water, sediment, surface soil, plants, and invertebrates and for fish to these levels.

- Sediment screening values – Mortality and other adverse effects (e.g., growth, feeding rates, behavioral changes) of benthic macroinvertebrates will be evaluated by comparing the measured

concentrations (maxima and averages) of chemicals in the sediment to screening values designed to be protective of ecological receptors.

- Surface water screening values – Mortality and other adverse effects (e.g., growth, feeding rates, behavioral changes) of aquatic organisms will be evaluated by comparing the measured concentrations (maxima and averages) of chemicals in the surface water to screening values designed to be protective of ecological receptors.

D.2.4.3 Selection of Receptor Species

Many receptors in the 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 may be required so that intake through eating, drinking, and other routes can be estimated.

Receptor identification is influenced by the contaminants, their likely mode of transport, ultimate fate, and toxicity. For example, most metals (with notable exceptions of cadmium and mercury) typically do not bioaccumulate. For contaminants that bioaccumulate, such as mercury compounds and chlorinated pesticides, effects on upper trophic level receptors need to be assessed. For contaminants that do not bioaccumulate, organisms that are in direct contact with soil/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. 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.

As previously mentioned, for most receptor species, ingestion is the primary route of exposure. Indicator species are selected for their preferred habitat, body size, sensitivity, home range, abundance, commercial or sport utilization, legal status, and functional role (e.g., predators). For conservativeness, indicator species may be small and have small home ranges. Species known to be sensitive to particular contaminants may be selected or toxicity values for those species may be used. For example, mink are sensitive to PCBs for reproductive endpoints and therefore mink TRVs would be selected for a scenario involving exposure to PCBs from an aquatic or sedimentary source. The availability of exposure parameters such as body mass, feeding rate, and drinking rate may also be a factor in selecting indicator species. The following indicator species will be used for the food chain modeling (discussed later), if necessary:

- Herbivorous mammal: Meadow Vole
- Herbivorous bird: Bobwhite Quail
- Carnivorous bird: American Robin
- Carnivorous mammals: Short Tail Shrew and Little Brown Bat
- Piscivorous mammal: Raccoon
- Piscivorous bird: Belted Kingfisher

Note that the Little Brown Bat is being used as an indicator species for the Indiana Bat based on the availability of exposure parameters for the Little Brown Bat. Receptor profiles for each of these species are presented in Attachment D-1.

D.3 ECOLOGICAL EFFECTS EVALUATION

The preliminary ecological effects evaluation is an investigation of the relationship between the magnitude of exposure to a chemical and the nature and magnitude of adverse effects resulting from exposure. In addition to being a toxicity study, it may also include descriptions of apparent effects seen during the site visit. Toxicity thresholds are usually expressed in units of concentration when the medium of concern is in intimate contact with the receptor, such as surface water for pelagic organisms or soil for soil invertebrates. For other receptors, such as terrestrial vertebrates, toxicity data are typically available as doses, with units equal to mass of contaminant per unit of body mass per unit of time (usually mg/kg/day).

As the first step in the ecological effects evaluation, Contaminants of Potential Concern (COPCs) will be selected by comparing the contaminant concentrations in the surface water, ground water, sediment, and surface soil samples to Region 5 Ecological Data Quality Levels (EDQLs) (U.S. EPA, Region 5, October 1999). Note that the ground water data will be compared to surface water EDQLs. The following bullets summarize the procedures that will be used in the SERAs for the Jeep Trail and Little Sulphur Creek to select COPCs.. Calcium, magnesium, potassium, and sodium will not be retained as COPCs in any medium because of their relatively low toxicity to ecological receptors, and their high natural variability in concentrations. Contaminants without EDQLs will be retained as COPCs but they may only be evaluated qualitatively.

Surface Water, Ground Water, and Sediment for Benthic Macroinvertebrates, Fish, and Terrestrial Wildlife

1. Inorganic and organic contaminants whose maximum concentrations do not exceed EDQLs will not be retained as COPCs.
2. Inorganic contaminants whose maximum concentrations do not exceed the maximum upstream/upgradient concentrations will not be retained as COPCs

It is recognized that the EDQLs were not established for the protection of wildlife ingesting water. However, based on the very low and conservative EDQLs for surface water, contaminants that do not exceed the EDQL are not expected to be toxic to terrestrial wildlife.

Surface Soil for Invertebrates, Plants, and Terrestrial Wildlife

1. Inorganic and organic contaminants whose maximum concentrations do not exceed EDQLs will not be retained as COPCs.

2. Inorganic contaminants whose maximum concentrations do not exceed the site-specific background concentrations will not be retained as COPCs.

Contaminants that are retained as COPCs will be further evaluated as part of Step 3a of the eight-step ERA process. The next section presents the additional data sources that will be used to evaluate the COPCs.

D.4 STEP 3A – REFINEMENT OF COPCs

Step 3a consists of refining the list of COPCs from the SERA using less conservative screening values and more site-specific exposure assumptions (where available) to more realistically estimate potential risks to ecological receptors (i.e., plants, invertebrates, and aquatic receptors). Note that the Step 3a evaluation will be included as an attachment to the SERA. For example, for all the media, both maximum and average concentrations will be compared to the benchmark values because most receptors (other than immobile plants) will have an average exposure to contaminants as they move across the surface water, sediment, or soil. This evaluation may include (but is not necessarily limited to) a consideration of the following topics:

- Magnitude of criterion exceedance: Although risks may not relate directly to the magnitude of a criterion exceedance, the magnitude may be one item used in a lines-of-evidence approach to determine the need for further site evaluation.

- Frequency of chemical detection: A chemical that is detected at a low frequency typically will be of less concern than a chemical detected at higher frequency provided that toxicity and concentrations of the constituents are similar. All else being equal, chemicals detected frequently will be 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 will be considered when evaluating the exposures of receptors to site contaminants.

- 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 will be used qualitatively when considering the site for additional evaluation.

D.4.1 Alternate Benchmarks

The following sections present some of the alternate benchmarks and evaluations that will be conducted as part of Step 3a.

D.4.1.1 Terrestrial Plants and Invertebrates

Risks to terrestrial plants and invertebrates resulting from exposure to the COPCs will be evaluated by comparing the contaminant concentrations in the surface soil to alternate soil benchmark values. These alternate benchmarks will be designated as Surface Soil Screening Levels (SSSLs). Currently, neither Indiana nor U.S. EPA has developed ecological SSSLs. The following list presents the SSSLs that have been developed by a few groups/agencies. Additional details explaining the origin and basis for the alternate benchmarks are provided below the list.

- Dutch Intervention Values and Target Values – Soil Quality Standards (MHSPE, 1994)

- Canadian Soil Quality Guidelines (CCME, 1997)

- Oak Ridge National Laboratory Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision (Efroymson R.A. et al., 1997a)

- Oak Ridge National Laboratory Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision (Efroymson R.A. et al., 1997b)

The Intervention Values and Target Values – Soil Quality Standards were developed by the Netherlands Ministry of Housing, Spatial Planning, and Environment, Department of Soil Protection and will be referred to as the Dutch Screening Values (MHSPE, 2000). The Dutch Screening Values for surface soil consist of Target Values and Intervention Values. The Target Values are the soil quality levels at which there is sustainable soil quality (MHSPE, 2000). The values for heavy metals, arsenic, and fluoride were derived from analysis of field data from relatively pollution-free rural areas. The Intervention Values indicate the concentration levels of the contaminants in the soil above which the functionality of the soil for human, plant, or animal life is seriously impaired or threatened (MHSPE, 2000). The target value will be used to determine ecological effects and the need for additional evaluation of the data.

The Canadian Soil Quality Guidelines were developed by the Canadian Council of Ministers of the Environment (CCME, 1997 and 1999). They are derived using toxicological data to determine the threshold level for key receptors (CCME, 1997 and 1999). The values are calculated for four land uses: agricultural, residential/parkland, commercial, and industrial. Exposure from direct soil contact is used to derive guidelines for the residential/parkland, commercial, and industrial land uses (CCME, 1997 and 1999). However, the soil guidelines for the agricultural land use incorporates direct soil contact as well as soil and food ingestion (CCME, 1997). A more detailed discussion of the derivation of the soil quality guidelines is presented in A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines (CCME, 1996).

The Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision (Efroymson R.A., et al., 1997a) and the Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision (Efroymson R.A. et al., 1997b) were developed by the Oak Ridge National Laboratory (ORNL). These benchmarks were intended to be used as screening values, and as such, may be overly conservative. They are based on a 20 percent reduction in growth, reproduction, or activity (for invertebrates) or growth and yield (for plants) as the threshold for significant effects (Efroymson R.A. et al., 1997a, b).

Additional sources of toxicity data from the literature may be used to evaluate potential risks to soil flora and invertebrates from contaminants in the surface soil for contaminants that are not evaluated in the above documents.

D.4.1.2 Surface Water

Water Quality Standards (WQS) for surface water have been developed for Indiana (IDEM, 1998). These are the primary enforceable surface water standards for the Jeep Trail and Little Sulphur Creek. In addition, the U.S. EPA has established Ambient Water Quality Criteria (AWQC) for a few contaminants. Other, non-regulatory surface water screening values will be used to evaluate the surface water data that do not have WQS or AWQC. All values will be collectively referred to as surface water screening levels (SWSLs) in this SERA QAPP. The following presents the SWSLs that will be used in this evaluation.

- Indiana Water Quality Standards (IDEM, 1998)
- Recommended Water Quality Criteria (U.S. EPA, 1999)
- Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota, 1996 Revision (Suter and Tsao, 1996)
- "Eco Update-Ecotox Thresholds" (U.S. EPA, 1996)

The Indiana WQS are the concentrations of toxic substances that will not result in acute or chronic toxicity to aquatic life. All of the WQS used in this SERA will be based on total recoverable metals in accordance with the Indiana WQS (IDEM, 1998).

The Recommended Water Quality Criteria were developed by U.S. EPA to provide states with guidance for developing their own criteria (U.S. EPA, 1999). These values are set to protect the majority of aquatic organisms from adverse impacts from contaminants in the surface water.

The publication "ECO Update-Ecotox Thresholds" was prepared by U.S. EPA for use as benchmark screening values in the first step of a baseline risk assessment (U.S. EPA, 1996). Most of the surface water thresholds for the contaminants that are evaluated in this SERA are based on Suter and Mabrey, (1994) in the Ecotox Thresholds. Because Suter and Mabrey (1994) has been updated, Suter and Tsao (1996) values will be used when the Ecotox Thresholds were based on the Suter and Mabrey (1994) data. The Suter and Tsao (1996) benchmarks were calculated using Tier II methodology as described in the U.S. EPA's Proposed Water Quality Guidance for the Great Lakes System (U.S. EPA, 1993b). Tier II values are developed so that aquatic benchmarks could be established with fewer data than are required for the U.S. EPA AWQC.

Both the acute and chronic SWSLs will be used to evaluate the COPCs to determine potential impacts in a lines-of-evidence approach.

D.4.1.3 Sediment

Indiana has not established sediment-screening levels (SSLs) for any contaminants, and the U.S. EPA has established SSLs for only a few contaminants. Therefore, other, non-regulatory alternate benchmarks will be used to evaluate the sediment data. SSLs based on freshwater studies will be used where available. The following list presents the SSLs that will be used in this evaluation. The paragraphs following this list discuss the SSLs in more detail:

- "Eco Update-Ecotox Thresholds" (U.S. EPA, 1996)
- "Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario" (OMOE, 1993)
- "Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments" (Long et al., 1995).

The sediment Ecotox Thresholds include draft U.S. EPA Sediment Quality Criteria (SQC) that have been established for five contaminants (acenaphthene, dieldrin, endrin, fluoranthene, and phenanthrene), Sediment Quality Benchmarks (SQB) that have been established using equilibrium partitioning, and Effects Range-Low values from Long et al., (1995). The SQC and SQBs Ecotox Thresholds are based on an assumption of 1 percent organic carbon [10,000 mg/kg total organic carbon (TOC)]. The three PAH SQC documents (acenaphthene, fluoranthene, and phenanthrene) have been withdrawn in favor of a Draft PAH Mixture Sediment Guideline (U.S.EPA, 2000). In addition, the Draft Sediment Guidelines for Metals (cadmium, copper, lead, nickel, silver, and zinc) was published by U.S. EPA (U.S. EPA, 2000). These documents will be utilized if they are finalized when the SERA is prepared.

The "Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario" (OMOE, 1993) are based on freshwater studies. The Ontario Ministry of Environment and Energy (OMOE) guidelines establish three effects levels, as follows:

- ***No Effect Level:*** Sediment will not affect fish or sediment-dwelling organisms. In addition, no transfer through the foodchain and no effect on water quality is expected.

- ***Lowest Effect Level:*** Sediment is considered marginally polluted but will not affect the majority of sediment-dwelling organisms.

- ***Severe Effect Level:*** Sediment is considered highly polluted and likely to affect the health of sediment-dwelling organisms.

The "Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments" (Long et al., 1995) will be used if no freshwater data are available because they are generally accepted by many state agencies and U.S. EPA regions, even though they are based primarily on estuarine and marine studies. Long et al. (1995) establishes three effects levels, as follows:

- ***Below Effects Range-Low (ER-L):*** (Effects Range-Low) Minimal-effects range (adverse effects would be rarely observed);

- ***Between ER-L and Effects Range-Median (ER-M):*** Possible-effects range (adverse effects would occasionally occur); and

- ***Above the ER-M:*** Probable-effects range (adverse effects would probably occur).

Additional sources of toxicity data from the literature may be used to evaluate potential risks to aquatic receptors from contaminants in the sediment for contaminants that are not evaluated in the above documents.

Contaminants that exceed the SSLs also will be compared to background contaminant levels developed in the Sediment Background Concentration Distributions of 172 Potential Pollutants in Indiana (Wente, 1994) document. The term "background" was interpreted in that document as "the concentration that would be present in the absence of any particular pollutant source." Background values will be used as another piece of information in the lines-of-evidence approach for evaluating the sediments.

D.4.2 Terrestrial Food Chain Modeling

Most of the above-mentioned additional surface soil standards/benchmark values are not designed to screen out risks to terrestrial wildlife ingestion of the soil, sediment, surface water, plants, invertebrates, and fish. Therefore, in addition to comparing the soil concentrations to toxicity values for terrestrial invertebrates and plants, a terrestrial intake model will used to estimate the exposure of the COPCs to terrestrial receptors.

Risk to terrestrial receptors to the COPCs in the soil, sediment, and surface water will be determined by estimating the Chronic Daily Intake (CDI) (see Section D.4.3) and comparing the CDI to Terrestrial Reference Values (TRVs) representing acceptable daily doses in mg/kg/day. The TRVs will be developed from No-Observed-Adverse-Effect-Levels (NOAELs) and Lowest-Observed-Adverse-Effect-Levels (LOAELs) obtained from wildlife studies, if available. The majority of the TRVs will come from the ORNL Toxicological Benchmarks for Wildlife: 1996 Revision (Sample et al., 1996). Toxicity data in the Agency for Toxic Substances and Disease Registry toxicity profiles and Integrated Risk Information System printouts will be utilized, when necessary.

For avian species, the NOAEL (or LOAEL) for the test species will be 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 one species will be adjusted to a NOAEL (or LOAEL) for the surrogate species using the following body weight scaling equation from Sample et al., 1996):

$$NOAEL_w = NOAEL_t * (bw_t/bw_w)^{1/4}$$

Where: $NOAEL_w$ = No Observed Adverse Effect Level for the surrogate wildlife species
$NOAEL_t$ = No Observed Adverse Effect Level for the test species
bw_t = body weight of the test species
bw_w = body weight of the surrogate test species

The body weight scaling is done 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, a scaling factor of 1.0 will be used for birds in this SERA.

Table D-1 presents the body weights that will be used for the surrogate and potential test species. If a subchronic study is used to develop the TRV, the final value will be multiplied by a factor of 0.1 to account for uncertainty between subchronic and chronic effects. Also, if a LOAEL study is used to develop the NOAEL TRV, then the LOAEL will be multiplied by a factor of 0.1 to obtain the NOAEL. Finally, the estimated doses will incorporate literature-based soil to plant and soil to earthworm bioaccumulation factors.

D.4.3 Characterization of Exposure

This section describes the potential or actual contact or co-occurrence of the contaminants with the receptors to determine their exposure dose.

Terrestrial soil invertebrates and plants are exposed to contaminants in the surface soil through direct contact and/or ingestion. Aquatic organisms are exposed to contaminants in the surface water and sediment through direct contact and/or ingestion. 95 percent Upper Confidence Levels (UCLs) and average soil, surface water, and/or sediment concentrations will be compared to the applicable soil screening values to determine potential risk to these ecological receptors to obtain a range of exposures.

Exposure of the terrestrial receptors to the COPCs in the surface soil, sediment, and surface water will be determined by estimating the daily doses in mg/kg/day using exposure equations. The contaminant concentrations in the surface soil, sediment, and surface water will be used to calculate the chronic daily intake (CDI) doses. The following equation presents a generic food chain model that will be used for the surrogate species that are selected for modeling:

$$\text{CDI Dose (mg/kg/day)} = \frac{(MFI * MFC) + (MWI * MSW) + (MSI * MSC)}{MBW}$$

Where: MFI = Maximum food ingestion rate
MFC = Maximum food concentration
MWI = Maximum surface water ingestion rate
MSW = Maximum surface water concentration
MBW = Minimum body weight
MSI = Maximum incidental sediment ingestion rate
MSC = Maximum sediment concentration

For inorganic constituents in surface soil and sediment, as well as organic constituents in surface soil, the contaminant concentration of the prey items (i.e., earthworms, fish) is calculated using the following equation:

$$FC = SC * BAF$$

Where: FC = Contaminant concentration in food
SC = Contaminant concentration in surface soil or sediment

BAF = Bioaccumulation Factor

For organic constituents in the sediment, the contaminant concentration of the prey items is calculated using the following equation:

$$FC = \frac{SC * \%L * BSAF}{\%TOC}$$

Where: FC = Contaminant concentration in food
SC = Contaminant concentration in sediment
%L = Percentage of lipids in fish [3.6% = the average of various species of sunfish. Attachment D-1 presents the calculation used to derive this value (USEPA, 1997)]
BSAF = Biota-Sediment Accumulation Factor (chemical-specific)
%TOC = Percentage of total organic carbon in sediment (site-specific)

Because insects were collected and analyzed for metals and explosives from two locations along Little Sulphur Creek, the contaminant concentrations in the insects will be used as the FC for the Little Brown Bat.

The lower bound of the threshold effects is based on consistently conservative assumptions and NOAEL toxicity values (U.S. EPA, 1997). This bound will present the highest potential risks. The upper bound is based on observed impacts or predictions that ecological effects could occur and is developed using consistent assumptions, site-specific data, LOAEL toxicity values, or an impact evaluation (U.S. EPA, 1997). This bound will present the average potential risk. Both the upper and lower bounds will be evaluated in this SERA to provide the overall range of potential risks as presented in the following table:

Conservative Scenario	Average Scenario
95% UCL soil, surface water, or sediment concentration	Average soil, surface water, or sediment concentration
90% BAF/BSAF value from the literature (when available)	Median BAF/BSAFvalue from the literature (when available)
Highest receptor body weight for NOAEL calculation	Average receptor body weight for LOAEL calculation
Lowest receptor body weight for CDI equation	Average receptor body weight for CDI equation
Conservative receptor ingestion rate	Average receptor ingestion rate
Use NOAELS	Use LOAELs
Receptors spend 100% of their time at the site	Receptor's home range taken into account

The exposure assumptions (i.e., ingestion rate, body weight) will be obtained from the Wildlife Exposure Factors Handbook (U.S. EPA, 1993), or other literature sources, if necessary. Table D-1 presents the exposure parameter that will be used in the SERA. Table D.A-1 in Attachment D-1 presents the values that were used to calculate the exposure parameters, and a discussion of how they were calculated.

D.5 ECOLOGICAL RISK CHARACTERIZATION

The risk characterization is the final phase of a risk assessment that 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 will be evaluated. An Ecological Effects Quotient (EEQ) approach will be used to characterize the risk to terrestrial receptors. This approach characterizes the potential effects by comparing exposure concentration with the effects data. An EEQ of greater than "1.0" is considered to indicate a potential risk. The EEQ is not an expression of probability, and the meaning of values greater than 1.0 must be interpreted in light of attendant uncertainties in risk management.

An EEQ for the aquatic receptors will be calculated as follows:

$$EEQ = \frac{C_{sw}}{SWSL} \text{ or } \frac{C_{sd}}{SSL}$$

Where: EEQ = Ecological Effects Quotient, (unitless)

C_{sw} = Contaminant concentration in surface water, (µg/L)

C_{sd} = Contaminant concentration in sediment, (µg/kg or mg/kg)

SWSL = Surface Water Screening Level, (µg/L)

SSL = Sediment Screening Level, (µg/kg or mg/kg)

An EEQ for terrestrial plants and invertebrates will be calculated as follows:

$$EEQ = \frac{C_{ss}}{SSSL}$$

Where: EEQ = Ecological Effects Quotient, (unitless)

C_{ss} = Contaminant concentration in surface soil, (µg/kg or mg/kg)

SSSL = Plant or Invertebrate Screening Level in Soil, (µg/kg or mg/kg)

The EEQ for the terrestrial wildlife model will be calculated as follows:

$$EEQ = \frac{Dose}{TRV}$$

Where: EEQ = Ecological Effects Quotient, (unitless)
Dose = Daily Intake Dose, (mg/kg-day)
TRV = Terrestrial Reference Value (NOAEL or LOAEL), (mg/kg-day)

D.6 ECOLOGICAL RISK UNCERTAINTY ANALYSIS

This section presents some of the uncertainties associated with ecological risk assessments.

D.6.1 Measurement and Assessment Endpoints

Measurement endpoints are used to evaluate the assessment endpoints that are selected for the SERA. For this SERA, the measures of effects are not the same as the assessment endpoints. Therefore, the measures are used to predict effects to the assessment endpoints by selecting surrogate species that will be evaluated. For example, a decrease in reproduction of a shrew is used to assess a decrease in reproduction of the small mammal population. However, predicting a decrease in reproduction of a shrew may either under- or overprotect the small mammal population, resulting from differences in ingestion rates, toxicity, food preferences, etc. between different species.

Risks to reptiles and amphibians will not be quantitatively evaluated because exposure factors are not established for most species, and toxicity data are very limited. However, risks to reptiles and amphibians will be qualitatively evaluated as part of the SERA.

D.6.2 Exposure Characterization

The contaminant dose to terrestrial wildlife is calculated using an equation that incorporates ingestion rates, body weights, bioaccumulation factors, and other exposure factors. These exposure factors are obtained from literature studies or predicted using various equations. Ingestion rates and body weights vary between species, especially between species inhabiting different areas. For example, the food ingestion rate for the robin was calculated as 0.89 gram/gram-day (g/g-day) in California and 1.52 g/g-day in Kansas (EPA, 1993a).

Bioaccumulation of contaminants into various biological media (i.e., plants, invertebrates, small mammals) depend on characteristics of the media such as pH, organic carbon, etc. Therefore, actual bioaccumulation factors at the site may be different than those used in the ERA that were obtained from the literature. Also, the bioavailability of the chemicals is not taken into account in this SERA. All the chemicals are assumed to be 100 percent bioavailable at the detected concentrations, which is unlikely to occur for contaminants in the environment.

There is uncertainty in the chemical data that are collected at the site. Measured levels of chemicals are only estimates of the true site chemical concentrations. For samples that are deliberately biased toward known or suspected high concentrations, predicted doses probably will be higher than actual doses.

Finally, under the conservative exposure scenario, terrestrial wildlife are assumed to live and feed only at the site. These assumptions will tend to overpredict risk because it is unlikely that most receptors will obtain all their food from within the site boundaries and from the most contaminated areas.

D.6.3 Ecological Effects Data

There is uncertainty in the ecological toxicity value comparison. The water quality criteria developed by EPA in theory protects 95 percent of the exposed species. Therefore, some sensitive species may be present at the site that are not protected by the use of these criteria. There also may be situations where the surface water screening levels (SWSLs) are over-predictive of risk if the sensitive species used to develop the criteria do not inhabit the site. Finally, with the exception of hardness for a few metals, the SWSLs do not account for site-specific factors, such as TOC or pH, that may affect toxicity.

Potential adverse impacts to aquatic receptors from constituents in the sediment are evaluated by comparing the COPC concentration to sediment screening levels (SSLs). The SSLs have more uncertainty associated with them than do the SWSLs for the following reasons: The procedures for developing them are not as well established so screening levels have been developed using different methodologies and there are fewer sediment toxicity data than surface water toxicity data. Sediment characteristics (i.e., pH, acid volatile sulfides, total organic carbon) also will have a large impact on the bioavailability and toxicity of constituents.

Potentially adverse impacts to terrestrial plants and invertebrates from constituents in the surface soil are evaluated by comparing the COPC concentration to surface soil screening levels (SSSLs). The SSSLs are similar to the sediment screening levels in that they are less established than the SWSLs. Fewer studies and fewer 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 endpoints, depending on the preference of the agency that developed them. Therefore, they have more uncertainty than surface water and sediment screening values.

The NOAELS that were selected for the wildlife endpoint species were based on species other than the endpoint species (i.e., rats, mice, ducks). There is uncertainty in the application of toxicity data across species because the contaminant may be more or less toxic to the endpoint species than it was to the test study species.

The toxicity of chemical mixtures is not well understood. All the toxicity information used in the ERA for evaluating risk to the ecological receptors is 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 a few of the COPCs are limited or do not exist. Therefore, there is uncertainty in any conclusions involving the potential impacts to ecological receptors from these constituents.

D.6.4 Risk Characterization

Risks are possible if an EEQ is greater than or equal to unity regardless of the magnitude of the EEQ. However, the magnitude of effects to ecological receptors cannot be inferred based on the magnitude of the EEQ. Rather, an EEQ greater than 1.0 simply indicates that the dose used to derive the toxicity reference value was exceeded. Finally, there is uncertainty in how the predicted risks to a species at the site translate into risk to the population in the area as a whole.

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TABLE D-1

EXPOSURE PARAMETERS FOR TEST SPECIES AND SURROGATE WILDLIFE SPECIES
NAVAL SURFACE WARFARE CENTER, CRANE, INDIANA

Species	Body Weight (kg)			Food Ingestion Rate (kg/day)		Water Ingestion Rate (L/day)		Soil/Sediment Ingestion Rate (kg/day)		Home Range (acres) (3)		
	Avg.	Min.	Max.	Avg.	Conserv.	Avg.	Conserv.	Avg.	Conserv.	Avg.	Min.	Max.
Potential Test Species (1)												
Rat	0.35	NA	NA	NA		NA		NA		NA		
Mouse	0.03	NA	NA	NA		NA		NA		NA		
Rabbit	3.8	NA	NA	NA		NA		NA		NA		
Mink	1	NA	NA	NA		NA		NA		NA		
Surrogate Wildlife Species (2)												
Bobwhite Quail	0.177	0.162	0.1855	0.0144	0.0164	0.0184	0.0231	0.001181	0.001345	28.6	15.8	41.3
American Robin	0.081	0.0773	0.0862	0.0976	0.1231	0.0113	0.0121	0.01015	0.012802	1.19	0.37	2
Short-Tailed Shrew	0.01687	0.01525	0.01921	0.0103	0.0162	0.0038	0.0043	0.001339	0.002106	0.97	0.97	0.97
Meadow Vole	0.03663	0.0329	0.0391	0.0119	0.0128	0.0064	0.0077	0.000286	0.000307	0.03	0.164	1.06
Raccoon	6.865	5.34	8.86	0.3347	0.4128	0.5664	0.5698	0.031462	0.038803	385.5	266.9	504.1
Belted Kingfisher	152	136	170	0.0689	0.0758	0.0167	0.0187	0.001378	0.001516	2.862	0.964	5.399
Little Brown Bat	0.0072	0.006	0.0103	0.0044	0.0081	0.0014	0.0015	NA	NA	1	0.8	1.2

Notes:
See Attachment D.A-2-1 for the source of calculation of the exposure factors
NA - Not Applicable
1 - Sample et al., 1996 (only one value was provided so it was placed in the average column)
2 - EPA, 1993 for all factors except soil ingestion; Beyer (1993) or Talmage and Walton (in press) for soil ingestion rates
3 - All of the exposure parameters are for the Little Brown Bat except for the home range, which is for the Indiana Bat.
4 - Home range for the kingfisher and Indiana Bat is presented in km of shoreline.

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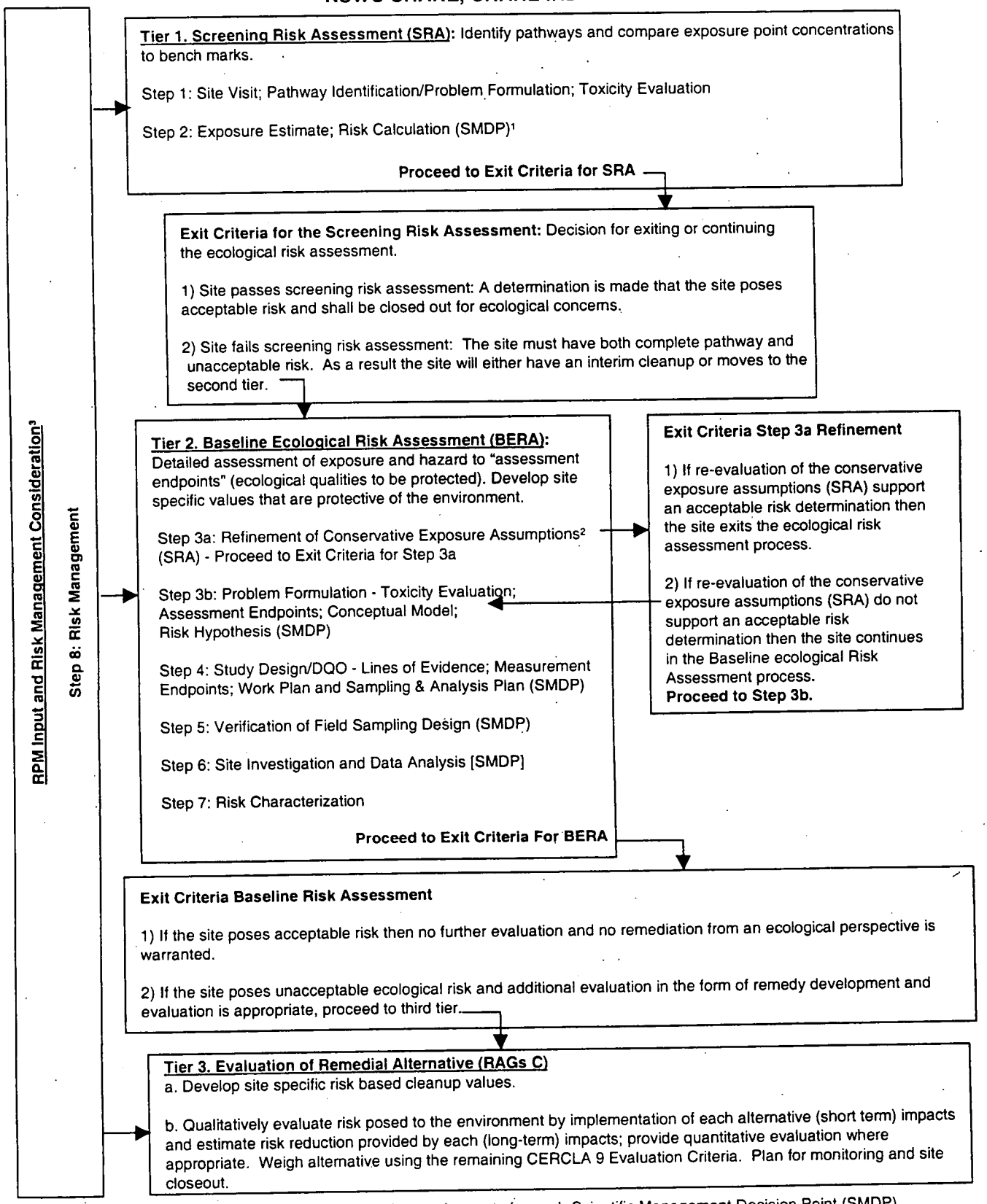
FIGURE D-1

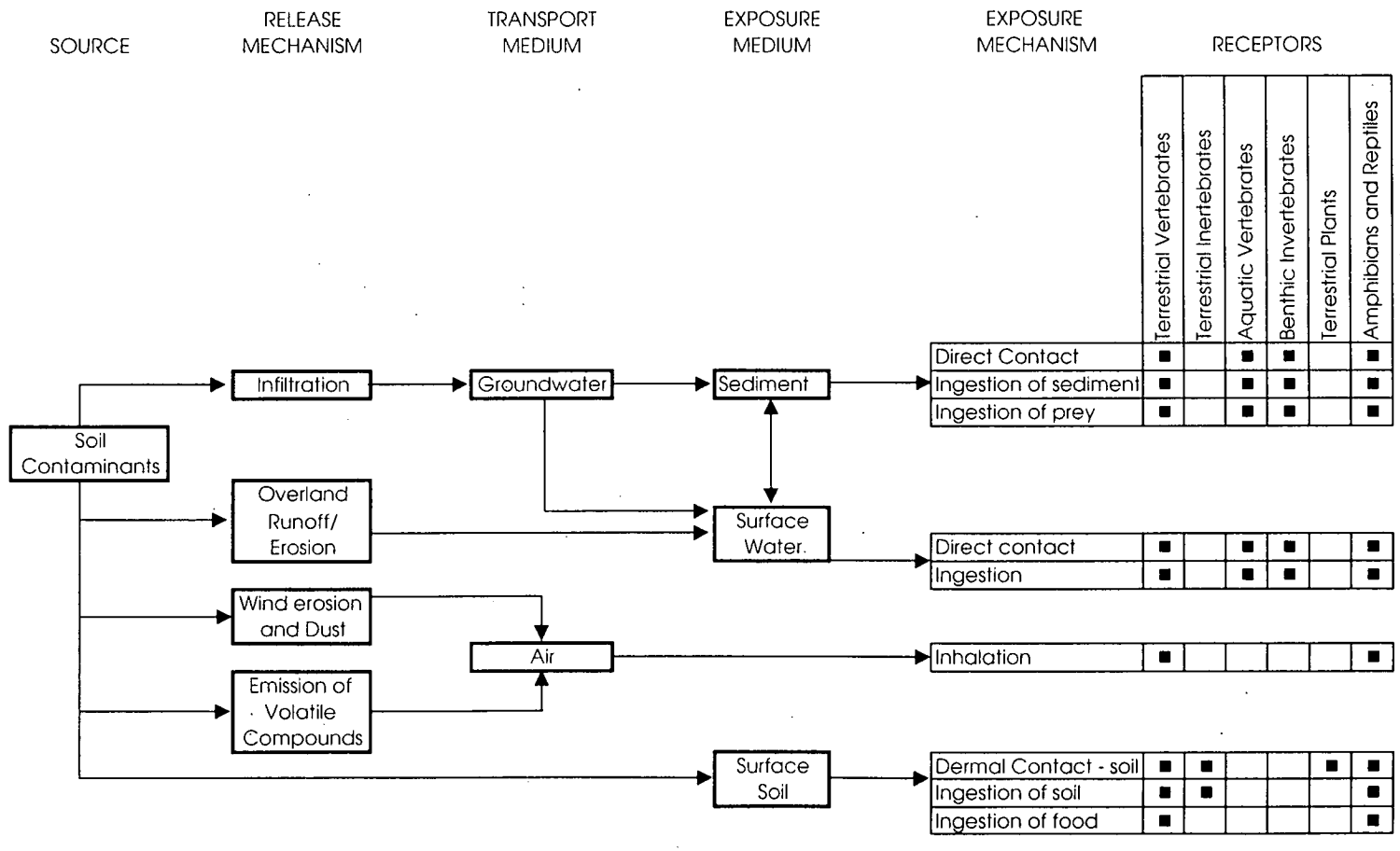
NAVY'S ECOLOGICAL RISK ASSESSMENT TIERED APPROACH
NSWC CRANE, CRANE INDIANA



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 D-2

ECOLOGICAL CONCEPTUAL SITE MODEL
JEEP TRAIL AND LITTLE SULPHUR CREEK
NSWC CRANE, CRANE, INDIANA



ATTACHMENT D-1

RECEPTOR PROFILES

RECEPTOR PROFILES

NSWC CRANE, CRANE, INDIANA

The following sections present the receptor profiles for the meadow vole, American robing, northern bobwhite quail, short-tailed shrew, raccoon, and belted kingfisher. The majority of the information for the profiles was obtained from the Wildlife Exposure Factors Handbook (EPA, 1993). The data for the incidental soil ingestion rates were obtained from the Estimates of Soil Ingestion by Wildlife (Beyer, 1993) except for the shrew data, which was in Talmage and Walton (undated). The exposure parameters that were selected for this SERA work plan are based on animals collected in or near southern Indiana, when available.

The food and water ingestion rate are presented in g/g (of body weight)-day on a wet weight basis. The home ranges for all species are presented in hectares in EPA (1993), but were converted to acres in this work plan by multiplying the number of hectares by 2.471. The only exception is the kingfisher's range, which is presented in km of shoreline. Also note that the estimated percent of soil in the diets are listed in dry weight, while the other exposure factors are in wet weight. The soil dry weight was not converted to a wet weight in this work plan because the percent moisture of the soils is not known. Also, incidental soil ingestion is only a small portion of the overall diet (2.0 to 13 percent).

The attached table presents the calculation of the exposure parameters. Note that in this table the ingestion rates in kg/day (or L/day) for the conservative scenario was calculated by multiply the maximum ingestion rate in g/g-day by the average body weight, while the ingestion rates in kg/day (or L/day) for the average scenario was calculated by multiplying the average ingestion rate in g/g-day by the average body weight. Typically, a minimum body weight is used in the conservative models. However, using the minimum body weight to calculate the maximum ingestion rate sometimes causes the conservative ingestion rate to be lower than the average ingestion rate. Therefore, the average body weight was selected to ensure that the ingestion rate for the conservative scenario was higher than the ingestion rate for the average scenario. The minimum body weight will be used in the dose equation for the conservative scenario. The only exceptions to this were for the food ingestion rate for the raccoon, and the water ingestion rates for the shrew, robin, and kingfisher. Because only one ingestion rate was available, the maximum body weights were used to calculate the conservative ingestion rates and the average body weights were used to calculate the average ingestion rates.

Meadow Vole *(Microtus pennsylvanicus)*

Meadow voles inhabit grassy fields, marshes, and bogs; however, they prefer fields with more grass, more cover, and fewer woody plants. They typically consume green succulent vegetation, sedges, seeds, roots, bark, fungi, insects, and animal matter. Green succulent vegetation makes up the majority of their diet.

The adult body weight for the vole in southern Indiana ranged from 0.0329 to 0.0391 kg with an average of 0.0366 kg. The only listed food ingestion rates were for voles in Russia, which ranged from 0.30 to 0.35 g/g-day, with an average of 0.325 g/g-day. The water ingestion rates are 0.14 (estimated) and 0.21 g/g-day, with an average of 0.175 g/g-day. Finally, the incidental soil ingestion rate was calculated by multiplying the ingestion rate by the percentage of soil that is incidentally ingested (2.4 percent) from Beyer (1993).

The home range for the meadow vole was calculated using data from a Michigan old field. The values ranged from 0.0297 to 1.06 acres with an average home range of 0.164 acres.

American Robin (*Turdus migratorius*)

American robins inhabit parks, lawns, moist forest, swamps, open woodland, and orchards. Robins forage on the ground in open areas, along habitat edges, or the edges of streams. They also may forage above ground in shrubs and within the lower branches of trees. In the months proceeding and during the breeding season, robins feed primarily on invertebrates and on some fruits. During the rest of the year their diet consists primarily of fruits.

The adult body weight for the American robin in New York woodlands and forests, and in Pennsylvania ranged from 0.0773 to 0.0862 kg with an average of 0.081 kg. The only listed food ingestion rates were for robin in Kansas (1.52 g/g-day) and California (0.89 g/g-day), with an average of 1.205 g/g-day. The water ingestion rate was estimated as 0.14 g/g-day. The incidental soil ingestion rate was calculated by multiplying the ingestion rate by the percentage of soil that is incidentally ingested (10.4 percent for a woodcock) from Beyer (1993).

The home range for the robin was calculated using data from an Ontario forest. The values ranged from 0.37 to 2 acres with an average home range of 1.19 acres.

Northern Bobwhite Quail *(Colinus virginianus)*

Quails inhabit grasslands, idle fields, pastures, and large clumps of grasses. Bobwhites forage in areas with open vegetation, some bare ground, and light litter. Seeds from weeds, woody plants, and grasses comprise the majority of an adult's diet, although green vegetation has been found to dominate their diet in winter in the south.

The adult body weight for the bobwhite quail in southern Illinois agricultural areas ranged from 0.162 to 0.1855 kg with an average of 0.177 kg. The listed food ingestion rates are for quails in Kansas and Texas lab studies, and in a captive study from Massachusetts. The values ranged from 0.067 to 0.093 g/g-day, with an average of 0.082 g/g-day. The water ingestion rate was estimated as 0.10 and 0.11 g/g-day, and measured in a Texas lab (0.86 to 0.131 g/g-day), for an average water ingestion rate of 0.104 g/g-day. The incidental soil ingestion rate is calculated by multiplying the food ingestion rate by the percentage of soil that is incidentally ingested (0.082 percent for a Canada goose) from Beyer (1993).

The home range for the quail was calculated using data from southern Illinois idle farms, woods, brush, and cornfields. The values for individuals ranged from 15.8 to 41.3 acres with an average home range of 28.6 acres.

Short-Tailed Shrew *(Blarina brevicauda)*

Shrews inhabit a wide variety of habitats and are common in areas with abundant vegetative cover. They need cool, moist habitats because of their high metabolic and water-loss rates. The short-tailed shrew is primarily carnivorous, eating insects such as earthworms, slugs, and snails.

The adult body weigh for the short-tailed shrew in various Pennsylvania habitats ranged from 0.01525 to 0.01921 kg with an average of 0.01687 kg. The listed food ingestion rates are for shrews in labs on Ohio (0.49 g/g-day), Wisconsin (0.43 to 0.96 g/g-day), and Virginia (0.541 g/g-day), with an average of 0.61 g/g-day. The water ingestion rate was determined as 0.223 g/g-day in an Illinois laboratory. The incidental soil ingestion rate was calculated by multiplying the ingestion rate by the percentage of soil that is incidentally ingested (13 percent) from Talmage and Walton (undated).

The home range for the shrew was calculated using data from a tamarak bog in Manitoba (only value available). The value was 0.9699 acres.

Raccoon *(Procyon lotor)*

Raccoons are found near virtually every aquatic habitat, particularly in hardwood swamps, mangroves, floodplain forests, and freshwater and saltwater marshes. They are also common in suburban residential areas. They use surface waters for both drinking and foraging. They feed primarily on fleshy fruits, nuts, acorns, and corn, but also eat grains, insects, frogs, crayfish, eggs, and virtually any animal and vegetable matter.

The adult body weights based on data from Illinois, range from 5.34 to 8.86 kg, with an average of 6.865 kg. The average food ingestion rate of 0.3347 kg/day was calculated using the average body weight and the following equation from EPA (1993):

$$FI = (0.0687)\ (BW^{0.822})$$

Where: FI = Food ingestion rate (kg/day)
BW = Body weight in kg

The range of water ingestion rates is listed as 0.082 to 0.083 g/g-day. The incidental soil ingestion rate is calculated by multiplying he ingestion rate by the percentage of soil that is incidentally ingestion (0.094), as presented in Beyer (1993).

Based on data from Michigan, home range sizes for the raccoon range from 266.9 to 504.1 acres for an average home range of 385.5 acres.

Belted Kingfisher *(Ceryle alcyon)*

Belted kingfishers are typically found along rivers, streams, and the edges of lakes and ponds. They are also common along seacoasts and estuaries. They prefer water that is free of thick vegetation and overhanging trees that obscure the view of the water. Because kingfishers eat primarily fish that swim near the surface or in shallow water, they require relatively clear water to see and catch their prey. Although kingfishers feed predominantly on fish, they have been known to consume crayfish, crabs, mussels, lizards, frogs, toads, small snakes, turtles, insects, salamanders, newts, young birds, mice, and berries.

Based on data from Michigan, Pennsylvania, Ohio, and Minnesota, the adult body weights range from 0.136 to 0.170 kg, with an average of 0.152 kg. The listed food ingestion rates, based on data from Michigan, range from 0.41 to 0.5 g/g-day. The water ingestion rate is estimated as 0.11 g/g-day. The

incidental soil ingestion rate was calculated by multiplying the ingestion rate by the percentage of soil that is incidentally ingested (2 percent), based on the mallard data presented in Beyer (1993).

The home range for the kingfisher ranges from 0.39 to 2.185 km of shoreline, based on data from streams in Pennsylvania and Ohio.

Little Brown Bat (*Myotis lucifugus*)/Indiana Bat (*Myotis sodalis*)

This receptor profile discusses both the Indiana bat and the Little Brown Bat. Although the Indiana bat is a Federally-listed endangered species, the Little Brown Bat is used as a surrogate species for the Indiana Bat because exposure parameters (e.g., ingestion rates) are available for the Little Brown Bat. Note that the home range discussed in the last paragraphs of this section is for the Indiana Bat, since this is really the species of concern.

The Indiana Bat hibernates during winter in caves and abandoned mines, and then migrates to summer roosts, which are generally in hardwood forests adjacent to streams and lakes (USDA, 1998). The most important characteristic of trees chosen as roost sites is not species, but structure. Bats choose trees with exfoliating bark that allows space for them to roost between the bark and the bole of the tree. The length and persistence of peeling bark varies with the species of tree and the severity of environmental factors to which it is subjected (USFWS, 1999). Indiana Bats weigh 4.5 to 9.5 grams and are approximately 7.6 to 8.9 cm n length (USDA, 1998). Indiana Bats are strict insectivores, and eat nuisance and pest insects such as alfalfa weevils and gypsy moths (USDA, 1998). Both aquatic and terrestrial insects are consumed. Diet varies seasonally and variation is observed among different ages, sexes, and reproductive-status groups (USFWS, 1999).

Little Brown Bats inhabit open areas, with strategic day, night, and hibernacula roosting sites in hollow trees, buildings, caves, and abandoned mines. The avoid areas with dense vegetation and other obstructions to flight. Like the Indiana Bat, Little Brown Bats are strict insectivores. Insects are generally captured in flight, or taken from the surface of water or vegetation. They forage primarily in open habitat, flood plain pastures, and frequently over bodies of water. Foraging along forest edges has also been observed (Sample et al., 1997).

The adult body weight of the Little Brown Bat in Indiana ranged from 6.03 to 12.27 grams, with an average weight of 7.2 grams. The only listed food ingestion rates for bats in New Hampshire ranged from 0.23 to 1.12 g/g-day, with an average of 0.61 g/g-day. The water ingestion rates ranges from 0.177 to 0.205 g/g-day with an average of 0.191 g/g-day. Because bats are aerial insectivores, soil ingestion is assumed to be negligible.

The extent of the foraging area used by an Indiana bat maternally colony has been reported to range from a linear strip of creek vegetation 0.8 km in length to a foraging area of 1.2 km in length (USFWS, 1999).

TABLE D.A-1

CALCULATION OF EXPOSURE PARAMETERS FOR WILDLIFE RECEPTORS
NAVAL SURFACE WARFARE CENTER, CRANE, INDIANA

Exposure Parameters	Meadow Vole		Short-Tailed Shrew		Little Brown Bat	American Robin	Bobwhite Quail		Raccoon		Belted Kingfisher
Body Weights (g)	32.9	35.5	17.61	16.87	6.15	77.3	180	181	7090	6160	150
	39.1	39	17.33	15.58	6.15	80.8	168	183	7140	6440	136
			19.21	15.7	6.03	86.2	162	179	7600	5340	158
			17.4	15.25	6.99	83.6	175	175	6000	5620	147
					10.27	77.4	178	183.2	6400	8860	148
					7.77	80.6	179	185.5	7740	7560	170
							180	173	6560	7600	
							162.8	180.4			
Minimum	***32.9***		***15.25***		***6.03***	***77.3***	***162***		***5340***		***136***
Maximum	***39.1***		***19.21***		***10.27***	***86.2***	***185.5***		***8860.0***		***170.0***
Average	***36.63***		***16.87***		***7.2***	***81.0***	***177***		***6865***		***152***
Food Ingestion Rate (g/g-day) [1]	0.3	0.35	0.49	0.77	1.12	0.89	0.067	0.079			0.5
			0.62	0.55	0.23	1.52	0.072	0.093			0.41
			0.43	0.96	0.48		0.09	0.089			
			0.52	0.54							
Minimum	***0.3***		***0.43***		***0.23***	***0.89***	***0.067***				***0.41***
Maximum	***0.35***		***0.96***		***1.12***	***1.52***	***0.093***				***0.5***
Average	***0.325***		***0.61***		***0.61***	***1.205***	***0.082***				***0.455***
Food Ingestion Rate (kg/day)											
Conservative	***0.0128***		***0.0162***		***0.0081***	***0.1231***	***0.0164***		***0.4128***		***0.0758***
Average	***0.0119***		***0.0103***		***0.0044***	***0.0976***	***0.0144***		***0.3347***		***0.0689***
Water Ingestion Rate (g/g-day)	0.14	0.21	0.223		0.177	0.14	0.115	0.1	0.082	0.083	0.11
					0.205		0.106	0.131			
							0.093	0.101			
							0.086	0.102			
							0.11	0.1			
Minimum	***0.14***		***0.223***		***0.177***	***0.14***	***0.086***		***0.082***		***0.11***
Maximum	***0.21***		***0.223***		***0.205***	***0.14***	***0.131***		***0.083***		***0.11***
Average	***0.175***		***0.223***		***0.191***	***0.14***	***0.104***		***0.083***		***0.110***
Water Ingestion Rate (L/day)											
Conservative	***0.0077***		***0.0043***		***0.0015***	***0.0121***	***0.0231***		***0.5698***		***0.0187***
Average	***0.0064***		***0.0038***		***0.0014***	***0.0113***	***0.0184***		***0.5664***		***0.0167***
Home Range (Ha) [2]	0.43	0.097	0.3925		0.80	0.15	7.6	6.4	204	108	2.185
	0.019	0.041			1.20	0.81	16.7	15.6			1.028
	0.013	0.033									1.03
	0.012	0.013									0.39
	0.043	0.057									
	0.023	0.032									
	0.051	0.078									
	0.058	0.061									
Minimum (acres)[2]	***0.0297***		***0.9699***		***0.80***	***0.37***	***15.8***		***266.9***		***0.39***
Maximum (acres)[2]	***1.06***		***0.97***		***1.20***	***2.00***	***41.3***		***504.1***		***2.19***
Average (acres)[2]	***0.164***		***0.970***		***1.00***	***1.19***	***28.6***		***385.5***		***1.16***

Notes:
Source of data is EPA, 1993 except for the Little Brown Bat.
Source of the Little Brown Bat data is Sample et al., 1997 except for the home range, which is USFWS, 1999.
1 - Food Ingestion Rate (kg/day) for the raccoon was calculated using the following equation:
$FI = (0.0687)(BW^{0.822})$, where FI = Food Ingestion Rate (kg/day) and BW = Body Weight (kg).
2 - Home range for the kingfisher and Indiana Bat is presented in km of shoreline.
Ingestion Rates (kg/day or L/day) (if more than 1 ingestion rate is available)
- Conservative value = Max Ingestion Rate (g/g-day)* Avg. Body Weight
- Average value = Avg. Ingestion Rate (g/g-day)*Avg. Body Weight

Ingestion Rates (L/day) (if only 1 ingestion rate is available)
- Conservative value = Ingestion Rate (g/g-day)* Max. Body Weight
- Average value = Ingestion Rate (g/g-day)*Avg. Body Weight

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TETRA TECH NUS, INC. **CALCULATION WORKSHEET**

CLIENT: NSWC CRANE	JOB NUMBER:
SUBJECT: PERCENT LIPID CALCULATION FOR FISH	
BASED ON: USEPA, 1997. The Incidence and Severity of Sediment Contamination in Surface Waters of the US.	DRAWING NUMBER: EPA 823-R-97-006
BY: J. VERBANIC	CHECKED BY: YMB
APPROVED BY:	DATE: 2-23-01

Percent Lipid Content in Fish:

Species	Whole Fish Lipid Content (Percent)*
Redbreast Sunfish	3.6
Green Sunfish	3.2
Pumpkinseed	3.9
Longear Sunfish	2.8
Bluegill Sunfish	3.5
Bluegill Sunfish	4.4
	3.5666 ≈ 3.6% LIPID FOR FISH

* Values taken from Appendix C, Table C-3b, USEPA (1997) The Incidence and Severity of Sediment Contamination in Surface Waters of the United States

APPENDIX E

EXAMPLE WILCOXON RANK-SUM TEST

CLIENT NSWC WHITE OAK	JOB NUMBER 7687.0304 (CTO-298)
SUBJECT SAMPLE CALCULATIONS OF STATISTICAL ANALYSIS	
BASED ON	DRAWING NUMBER
BY MBP / CHECKED BY BEL	APPROVED BY / DATE 6/3/99

USING ALUMINUM DATA FOR SUBSURFACE SOIL SAMPLES AT SITE 11, CALCULATION OF Z_{rs} VALUE IS PERFORMED VIA WILCOXON RANK-SUM TEST

① CALCULATION OF SUM OF RANKS (W_{rs}) [mg/kg]

SITE DATA	SAMPLE	BKGND DATA	SAMPLE	SITE RANKS	BKG RANKS
9430	11-SB01-1416	21800	BG-04-SB	10	15
5080	11-LW-03	10600	BG-05-SB	5	12
2860	11-SB05-1416	5780	BG-06-SB	2	7
3880	11-LW-06	22000	BG-07-SB(6)	4	16
10800	11-SB07-0607	40700	BG-10-SB(6)	13	18
7740	11-SB08-1416	9900	BG-12-SB(3)	8	11
5310	11-SB09-1416	22900	BG-13-SB(6)	6	17
2940	11-SB10-1012	20000	BG-SB-100(7)	3	14
1340	11-SB11-1214	8100	BG-SB-102(7)	1	9
				$\Sigma = 52$	$\Sigma = 119$

$^{*}W_{rs}$ (SITE) = 52

② CALCULATION OF Z_{rs}

$$Z_{rs} = \frac{W_{rs} - \frac{n_1(m+1)}{2}}{\sqrt{\frac{n_1 n_2 (m+1)}{12}}}$$

Where: W_{rs} = SUM OF RANKS (SITE) n_1 = No. SAMPLES (SITE)

$m = n_1 + n_2$ n_2 = No. SAMPLES (BCKGD)

CLIENT NSWC WHITE OAK	JOB NUMBER 7687.0304 (CTO-298)
SUBJECT SAMPLE CALCULATIONS OF STATISTICAL ANALYSIS	
BASED ON	DRAWING NUMBER
BY MBP / CHECKED BY BEL	APPROVED BY / DATE 6/3/99

$$Z_{rs} = \frac{52 - \frac{9(18+1)}{2}}{\sqrt{\frac{81(18+1)}{12}}}$$

$$Z_{rs} = \frac{52 - 85.5}{\sqrt{128.25}}$$

$$Z_{rs} = \frac{-33.5}{11.32} = -2.959$$

$Z_{rs(CRITICAL)}\ \alpha = .20 = 0.845$

Since $Z_{rs} = -2.959 < 0.845 = Z_{rs(critical)}\alpha = .20$, we accept the null hypothesis that the site and background samples were obtained from the same statistical population.

APPENDIX F

DATA MANAGEMENT PLAN

APPENDIX F
DATA MANAGEMENT PLAN

1.0 PROJECT PLANNING

A large amount of environmental and physical data has been collected in support of the Installation Restoration (IR) program. TtNUS has the responsibility of managing this data in a basewide relational database and geographical information system GIS. The contents of the database shall be outlined in the Sitewide Data Catalog (which at a minimum, contains the data fields identified in Attachment F1 of this appendix). The Data Catalog shall outline what data is contained within the database (by investigation, media, etc.), the generator of the data (TtNUS, Corps of Engineers, etc.), and the level of quality of the data where applicable. It should be noted whether or not the analytical data were validated and to what level. It is the responsibility of the TtNUS data manager to coordinate with the NSWC Crane project team in order to keep the Data Catalog current and make available the most recent version to all team members. A copy of the Data Catalog shall be maintained in the project central file at the office of TtNUS. It is the responsibility of the all team members to ensure that the Data Catalog is correct and current and shall notify the TtNUS data manager of any newly generated data that will support the needs of the project.

Prior to every data collection event, the TOM shall call a kick-off meeting to outline the data needs of the task order and to review the data flow process (Attachment F2). Attendees of the kick-off meeting should include the TOM, the Human Health Risk Assessment (HHRA) lead, the ecological Risk Assessment (ERA) Lead, the Field Operations Leader (FOL), the project chemist, the data management lead and the Geographic Information System (GIS) lead. The data management lead shall distribute a copy of the database checklist (Attachment F3) and shall lead the project team through its contents. The database checklist will allow the project team to determine how the data will be managed and manipulated in order to achieve the project needs and objectives. A completed copy of the database checklist shall be maintained in the project central file and distributed to all members of the project team within seven days of the kick-off meeting.

2.0 NEWLY GENERATED DATA

Upon directive from SOUTHDIV to collect additional site data, the TOM shall coordinate with the designated data management lead and GIS lead for the project. It is the responsibility of the FOL to comply with the sample and location nomenclature outlined in the QAPP. It is also the responsibility of

the FOL to coordinate with the GIS lead to ensure that all survey technical specifications require the proper coordinate system, which is Indiana State Planar - North American Datum 1983 for the horizontal coordinates and National Geodetic Vertical Datum 1988 for the vertical coordinates.

Prior to field mobilization, the FOL shall coordinate with the Sample Management Coordinator (SMC) to initiate a sample tracking process. It is the responsibility of the TOM to ensure that a sampling tracking procedure is implemented. Sample Tracking Request Forms, a sample tracking database example, and example jar labels are included as Attachments F4, F5 and F6, respectively. In the event that a field change has taken place, the FOL is required to complete the Field Task Modification Request (FTMR) that will be forwarded to all members of the project team.

According to all laboratory technical specifications for NSWC Crane, the analytical laboratories will be contractually required to deliver the analytical data in NSWC Crane standard Electronic Data Deliverable (EDD) format (Attachment F7). Particular attention should be paid to the EDD requirements for validated vs. non-valididated data. Once all samples and analyses have been accounted for, the SMC shall forward the analytical data to TtNUS for incorporation into the NSWC Crane database which is located on the Local Area Network (LAN) in Pittsburgh, PA. The NSWC Crane database structure is presented in Attachment F8.

3.0 HISTORICAL DATA

In the event that the NSWC Crane project team decides that existing hardcopy data not outlined in the Data Catalog (Attachment F1) needs to be incorporated into the project database, SOUTHDIV shall provide directive to the appropriate consultant to incorporate the data into the project database. The data management lead shall review the hardcopy data and prepare a summary of the samples and analyses that need to be entered. The format of the summary table should be similar to the sample tracking database provided in Attachment F5. It is the responsibility of the TOM to review the sample summary table and verify that the entry of this data will satisfy the project requirements. The data management lead shall physically edit the hardcopy analytical data to clearly designate which information on the hardcopy needs to be entered into the database. Copies of the marked-up data must be distributed to two separate parties for entry into an Excel spreadsheet. Upon completion of the dual-key entry, the data management lead shall electronically compare the two data files to identify discrepancies and correct the data appropriately. The database should then be queried against the sample summary table to ensure that all pertinent data has been entered and checked for accuracy.

The data management lead shall coordinate with the GIS lead to acquire the sample location data (Attachment F8) for those samples that need to be entered. Sample location maps should be used to digitize the sample locations using the base mapping layer in the GIS. To the extent possible, the GIS lead shall capture, as metadata, the accuracy of the sample location maps used to digitize the location coordinates. If no sample location maps or other positional information exist for the historical data, the project team should evaluate the utility of this data in the NSWC Crane database.

4.0 MAPPING AND GRAPHICS

CADD mapping is generally provided by the activity. We currently do not use metadata to track changes to the mapping. In addition, Tri-Service Spatial Data Standards (TSSDS) are not utilized unless the mapping from the base already incorporates them. TSSDS is not used in the final GIS, based on the view that limited utility is gained from the substantial time required to incorporate the standards.

In addition to CADD mapping, Digital Ortho Quarter (DOQ) Quads, Aerial Photography, and USGS 7.5 minute Quads are obtained. The Quads are obtained from either the USGS or other suppliers, while the aerial photography is provided by the activity. As necessary, the images are warped to the predetermined coordinate system using Microstation. Again, metadata are not used to track the changes. From survey data, sampling locations are organized, and then a sample-vs-location table is built so that the data can be loaded into the sample_data.dbf table (Attachment F8).

5.0 THE ENVIRONMENTAL GEOGRAPHIC INFORMATION SYSTEM (EGIS)

All environmental data collected in support of the NSWC Crane project shall be incorporated into the GIS. The themes, layers and database information contained in the GIS is outlined in the Data Catalog (Attachment F1). The NSWC Crane GIS shall be made available to all members of the project team. CD-ROM EGIS deliverables shall be made available upon request from SOUTHDIV.

6.0 ASSIMILATION OF DATA FROM OUTSIDE SOURCES

When environmental data is collected by a contractor other than TtNUS, it is the responsibility of the SOUTHDIV Remedial Project Manager (RPM) to notify the TtNUS TOM. The RPM should forward a scope of work directing TtNUS to coordinate with the contractor and incorporate their data into the basewide GIS. To the extent possible, the RPM should direct the Navy Contractor to supply the data to TtNUS in the format outlined in Attachment F8. Once TtNUS has incorporated the data into the GIS, a hardcopy report shall be sent to the contractor for verification that all pertinent data have been incorporated in a complete and accurate fashion.

7.0 SOFTWARE

TtNUS will standardize on the following software packages when managing and manipulating data for the NSWC Crane project:

- Data Management - Microsoft Visual FoxPro 6.0
- GIS - ArcView 3.1 (see Attachment F9 for instructions)
- Geostatistics (2-D Kriging) - Geosoft 3.1b
- 3-D Visualization - EVS Pro 3.0
- Ground Water Modeling - GMS
- Statistical Analysis - Statistica 5.1
- Terrain Analysis - TerraModel 9.4.1

8.0 STORAGE OF DATA

TtNUS utilizes Microsoft NT for Networks as its Information Management System (IMS). The NT IMS has a storage capacity of 6 Gigabytes and currently serves over 110 desktop computers. The NT IMS automatically backs-up the system on a daily basis, thereby disallowing more than one day of work being lost should the network crash or malfunction. The database management and GIS groups have been allocated distinct drives on the Local Area Network (LAN). All environmental data for the NSWC Crane Project shall be stored in the \\nusrpitbdc1\sdiv\NSWC_Crane subdirectory of this drive on the NT Server. All tables, queries, programs and reports shall be saved in the NSWC_Crane.pjx file in Microsoft Visual FoxPro. The NSWC Crane EGIS shall be stored in the \\nusrpitbdc1\gis\NSWC_Crane directory on the NT Server. All ArcView project files (*.apr) shall be documented in a text file called readme_project.txt. This text file shall also be stored in the \\nusrpitbdc1\gis\NSWC_Crane directory.

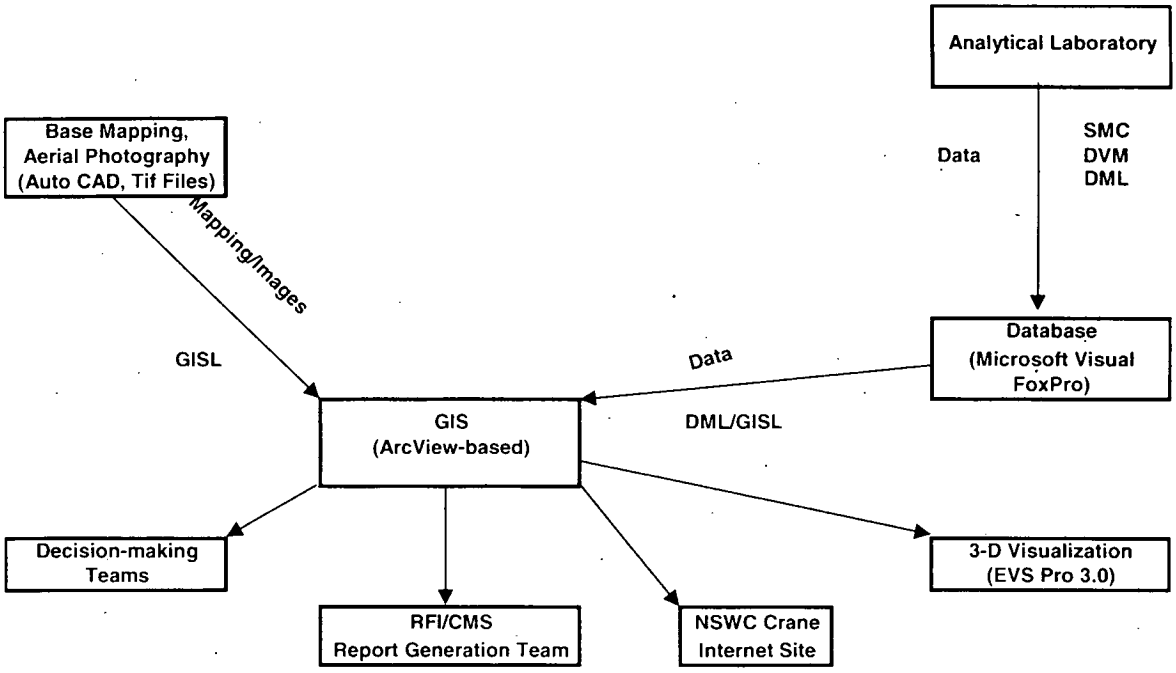
ATTACHMENT F1

DATA CATALOG
(Minimum Requirements)

Category	RFI Phase	Medium Sampled	Sample Type	No. of Samples	Fraction Analyzed

ATTACHMENT F2

THE DATA FLOW PROCESS



Notes:

SMC = Sample Management Coordinator
DVM = Data Validation Manager
DML = Data Management Leader
GISL = GIS Leader

ATTACHMENT F3

DATABASE CHECKLIST

DATABASE PLANNING CHECKLIST

PROJECT NAME _____ **PROJECT NUMBER** _____

PROJECT MANAGER _____ **PLANNING DATE** _____

1. Provide a general description of the project (regulatory authority, media to be sampled, approximate number of samples by media, analyses by media, data evaluation tasks required):

_____
_____
_____
_____
_____

2. Provide a general description of the sample nomenclature that will be used for samples collected by Tetra Tech NUS:

_____
_____
_____
_____

3. Will historical data be entered in the database? Yes No

4. Will historical data be used to define the nature and extent of contamination?
Yes No

5. Will historical data be used for risk assessment purposes?
Yes No

6. How much historical data exists (i.e., number of samples by matrix, analysis by matrix)?

_____
_____
_____
_____

7. In what format will the historical data be provided? Hardcopy Electronic

8. If historical data are in electronic form, what software was used and what is the format?

9. If historical data are in hardcopy form, will Form I's, summary tables, or reports be provided? Copies of historical data will be necessary to generate a budget estimate.

_____
_____
_____
_____

10. Will Quality Assurance review of historical data be necessary?
Yes No

11. If Quality Assurance review of historical data is necessary, describe the scope of the Quality Assurance review:

_____
_____
_____
_____

12. Will a GIS database be necessary for the project.
Yes No
If so, the GIS Group should be consulted for a budget estimate.

13. What nomenclature has been (will be) used to identify field duplicate samples?

_____
_____
_____
_____

14. Will field duplicate results be averaged and presented as one result in the database? Will they be presented as distinct results, or will both the average and the distinct results be presented?

_____
_____
_____
_____

15. How will the average value for duplicate samples be determined on a matrix-specific basis?

_____
_____
_____
_____

16. Are any unvalidated data to be included in the database? Yes No

17. Will unvalidated data be used for defining the nature and extent of contamination? Yes No

18. Will unvalidated data be used for risk assessment purposes? Yes No

19. Are any field screening (e.g., no-fixed base laboratory) data to be included in the database? Yes No

20. Will field screening data be used for defining the nature and extent of contamination? Yes No

21. Will field screening data be used for risk assessment purposes? Yes No

22. Will statistical correlation of laboratory and field screening data be necessary? Yes No

23. If a correlation exists between field screening and laboratory data, will the results of regression analysis be used to define nature and extent? Yes No

24. If a correlation exists between field screening and laboratory data, will the results of regression analysis be used to support the risk assessment? Yes No

25. Will fixed base laboratory field parameters be included in the database (e.g., pH, conductance, temperature)? Yes No

26. Will statistical correlations be necessary for TCLP versus total anlaysis data? Yes No

27. Will statistical correlations be necessary for filtered versus unfiltered samples? Yes No

28. Will any other statistical correlations be necessary? Yes No

29. Are there wells that have been screened in different aquifers? Yes No

30. Will data for various aquifers be segregated by depth? Yes No

31. Can the sample nomenclature system be used to identify wells in different aquifers? Yes No

32. Will samples from other matrices (soil, sediment, or surface water) be segregated by depth? Yes No

33. Can the sample nomenclature system be used to identify depth-specificity? Yes No

34. Have any removal actions been performed at the site? Yes No

If removal actions have been performed, plan and cross-sectional views reflecting the extent of the removal action must be provided.

35. Will any composite sample results be included in the database? Yes No

36. If composite samples are included, how will they be used for the nature and extent of contamination?

_____

_____

_____

37 If composite samples are included, how will they be used for the risk assessment?

_____

_____

_____

38. Will the site be segregated into Areas of Concern, Solid Waste Management Units, etc? Yes No

39. Is the sample nomenclature adequate for such segregation? Yes No

If the sample nomenclature is inadequate for assigning samples to an AOC or SWMU, the Project Manager or designee must provide a base map of tabular summary clearly delineating the relationship between each sample and each AOC/SWMU.

40. Were any temporal samples collected (e.g., quarterly sampling of wells)? Yes No

41. If temporal samples were collected, how will they be used to define the nature and extent of contamination?

42. If temporal samples were collected, how will they be used to support the risk assessment?

43. Are State, Federal, or Regional criteria to be included in data summary tables? Yes No

44. Identify the criteria that must be presented in the summary tables.

45. Will State, Federal, or Regional criteria be used to select COPCs? Yes No

46. Identify the criteria to be used as COPC selection tools.

47. Are filtered and unfiltered surface water samples differentiated? Yes No

48. If such samples are differentiated, how?

49. Which of these samples will be used for the human health risk assessment?
Surface Water Filtered Unfiltered
Groundwater Filtered Unfiltered

50. Which of these samples will be used for the ecological assessment?
Surface Water Filtered Unfiltered
Groundwater Filtered Unfiltered

51 Will background data be included in the database? Yes No

52. How are background samples identified?

53. Will background results be used to support selection of COPCs? Yes No

53. What statistical analyses will be required for the background data?

54. Will background data be segregated by depth? Yes No

55. What background matrices must be segregated by depth?

56. What format will be used for data presentation (e.g., appendices and summary tables, comprehensive text tables, tag maps, isoconcentration contours, etc.)?

ATTACHMENT F4

SAMPLE TRACKING REQUEST FORM

SAMPLE TRACKING AND DATA MANAGEMENT AT PROJECT INCEPTION

PROJECT START-UP CHECKLIST

ATTACHED IS A PROJECT START-UP CHECKLIST (CAN BE FOUND IN DATA MANAGEMENT CENTRAL FILE). WHENEVER A NEW PROJECT IS STARTED THE TOP PART SHOULD BE FILLED IN. A COPY SHOULD BE RETURNED TO THE DATA MANAGEMENT CENTRAL FILE, KEEP ORIGINAL FOR YOUR RECORDS TO KEEP TRACK OF WHAT HAS BEEN PROVIDED. IMSG WILL CHECK OFF WHEN ALL INFORMATION IS RECEIVED

FOLLOWING THIS PROCESS WILL IMPROVE THE FOLLOWING:

- TURN-AROUND TIME FOR DELIVERABLES NEEDED WHEN ALL RESULTS HAVE BEEN RECEIVED.
- CONFIDENCE THAT ALL SAMPLE RESULTS HAVE BEEN RECEIVED
- CONSISTENCY OF SAMPLE NOMENCLATURE
- CORRECTNESS OF SAMPLE ATTRIBUTES
- REVIEW OF INVOICES
- ENABLE IMSG PERSONNEL TO BETTER TRACK UPCOMING WORKLOAD

PROJECT START-UP CHECKLIST

INFORMATION NEEDED TO CREATE NEW DATABASE

PROJECT NAME:_____

CTO #:_____ JOB #:_____ ETS Code:_____

PROJECT MANAGER/CONTACT:_____

LABELS: Y / N DUE DATE:_____

VALIDATE: Y / N / L DUE DATE:_____

COMBINE WITH HISTORICAL DATA: Y/N

SAMPLE DATA CHECKLIST:

_____ SAMPLE NUMBERS AND ANALYSES (LOCATIONS,DEPTHS)

_____ SECTION OF WORK PLAN PERTAINING TO SAMPLE NOMENCLATURE

_____ LABORATORY/BOTTLE REQUIREMENTS

_____ LAB SPECS

_____ COC'S

_____ SAMPLE LOG SHEETS

_____ DUPLICATE ID'S / ORIGINALS

_____ SURVEY DATA / SAMPLE LOCATION MAPS

_____ BREAKDOWN OF PROJECT BY SITE / MATRIX FOR FUTURE PRINTOUTS

_____ TABLE HEADERS (SEE EXAMPLE)

TO BE COMPLETED BY IMSG:

_____ FINAL RESULTS GIVEN TO _____ (PM/IMSG)

DATE:_____

_____ SAMPLE DATA LOADED INTO NEW/EXISTING PROJECT DATABASE

_____ RESULTS LOADED INTO NEW/EXISTING PROJECT DATABASE

PATHNAME OF PROJECT DATABASE:_____

_____ DATA LOADED INTO GIS

ATTACHMENT F5

SAMPLE TRACKING DATABASE EXAMPLE

CTO 020 SDG U06972

Sdg	Sample Number	Lab id	Fraction	Sort	Lab Rec	Rec Date	Turn-time	Laboratory
F5717	H10MW0501	F5717-2	M	M	25-Jan-00	28-Feb-00	34	ACCUTEST, NJ
F5717	H10MW0501	F5717-2	MISC	CL	25-Jan-00	28-Feb-00	34	ACCUTEST, NJ
F5717	H10MW0501	F5717-2	MISC	NTA	25-Jan-00	28-Feb-00	34	ACCUTEST, NJ
F5717	H10MW0501	F5717-2	MISC	NTI	25-Jan-00	28-Feb-00	34	ACCUTEST, NJ
F5717	H10MW0501	F5717-2	MISC	SO4	25-Jan-00	28-Feb-00	34	ACCUTEST, NJ
F5717	H10MW0501	F5717-2	MISC	SUL	25-Jan-00	28-Feb-00	34	ACCUTEST, NJ
F5717	H10MW0501	F5717-2	OS	OS	03-Feb-00	28-Feb-00	25	ACCUTEST, NJ
F5717	H10MW0501	F5717-2	OV	ETHA	25-Jan-00	28-Feb-00	34	ACCUTEST, NJ
F5717	H10MW0501	F5717-2	OV	ETHE	25-Jan-00	28-Feb-00	34	ACCUTEST, NJ
F5717	H10MW0501	F5717-2	OV	METH	25-Jan-00	28-Feb-00	34	ACCUTEST, NJ
F5717	H10MW0501	F5717-2	OV	OV	25-Jan-00	28-Feb-00	34	ACCUTEST, NJ
F5717	H10MW0501	F5717-2	PAH	PAH	25-Jan-00	28-Feb-00	34	ACCUTEST, NJ

ATTACHMENT F6

EXAMPLE SAMPLE JAR LABELS

Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090		Project: CTO 038 Location: NSWC CRANE	
Sample No: BGSBP0401		Tag # : A0001	
Date: (1)	Time: (2)	Preserve:	
Analysis: TAL Metals + Tin		Matrix: SOIL	
Sampled By: (3)		Laboratory: LAUCKS	

Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090		Project: Location:	
Sample No:		Tag # :	
Date: (1)	Time: (2)	Preserve:	
Analysis:		Matrix:	
Sampled By:		Laboratory:	

Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090		Project: CTO 038 Location: NSWC CRANE	
Sample No: BGSBP0401		Tag # : A0001	
Date: (1)	Time: (2)	Preserve:	
Analysis: TAL Metals + Tin		Matrix: SOIL	
Sampled By: (3)		Laboratory: LAUCKS	

Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090		Project: Location:	
Sample No:		Tag # :	
Date: (1)	Time: (2)	Preserve:	
Analysis:		Matrix:	
Sampled By:		Laboratory:	

Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090		Project: CTO 038 Location: NSWC CRANE	
Sample No: BGSBP0401		Tag # : A0001	
Date: (1)	Time: (2)	Preserve:	
Analysis: TAL Metals + Tin		Matrix: SOIL	
Sampled By: (3)		Laboratory: LAUCKS	

Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090		Project: Location:	
Sample No:		Tag # :	
Date: (1)	Time: (2)	Preserve:	
Analysis:		Matrix:	
Sampled By:		Laboratory:	

Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090		Project: Location:	
Sample No:		Tag # :	
Date: (1)	Time: (2)	Preserve:	
Analysis:		Matrix:	
Sampled By: (3)		Laboratory:	

Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090		Project: Location:	
Sample No:		Tag # :	
Date: (1)	Time: (2)	Preserve:	
Analysis:		Matrix:	
Sampled By: (3)		Laboratory:	

ATTACHMENT F7

ELECTRONIC DATA DELIVERABLE REQUIREMENTS FOR ANALYTICAL LABORATORIES

ELECTRONIC DATA FORMAT REQUIREMENTS

1.0 INTRODUCTION

The laboratory is to provide 3.5" high density diskette(s) containing separate database (DBF) files in the format specified in this Attachment. The electronic deliverable includes all environmental samples, sample dilutions, sample reanalyses, and laboratory quality control samples. **All entries in the electronic deliverable must agree exactly with the final entries reported on the hardcopy data package sample result summaries.** Any corrections made to the hardcopy data must also be made to the electronic file. Appropriate qualifiers as identified by the analytical protocol must also be designated; laboratory QC non-compliance codes are not to be depicted.

Each diskette is to be properly labeled with the laboratory name, project name, file name(s), and laboratory point of contact. Electronic files should be delivered in the same fashion as are the hard copy data packages. A separate .dbf file shall be made for each analytical fraction (by method) and each sample delivery group (SDG). The files shall be named with the first character being the analytical fraction designator, followed by an underscore, followed by the SDG name. For example, the file for the volatile fraction for SDG BR001 should be named V_BR001.DBF. Additionally, the laboratory must provide a hardcopy listing all electronic files saved to the diskette, indicating what analytical fraction and matrix the file data contained therein pertain to. All electronic data deliverables are due within the same time established for the associated hardcopy data packages.

In addition, the laboratory QC officer must read and sign a copy of the Quality Assurance Review Form displayed on the next page of this Attachment. Electronic deliverables are not considered to be complete without the accompanying Quality Assurance Review Form.

I _____, as the designated Quality Assurance Officer, hereby attest that all electronic deliverables have been thoroughly reviewed and are in agreement with the associated hardcopy data. The enclosed electronic files have been reviewed for accuracy (including significant figures), completeness and format. The laboratory will be responsible for any labor time necessary to correct enclosed electronic deliverables that have been found to be in error. I can be reached at ( ) _____ if there are any questions or problems with the enclosed electronic deliverables.

Signature:_____ Title: _____ Date: _____

The analytical data shall be delivered electronically in a Dbase III file format (filename.dbf). The exact structure of the database is described in the table below. It shall be the responsibility of the laboratory to ensure that all electronic entries are in strict accordance with the information provided on the Form I.

An example database shall be sent for review prior to the first electronic deliverable in Dbase III format. The example file will be examined for completeness and comments will be sent to the laboratory. Any questions regarding the electronic deliverable shall be directed to Patrick Hooper at Tetra Tech NUS (412) 921-8250.

DATA FIELD	DATA TYPE	FIELD WIDTH	DATA FIELD DESCRIPTION
SAMPLE_NO	C	25	Field sample ID as listed on the chain-of-custody. The sample number indicated in this field should never be truncated. The only exception for this field not matching the chain-of-custody is for reanalyses and matrix spike results in which a RE or MS suffix will be added to the sample number respectively.
TRUNCATE	C	15	If the field sample ID listed on the Chain of Custody is truncated by the laboratory for use with the laboratory software, the truncated sample ID should appear in this field.
LAB_ID	C	15	Laboratory number for the given sample.
LABORATORY	C	25	Laboratory name.
BATCH_NO	C	10	Laboratory code for batch of samples included in a given run.
ASSOC_BLNK	C	15	Laboratory name of the method blank associated with that particular batch of samples.
QC_TYPE	C	15	Normal Environmental Sample = "NORMAL", Laboratory Duplicate = "DUPLICATE", Matrix Spike = "MS", Matrix Spike Duplicate = "MSD", Laboratory Control Sample = "LCS", Laboratory Control Sample Duplicate = "LCSD", Method Blank = "M_BLANK", Preparation Blank = "P_BLANK".
SAMP_DATE	D	8	Date of sample collection as indicated on the Chain of Custody. Example: 11/07/93.
REC_DATE	D	8	Date sample was received by the laboratory.
EXTR_DATE	D	8	Date sample was extracted or prepared by the laboratory.
ANAL_DATE	D	8	Date sample was analyzed by the laboratory.
RUN_NUMBER	N	2 (0)	The number of the analytical run for a given sample in sequence. For example, if a sample is diluted and reanalyzed, the original run number would be 1 and the reanalysis would be 2.
SDG	C	15	Sample delivery group identifier assigned by the laboratory. This number should exactly match the SDG designated on the hardcopy data package.

DATA FIELD	DATA TYPE	FIELD WIDTH	DATA FIELD DESCRIPTION
PROJECT_NO	C	10	Identification of Project Number or CLEAN Task Order (CTO) number.
PROJ_MNGR	C	25	The Tetra Tech NUS Project Manager's last name, followed by a comma, followed by the first initial of the Project Manager (e.g. Hutson, D).
PARAMETER	C	45	Chemical or analyte name exactly as reported on Form I.
CAS_NO	C	10	Chemical Abstract Service number for the parameter listed. The CAS number should be reported exactly as it is listed in publications such as the Merck Index. This field should be left blank for those parameters not having CAS numbers (e.g. Total Organic Carbon).
FRACTION	C	5	Metals = 'M', Volatiles = 'OV', Semivolatiles/BNAs = 'OS', Pesticides = 'PEST', Herbicides = 'HERB', Polychlorinated Biphenyls = 'PCB', Explosives = 'EXP', Any petroleum hydrocarbon or fuel = 'TPH', Wet Chemistry = 'WET', Radionuclide = 'RAD', Miscellaneous = 'MISC'
METHOD	C	20	Analytical method used to quantitate parameter concentrations as listed in the laboratory technical specification (e.g. '8270A' for SW-846 Method 8270A.
LAB_RESULT	N	20 (6)	Reported value in units specified in the UNITS field containing the proper number of significant digits. The % Recovery shall be placed in this field for matrix spike and laboratory control sample results.
UNITS	C	5	The units of measure as reported on the Form I.
LAB_QUAL	C	2	The laboratory qualifier as reported on the Form I. For example, a 'U' qualifier should be used for all nondetected results.
IDL	N	15 (6)	Instrument detection limit in units specified in the UNITS field.
MDL	N	15 (6)	Method detection limit in units specified in the UNITS field and method specified in the METHOD field.
CRDL_CRQL	N	15 (6)	Contract Required Detection/Quantitation Limit in the units specified in the UNITS field. RDL for non-CLP parameters.
DIL_FACTOR	N	6 (1)	Dilution factor.
PCT_MOIST	N	5 (1)	Percent moisture for soil samples; blank for water samples.
COMMENTS	C	20	Analytical result qualifier or comment other than that listed in the LAB_QUAL field. Example: 'Reanalysis'.

C = Character string (everything shall be reported in capital letters)
N = Numeric string (decimal places are in parentheses in field width column)
D = Date (Ex: 05/25/97)

ATTACHMENT F8

DATABASE STRUCTURE

DATA DICTIONARY

TETRA TECH NUS DATABASE STANDARDS

January, 1999

DRAFT

TABLE: well
PRIMARY KEY: location

Table Structure

FIELD	DESCRIPTION
location	Unique location name.
post_id	Location name as derived from original source document.
instal_date	Date the monitoring well was installed. Null for other location types.
loc_type	Type of location (e.g., soil boring, GW well, drive point, wipe)
Northing	Northing coordinate in horizontal datum referenced in the HORIZ_DATUM field.
Easting	Easting coordinate in horizontal datum referenced in the HORIZ_DATUM field.
horiz_datum	Datum in which the horizontal coordinates were derived.
grnd_surf	Ground surface elevation with reference to mean sea level in vertical datum referenced in the VERT_DATUM field.
vert_datum	Datum in which the vertical coordinates were derived.
datum_state	State for which datum was developed.
surveyed	Logical field denoting whether positional data were surveyed or digitized.
Surveyor	Company who performed the survey.
survey_date	Date in which survey was performed.
surv_method	Surveying method used.
longitude	Longitude.
latitude	Latitude.

Table Indexes

INDEX	TYPE
location	Primary
hd	Regular
vd	Regular
loc_type	Regular

Table Relations:
Relation 1
*RelatedChild loc_type
*RelatedTable loc_type_vvl
*RelatedTag loc_type
Relation 2
*RelatedChild cd
*RelatedTable coord_datum_vvl
*RelatedTag cd

TABLE: loc_type_vvl - Valid value list for LOC_TYPE field in the well table.
PRIMARY KEY: loc_type

Table Structure

FIELD	DESCRIPTION
loc_type	Location type
description	Description of location type

Table Indexes

INDEX	TYPE
loc_type	Primary

TABLE: coord_datum_vvl - Valid value list for HORIZ_DATUM field in the well table.
PRIMARY KEY: cd (coord_datum)

Table Structure

FIELD	DESCRIPTION
coord_datum	Datum in which coordinates reflect.

Table Indexes

INDEX	TYPE
cd (coord_datum)	Primary

TABLE: sample_data - Sample data table
PRIMARY KEY: nsample

Table Structure

FIELD	DESCRIPTION
location	Unique location name.
Matrix	Sample matrix.
nsample	Unique sample identification.
sample	Sample identification as designated on Chain-of-Custody.
sacode	Sample code for reference to field duplicates.
top_depth	Depth in feet to the top of the sample interval. Applicable for soil and sediment samples.
Bottom_depth	Depth in feet to the bottom of the sample interval. Applicable for soil and sediment samples. *Rule Expression*: if(bottom_depth>0,top_depth<=bottom_depth)
qc_type	Quality control type.
status	Status of sample location - Normal or excavated.
sample_date	Date in which sample was collected.
validated	Logical field denoting whether or not data validation was performed on sample.
coll_method	Sample collection method.
cto_proj	Clean task order (Navy) or project number in which the sample was collected (e.g., "129").
proj_manager	Internal project manager for which the data were originally generated (e.g. "Hutson, D.").

Table Indexes

INDEX	TYPE
location	Regular
nsample	Primary
sacode	Regular
matrix	Regular
status	Regular
qc_type	Regular
coll_meth	Regular

Table Relations:

Relation 1
*RelatedChild sacode
*RelatedTable sacode_vvl
*RelatedTag sacode

Relation 2
*RelatedChild qc_type
*RelatedTable qc_type_vvl
*RelatedTag qc_type

Relation 3
*RelatedChild matrix
*RelatedTable matrix_vvl
*RelatedTag matrix

Relation 4
*RelatedChild location
*RelatedTable well
*RelatedTag location

Relation 5
*RelatedChild coll_meth
*RelatedTable coll_method_vvl
*RelatedTag coll_meth

TABLE: sacode_vvl - Sample code valid value list for SACODE field in sample_data.dbf
PRIMARY KEY: sacode

Table Structure

FIELD	DESCRIPTION
sacode	Sample code designating whether sample is a normal environmental sample, a field duplicate, or the average of field duplicate pairs.
description	Description of sacode entry.

Table Indexes

INDEX	TYPE
sacode	Primary

TABLE: qc_type_vvl - Quality control valid value list for QC_TYPE field in sample_data.dbf
PRIMARY KEY: qc_type

Table Structure

FIELD	DESCRIPTION
qc_type	Quality control type.
description	Description of quality control type.

Table Indexes

INDEX	TYPE
qc_type	Primary

TABLE: matrix_vvl - Matrix valid value list for MATRIX field in sample_data.dbf
PRIMARY KEY: matrix

Table Structure

FIELD	DESCRIPTION
matrix	Sample matrix.
description	Description of sample matrix code.

Table Indexes

INDEX	TYPE
matrix	Primary

TABLE: well_completion
PRIMARY KEY: None

Table Structure

FIELD	DESCRIPTION
location	Unique location name.
top_casing	Elevation of top of well casing in vertical datum found in VERT_DATUM in the well table.
hole_diameter	Diameter of the drilled hole in inches. *Rule Expression*: hole_diameter>casing_id.AND.hole_diameter>casing_od
scr_aquifer	Aquifer name in which the screen resides.
screen_material	Type of material from which the screen is constructed.
scrn_slot_size	Screen slot size in thousandths of an inch.
scrn_top_depth	Depth below ground surface to the top of the screen (in feet).
scrn_bot_depth	Depth below ground surface to the bottom of the screen. *Rule Expression*: if(scrn_bot_depth>0,scrn_top_depth<scrn_bot_depth)
scrn_top_elev	Elevation the top of the screen in vertical datum found in VERT_DATUM in the well table.
scrn_bot_elev	Elevation the top of the screen in vertical datum found in VERT_DATUM in the well table. *Rule Expression*: if(scrn_bot_elev>0,scrn_top_depth>scrn_bot_depth)
drill_method	Drilling method for well installation.
contractor	Drilling contractor.
casing_material	Type of material in which the casing is constructed from.
depth_to_seal	Depth below ground surface to seal (in feet).
seal_material	Type of material in which the seal is constructed from.
fill_top_depth	Depth below ground surface to the top of fill material (in feet).
fill_bot_depth	Depth below ground surface to the bottom of fill material (in feet). *Rule Expression*: if(fill_bot_depth>0,fill_top_depth<scrn_bot_depth)
fill_material	Type of material used for fill.
comments	Geologist's comments

Table Indexes

INDEX	TYPE
location	Regular

Table Relations:
Relation 1
*RelatedChild location
*RelatedTable well
*RelatedTag location
TABLE: lithology
PRIMARY KEY: None

FIELD	DESCRIPTION
location	Unique location name.
top_lithology	Depth in feet below ground surface to the top of lithologic unit.
bottom_lithology	Depth in feet below ground surface to the bottom of lithologic unit.
uscs_code	Unified Soil Classification System for lithology type.
blow_counts	Number of blow counts recorded on boring log.
description	Geologist's description of lithology.
comments	Geologist's comments.

Table Indexes

INDEX	TYPE
location	Regular
uscs_code	Regular

Table Relations:
Relation 1
*RelatedChild location
*RelatedTable well
*RelatedTag location
Relation 2
*RelatedChild uscs_code
*RelatedTable lithology_vvl
*RelatedTag uscs_code

TABLE: lithology_vvl - Lithology valid value list for USCS_CODE field in lithology.dbf
PRIMARY KEY: uscs_code

Table Structure

FIELD	DESCRIPTION
uscs_code	Unified Soil Classification System for lithology type.
descript	Description of lithology for given USCS code.

Table Indexes

INDEX	TYPE
uscs_code	Primary

TABLE: coll_method_vvl - Collection method valid value list for COLL_METHOD field in sample_data.dbf
PRIMARY KEY: coll_meth

Table Structure

FIELD	DESCRIPTION
coll_method	Sample collection method

Table Indexes

INDEX	TYPE
coll_method	Primary

TABLE: cas_vvl - CAS number valid value list for CAS field in analytical results.dbf
PRIMARY KEY: cas

Table Structure

FIELD	DESCRIPTION
parameter	Parameter or chemical name
cas	Chemical Abstracts Service Number

Table Indexes

INDEX	TYPE
parameter	Regular
cas	Primary

TABLE: analytic_results
PRIMARY KEY: nfp (nsample+fraction+parameter)

Table Structure

FIELD	DESCRIPTION
nsample	Unique sample identification.
lab_id	Laboratory sample identification.
laboratory	Laboratory name.
batch_no	Analytical batch number.
assoc_blnk	Associated blank.
extr_date	Extraction date.
anal_date	Analysis date.
run_number	Sequential analytical run number.
sdg	Sample delivery group.
parameter	Parameter or chemical name (using IUPAC nomenclature where appropriate).
cas	Chemical Abstracts Service Number.
fraction	Analtytical fraction.
method	Analytical method.
lab_result	Analytical result as reported by the laboratory.
lab_qual	Qualifier as reported by the laboratory.
val_res	Final result (via validation or otherwise).
result	Final analytical result with the correct number of significant figures.
val_qual	Validation qualifer (null if data were not validated).
qual	Final qualifer (validation or otherwise).
qual_code	Validation flag used to define the quality control noncompliance.
units	Units of measure for the RESULT field.
idl	Instrument detection limit (same units as UNITS field).
mdl	Method detection limit (same units as UNITS field).
crdl_crql	Contract required detection/quantitation limit (same units as UNITS field).
dil_factor	Dilution factor.
pct_moist	Percent moisture.
comments	Comments from laboratory analyst.

Table Indexes

INDEX	TYPE
nfp	Primary
units	Regular
qual	Regular
fraction	Regular
parameter	Regular
nsample	Regular
cas	Regular

Table Relations:
Relation 1
*RelatedChild cas
*RelatedTable cas_vvl
*RelatedTag cas

Relation 2
*RelatedChild units
*RelatedTable units_vvl
*RelatedTag units
Relation 3
*RelatedChild qual
*RelatedTable qual_vvl
*RelatedTag qual
Relation 4
*RelatedChild fraction
*RelatedTable fraction_vvl
*RelatedTag fraction
Relation 5
*RelatedChild parameter
*RelatedTable para_vvl
*RelatedTag para
Relation 6
*RelatedChild nsample
*RelatedTable sample_data
*RelatedTag nsample

TABLE: units_vvl - Units valid value list for UNITS field in analytical_results.dbf
PRIMARY KEY: Units

Table Structure

FIELD	DESCRIPTION
units	Units of measure for chemical analysis
description	Description of units

Table Indexes

INDEX	TYPE
units	Primary

TABLE: qual_vvl
PRIMARY KEY: qual - Qualifier valid value list for QUAL field in analtyic_results.dbf

Table Structure

FIELD	DESCRIPTION
qual	Final QA qualifier
description	Definition of qualifier

Table Indexes

INDEX	TYPE
qual	Primary

TABLE: fraction_vvl - Analytical fraction valid value list for FRACTION field in analytic_results.dbf
PRIMARY KEY: fraction

Table Structure

FIELD	DESCRIPTION
fraction	Analytical fraction
description	Description of fraction

Table Indexes

INDEX	TYPE
fraction	Primary

TABLE: para_vvl
PRIMARY KEY: parameter

Table Structure

FIELD	DESCRIPTION
para	Parameter or chemical name
frac_name	Analytical fraction for given parameter

Table Indexes

INDEX	TYPE
para	Primary

TABLE: fluid
PRIMARY KEY: None

Table Structure

FIELD	DESCRIPTION
location	Unique location name
meas_elev	Measuring point elevation
dep_to_water	Depth below ground surface to water table (in feet)
dep_to_fp	Depth below ground surface to free product (in feet)
elev_water	Elevation of water level
elev_fp	Elevation of free product
prod_thick	Product thickness in feet
meas_date	Date measurement was taken.

Table Indexes

INDEX	TYPE
location	Regular

Table Relations:
Relation 1
*RelatedChild location
*RelatedTable well
*RelatedTag location

ATTACHMENT F9

ARCVIEW GIS STRUCTURE

ARCVIEW GIS STRUCTURE

The project ArcView GIS shall have the following directory structure and database table structure.

PART ONE: DIRECTORY STRUCTURE

The following table defines the directory structure and major file names/types located within each directory.

Main subdirectory	First tier subdirectories	Second tier subdirectories	Files/Types
p:\gis\project name\	database\		coordinate.dbf cross_reference.dbf res_ gw.dbf res_so.dbf res_sd.dbf res_sw.dbf well_completion.dbf
		criteria\	crit_ gw.dbf crit_so.dbf crit_ sd.dbf crit_sw.dbf crit_des.dbf
	mapping\	aerial\	registered aerial photos
		drg\	USGS Digital Raster Graphic
		image\	GeoStatistic Layers, pictures of sites, equipment, EVS, and all other raster files.
		dwg\	AutoCAD files
		dgn\	Microstation files
		shp\	samp_gw.shp .dbf .shx samp_so.shp .dbf .shx samp_sd.shp .dbf .shx samp_sw.shp .dbf .shx and all other AV shape files
	working\	database\	files used to generate specific drawings will be put under the working subdirectory in subdirectories similar to database & mapping. These will not be included in CD deliverable.
		mapping\	same as above

PART TWO: DATABASE TABLE STRUCTURE

The project ArcView GIS will contain separate database tables to store analytical, criteria, and coordinate information. The structure of these tables is presented below.

Analytical Data Table

The following table lists all the fields contained in the analytic database table.

FIELD	VISIBLE	ALIAS*	DESCRIPTION
site	Yes	Site or SWMU	Site or SWMU.
location	Yes	Location	Unique location name.
nsample	Yes	Sample	Unique sample identification.
sample	No		Sample identification as designated on Chain-of-Custody.
sample_date	Yes	Sample Date	Date on which sample was collected.
matrix	Yes	Matrix	Sample matrix.
sacode	Yes	Sample Code	Sample code for reference to field duplicates.
depth	Yes	Depth	Depth in feet to the middle of the sample interval. Applicable for soil and sediment samples.
top_depth	Yes	Top Depth	Depth in feet to the top of the sample interval. Applicable for soil and sediment samples.
bottom_depth	Yes	Bottom Depth	Depth in feet to the bottom of the sample interval. Applicable for soil and sediment samples. Rule Expression: if(bottom_depth>0,top_depth<=bottom_depth)
parameter	Yes	Parameter	Parameter or chemical name (using IUPAC nomenclature where appropriate).
cas	Yes	CAS	Chemical Abstracts Service Number.
fraction	Yes	Fraction	Analytical fraction.
val_res	Yes	Numeric Result	Final result (via validation or otherwise).
qual	Yes	Qualifier	Final qualifier (validation or otherwise).
units	Yes	Units	Units of measure for the RESULT field.
method	Yes	Method	Analytical method.
status	Yes	Status	Status of sample location – Normal or excavated.
validated	Yes	Validated	Logical field denoting whether or not data validation was performed on sample.
coll_method	Yes	Collection Method	Sample collection method (e.g., grab/composite).
cto_proj	Yes	CTO	Clean task order (Navy) or project number for which the sample was collected (e.g. "129").

FIELD	VISIBLE	ALIAS*	DESCRIPTION
proj_manager	Yes	Project Manager	Internal project manager for which the data was originally generated (e.g. "Hooper, P.").
lab_id	No	Laboratory ID	Laboratory sample identification.
laboratory	No	Laboratory	Laboratory name.
batch_no	No	Batch Number	Analytical batch number.
assoc_blnk	No	Associated Blank	Associated blank.
extr_date	No	Extraction Date	Extraction date.
anal_date	No	Analysis date	Analysis date.
run_number	No	Run Number	Sequential analytical run number.
sdg	No	SDG	Sample delivery group.
lab_result	No	Result	Analytical result as reported by the laboratory.
lab_qual	No	Lab Qualifier	Qualifier as reported by the laboratory.
result	No	String Result	Final analytical result with the correct number of significant figures.
val_qual	No	Validation Qualifier	Validation qualifier (null if data were not validated).
idl	No	Detection Limit	Instrument detection limit (same units as UNITS field).
mdl	No	Detection Units	Method detection limit (same units as UNITS field).
crdl_crql	No		Contract required detection/quantitation limit (same units as UNITS field).
dil_factor	No	Dilution factor	Dilution factor.
pct_moist	No	Percent moisture	Percent moisture.
ourresult	No		
qc_type	No		Quality control type.
comments	No	Comments	Comments from laboratory analyst.

*A blank indicates that no alias exists.

Criteria Table

Each medium will have a criteria table to specify the applicable criteria for all parameters.

FIELD	ALIAS	DESCRIPTION
parameter	Parameter	Parameter or chemical name (using IUPAC nomenclature where appropriate)
epa_mcl	None	Federal MCL – groundwater

Note: usually there will be many criteria fields. This example table only shows the "epa_mcl" criteria field.

Criteria Description Table

This table stores the definition or description of all standards and criteria used in the project. For example, epa_mcl's media would be GW, description would be "Federal Maximum Contaminant Level".

FIELD	Visible	DESCRIPTION
Field	Yes	
Media	Yes	
Descript	Yes	

Coordinate Table

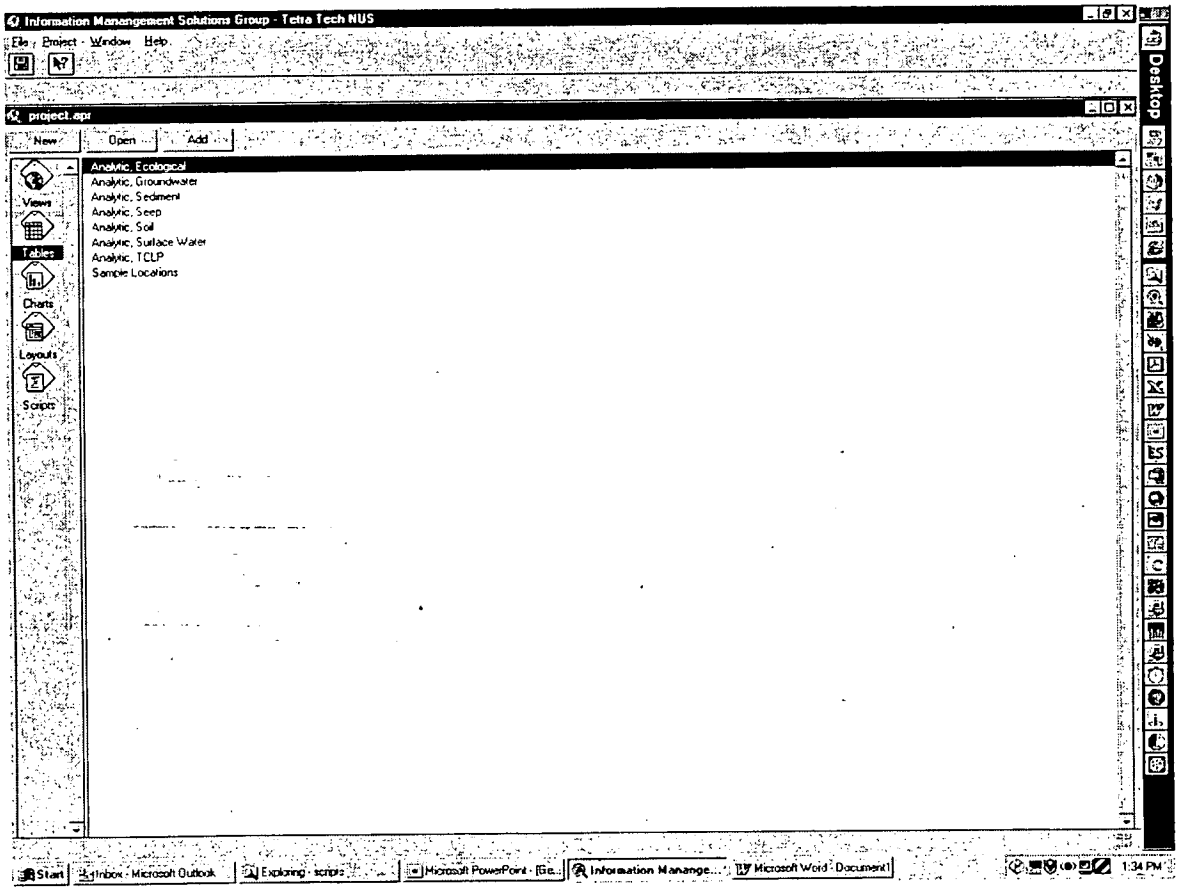
The coordinate table holds all the geographic position information of sampling locations

FIELD	Visible	ALIAS*	DESCRIPTION
location	Yes		Unique location name.
post_id	Yes	Location Designation	Location name as derived from original source document.
instal_date	No	Installation Date	Date the monitoring well was installed. Null for other location types.
loc_type	Yes	Location Type	Type of location. Example MW, HP, etc.
northing	Yes		Northing coordinate in horizontal datum referenced in the HORIZ_DATUM field.
easting	Yes		Easting coordinate in horizontal datum referenced in the HORIZ_DATUM field.
grnd_surf	Yes	Ground Surface Elevation	Ground surface elevation with reference to mean sea level in vertical datum referenced in the VERT_DATUM field
horiz_datum	Yes	Horizontal Datum	Datum in which the horizontal coordinates were derived.

FIELD	Visible	ALIAS*	DESCRIPTION
vert_datum	Yes	Vertical Datum	Datum in which the vertical coordinates were derived.
fatum_state	Yes	Coordinate System	State for which datum was developed.
durveyed	Yes		Logical field denoting whether positional data were surveyed or digitized.
durveyor	Yes		Company who performed the survey.
durvey_date	No	Survey Date	Date on which survey was performed.
durv_method	No	Survey Method	Surveying method used.
longitude	No		Longitude.
latitude	No		Latitude.
gw_code	Yes		This will be populated by database personnel. It will be used for event driven theme.
sd_code	Yes		This will be populated by database personnel. It will be used for event driven theme.
so_code	Yes		This will be populated by database personnel. It will be used for event driven theme.
sw_code	Yes		This will be populated by database personnel. It will be used for event driven theme.
_nullflags	No		Various fields are put in by database personnel starting here and followed by several fields. Make all of these invisible.

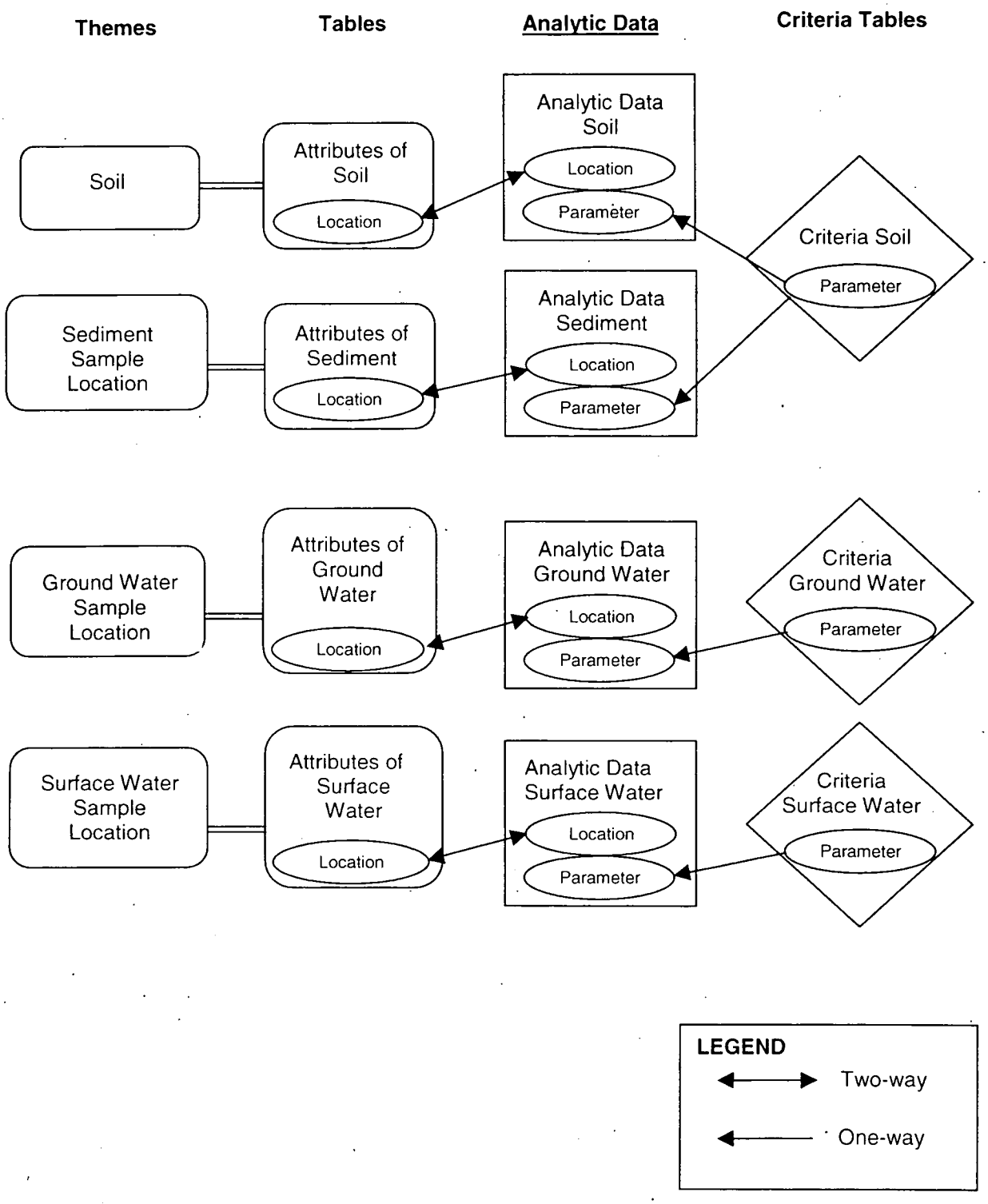
*A blank indicates that no alias exists.

TABLE LINKS



All sample location theme attribute tables are two-way linked to the corresponding analytical data table. In addition, the analytical data tables are joined to the criteria table. The following diagram illustrates the relationship.

Database Model:



APPENDIX G

FIELD AUDIT CHECKLIST

Location: NSWC Crane, Crane, Indiana

Project: NSWC Crane Ammunition Burning Ground Study Area, CTO 126

Date of Audit: _____

Instructions: Record answers to questions below, providing comments as required for clarification.

QA/QC Procedures

1. Were any field observations, deficiencies, non-conformances, or complaints recorded by the site QA/QC Officer or other personnel?
   If so, summarize below.

   _____
   _____
   _____
   _____
   _____

2. Based on personnel interviews, did any variances from the project planning documents occur? If so, what were they?

   _____
   _____
   _____
   _____

3. Were field modification records pertinent to the above initiated in an appropriate manner?

   _____

4. If applicable, were corrective action plans implemented (according to proper procedure) regarding Question 2?

   _____
   _____
   _____

5. Were field QC samples obtained with the frequency specified in the QAPP?

   _____

6. For this site, were field duplicates submitted "blind" to the laboratory?

7. For this site, are sufficient replicate aliquots of samples designated for the laboratory for the matrix spike/duplicate analyses specified in the QAPP?

Boring/Drilling

8. Is the drilling method specified in the QAPP being used?

9. In accordance with TtNUS policies and field SOPs, the FOL has the authority to change drilling methods if site conditions so dictate. Did any change in drilling methods from that cited in the project planning documents occur? If so, discuss.

10. If a change in drilling methods was required, did the FOL properly document the change and the rationale for the change?

11. Were any field changes initiated by the drilling subcontractor? If so, was the FOL notified and were the changes documented?

12. Was the air rotary rig outfitted with a filter on the compressed line?

_____
_____
_____
_____

13. Have all abandoned borings been backfilled as specified in the QAPP or applicable SOP?

_____
_____

14. When applicable, was the casing cleaned before sampling? (In most cases, an inch or two of cuttings may be left in the borehole with little or no problem. However, if more than a few inches for cuttings are encountered, the borehole must be recleaned prior to attempting sampling.)

water wash (disturbed samples above and below water table) _____
clean-out auger (undisturbed samples below water table) _____
dry method (undisturbed samples above water table) _____

15. Were any drilling lubricants used? If so, were the procedures cited in TtNUS SOP CTO126-12 observed?

_____
_____
_____

16. Were detailed boring logs maintained by the site geologist for each borehole? (Logging is not required if explicitly stated so in the associated FSAP.)

_____
_____
_____
_____

17. Was the following information complete on the borehole logs:
description of materials _____
description of samples _____
sampling method _____
blow counts _____
final location for drilling _____

Soil Sampling

18. Are the sampling devices and boring methods designated in the QAPP or applicable project-specific SOP being used?

_____
_____
_____
_____

19. Was the following information recorded in the boring logs or the field notebook?

For soil classification:

Was the USCS classification and soil type (clay, silt, sand) indicated?

_____

Were the following characteristics identified per the relevant TtNUS SOP CTO126-07 sections?

color _____
soil type _____
relative density and consistency _____
stratification _____
texture/fabric/bedding _____

20. For surface soil samples obtained by hand auger or scoop or trowel, were the following activities performed?

area cleared of loose debris prior to sampling _____
location marked with numbered stake or pin flag _____
sketch of approximate locations of sample points in site notebook _____

21. Were soil samples NOT collected from the top 6" soil interval? Yes/No

Groundwater Sampling

22. Were all monitoring wells properly developed, purged and recovered prior to sampling?

_____
_____

23. When applicable, were well volumes calculated as described in SOP CTO126-16?

_____

24. If a peristaltic pump was used to obtain Volatile Organic Compound (VOC) samples, was it verified that no degassing "bubbles" developed?

_____

25. If samples were acquired by a pump, was the pump lowered to midscreen (middle of open section of uncased wells) for sample acquisition?

_____

26. If samples were collected using bailers, were only bailers equipped with check balls used?

_____

27. For samples acquired by packer assembly, was the packer positioned just above the screen (or open section for uncased wells), prior to inflating?

_____

Surface Water and Sediment Sampling

28. In accordance with SOP 126-19, surface water samples will be taken downstream and will proceed upstream, was the above rule observed?

_____
_____

29. Per SOP CTO126-19; it is preferable to sample with the mouth facing upstream, was this practice observed?

_____
_____

30. Were the appropriate field parameters collected and recorded in accordance with SOP CTO 126-19?

_____
_____
_____
_____

Equipment Decontamination Procedures

31. Has an adequate, pre-determined area for steam cleaning of equipment been established?

_____

_____

32. Is the decontamination (decon) area lined and/or bermed?

_____

_____

33. Is sampling equipment decontaminated as required?

_____

_____

34. Was steam cleaning conducted:

prior to commencement of field activities? _____
between boring/pit locations? _____
at the end of field activities? _____

35. Verify that all sampling equipment not subject to steam cleaning (e.g., trowels, mixing bowls, etc.) are subjected to decontamination per the sequence outlined in the QAPP and project-specific SOP

_____

_____

Calibration and Use of Field Monitoring Equipment

36. Were the following calibration criteria observed:

calibration according to manufacturer's instructions _____
calibration only by qualified individuals _____
calibrated and operationally checked prior to project assignment _____
use of certified/traceable standards _____
calibration documented _____
if applicable, maintenance documented _____

37. For Photoionization Detectors (PIDs), is the proper eV Lamp (e.g., 9.5, 10.2, 11.7) installed?

_____
_____
_____
_____

38. Confirm that proper PID Start-up and Shut-down procedures are performed as required.

_____
_____
_____
_____

39. Has PID UV light source window cleaning been conducted as required?

_____

40. Has the PID ionization chamber been cleaned as required?

_____

41. Has the PID unit been recharged after every use?

_____
_____

Waste Handling Procedures

42. Were cuttings or fluids disposed of in accordance with the QAPP Section 4 requirements (i.e., discharged to ground, drummed, or tanked)?

_____

43. Do the project planning documents provide for the disposal of Personal Protective Equipment (PPE) by double-bagging and discard?

_____

44. By what method are PPE disposed of?

_____

45. If applicable, were used spill-containment materials containerized or otherwise acceptably disposed of?

_____

_____

Sample Handling

46. Are the appropriate containers provided by the laboratory being used for each sample?

_____

_____

_____

47. Has the temperature blank been handled properly and one submitted with each cooler of samples?

_____

_____

48. Have equipment rinsate blanks of the proper type and frequency been obtained?

_____

_____

49. Have source water blanks been obtained from water sources applicable to the field effort?

_____

_____

50. Have the rinsate and source water blanks been designated for the same analyses as the associated samples?

_____

_____

51. Has sample custody been maintained with regard to the following criteria:

A sample is under an individual's custody if:

- it is in the individual's actual possession
- it is in the individual's view after possession
- it was locked up to prevent tampering
- it was placed in a designated and identified secure area

(The sample remains in the individual's custody until it is entrusted to a laboratory courier or commercial express carrier.)

_____

_____

Documentation

52. Are all sample logs complete (i.e., containing all information stipulated in SOPs CTO126-6, -19, -21, and -22)?

_____

_____

53. Have chain-of-custody (COC) forms been filled out for all samples, including field quality control samples?

_____

_____

54. Have the COC forms been signed by the appropriate individual at each step that the samples are relinquished?

_____

_____

55. Have the COC forms been filled-out using black waterproof ink?

_____

_____

56. If the COC form or other field document was corrected, was a line drawn through the information and was the change dated and initialed? (Use of white-out or erasure is not permitted.)

_____

_____

57. Have the appropriate analyses (per the QAPP) been properly designated for each sample on the COC form?

58. Have all sample labels been filled out appropriately and completely?

59. Have sample tags been properly completed and attached securely to samples?

60. Have all sample labels been filled out using indelible ink?

61. Do the sample identifications agree between the sample log, field notebook, sample label and COC form?

62. When applicable, have the name of the photographer, date, time, site location, and site description been entered sequentially into the site logbook as documentational photographs of the sampling have been taken?

63. Has the following information (at a minimum) been recorded in the site logbook:

- arrival/departure of site visitors
- arrival/departure of equipment
- start/completion of sampling activities
- health and safety issues

64. Is the site logbook a hard paginated, controlled distribution record bound book?

65. As required by SOP CTO126-03, does the cover of the site logbook contain the following information?

project name _____
project number _____
book number _____
start date _____
end date _____

66. Do the site logbook entries summarize the contents of other site notebooks where applicable?

_____

67. Have all site logbook entries been made in indelible ink?

_____
_____

68. If a logbook entry was corrected, was a line drawn through the information and was the change dated and initialed? (Use of white-out or erasure is not permitted.)

_____
_____

69. Did the Field Operations Leader sign all logbook pages utilized that day at the end of each day?

_____
_____

Auditor Name:_____

Auditor Signature:_____

Date:_____

APPENDIX H

FIELD STANDARD OPERATING PROCEDURES

SOP TABLE OF CONTENTS

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CTO126-02	Sample Identification Nomenclature
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CTO126-04	Borehole Advancement and Soil Coring Using Direct Push Technology
CTO126-05	Monitoring Well Sampling
CTO126-06	Calibration and Use of Photoionization Detector
CTO126-07	Borehole and Soil Sample Logging
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CTO126-09	Inspection of Existing Monitoring Wells
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CTO126-13	Packer Testing of Uncased Boreholes
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CTO126-15	Management of Investigation Derived Waste
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CTO126-21	Estimating Flow in Small Streams
CTO126-22	Hydraulic Conductivity Testing

STANDARD OPERATING PROCEDURE
NUMBER CTO126-01

SAMPLE LABELING

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the procedures to be used for labeling and tagging sample containers. Sample labels and tags are used to document the sample ID, date, time, analysis to be performed, preservative, matrix, sampler, and the analytical laboratory. A sample label and a sample tag will be attached to each sample container. The label and tag for each container will contain identical information.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Writing utensil

Disposable medical-grade gloves (e.g. latex, nitrile)

Sample Logsheets

Required sample containers: All sample containers for analysis by fix-based laboratories will be supplied and deemed certified clean by the laboratory.

Preprinted Sample Labels and Sample Tags

Chain-of-Custody records

Sealable Polyethylene bags

Heavy-Duty Cooler

Ice

3.0 PROCEDURES

3.1 The following information will be printed on the labels and tags prior to field activities.

- Project number (CTO 126)
- Project Location (NSWC Crane)
- Sample ID
- Preservative

- Analysis to be performed
- Matrix type, and
- Laboratory name.

3.2 Preprinted sample labels and tags will be prepared prior to mobilizing to the field. Check to determine if:

- One sample label and tag exists for each sample container that is to be collected for all media during the field activities.
- The information printed on each tag and label are correct.
- Extra blank labels and tags are brought to the site in case additional environmental samples or QA samples are collected that are not anticipated in the QAPP. Additional blank labels and tags should also be brought to the site in case a sample container is broken or some of the preprinted labels or tags are accidentally lost before being attached to a container.

3.3 Once at the field site, sample containers should have labels affixed before sampling activities begin.

3.4 Select the labeled containers that are appropriate for a given sample and fill in the date, time, and sampler's initials just before sampling begins. Use a black waterproof marker or pen.

3.5 Fill the appropriate containers with sample material. Securely close the container lids without overtightening.

3.6 Write the same date, time, and sampler's initials on the sample tag as written on the label.

3.7 Place the sample container in a ziplock plastic bag and place in a cooler containing ice.

3.8 Fill in appropriate information on the Sample Collection Log form and the Chain-of-Custody form.

Example sample labels and tags are attached at the end of this SOP.

4.0 ATTACHMENTS

1. Sample Label and Tag

ATTACHMENT 1

SAMPLE LABEL AND TAG

Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090	**Project:** CTO 126 **Location:** NSWC CRANE	
Sample No: L-SW-01-01		
Date:	**Time:**	**Preserve:** 4° C / HNO3
Analysis: Appendix IX Metals		**Matrix:** SW
Sampled by:	**Laboratory:** LAUCKS	

Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090	**Project:** CTO 126 **Location:** NSWC CRANE	
Sample No: L-SW-01-01		
Date:	**Time:**	**Preserve:** 4° C / HNO3
Analysis: Appendix IX Metals		**Matrix:** SW
Sampled by:	**Laboratory:** LAUCKS	

STANDARD OPERATING PROCEDURE
NUMBER CTO126-02

SAMPLE IDENTIFICATION NOMENCLATURE

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to establish a consistent sample nomenclature system that will facilitate subsequent data management at the Naval Surface Warfare Center (NSWC). The sample nomenclature system has been devised such that the following objectives can be attained.

- Sorting of data by site, location or matrix
- Maintenance of consistency (field, laboratory, and database sample numbers)
- Accommodation of all project-specific requirements
- Accommodation of laboratory sample number length constraints
- Ease of identification and direct link to site and year

The NSWC Crane Environmental Protection Department must approve any deviations from this procedure.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Pen with indelible ink
Sample tags
Sample container labels

3.0 SAMPLE IDENTIFICATION NOMENCLATURE

3.1 Monitoring Samples

All monitoring samples collected at NSWC Crane will be properly labeled with a sample label affixed to the sample container and a tag tied around the neck of the sample container. Each sample will be assigned a unique sample tracking number. The sample tracking number will consist of a four or five segment alpha-numeric code that identifies the sample's associated solid waste management unit (SWMU) or associated

site, sample type, location, and, for aqueous samples where applicable, whether a sample is filtered, and/or the sample round number. For soil or sediment samples the final four tracking numbers will identify the depth at which the soil or sediment sample was collected.

The alpha-numeric coding to be used in the NSWC Crane sample system is explained in the diagram and the subsequent definitions:

NN	**AA**	**A or N** **2 to 5-Characters**	**NN and/or A** **Aqueous only**	**NNNN** **Soils and Sediment only**
SWMU or Site Number	Sample Type	Location	Round Identifier and/or Filtered	Depth Interval

Character Type:

A = Alpha
N = Numeric

SWMU or Site Number:

03 = Ammunition Burning Grounds including Jeep Trail and Little Sulphur Creek

Sample Type:

GW - Ground water Sample from a Permanent Monitoring Well
ID - Investigation Derived Waste Sample
SB - Soil Boring Sample
SD - Sediment Sample
SP - Seep Sample or Spring Sample
SS - Surface Soil Sample
SW - Surface Water Sample

Location:

The sample location code is the well number, soil sample location, sediment sample location or the stream sample location (i.e. surface water, springs, or seeps). The location code for each sample is listed on figures and tables in the site-specific Work Plan. Existing well numbers are used when unique. New wells will be designated by a SWMU or site number, followed by MW for permanent monitoring well, TW for temporary well, etc.; a "T" for Tetra Tech NUS; and numbered sequentially, by SWMU, beginning with zero one (MWT01).

Well clusters that are newly installed by TtNUS (two or more wells in close proximity) in the same investigative effort will be designated with the letter P followed by the number 2, 3, 4 etc. The number signifies the well depth in relation to other wells in that cluster. This two-digit code will follow the well identification. Using well T02 as an example, of a three well cluster, the well identification will be as follows:

T02	=	The deepest well in the cluster.
T02P2	=	Intermediate well
T02P3	=	Shallowest well in the cluster

Note: To keep the sample identification nomenclature to a minimum number of characters and to avoid redundancy, MW (monitoring well) is used for text, figures and tables and replaced with GW (groundwater) in the sample identification, example MWT01 would be GWT01.

Round Identifier and/or Filtered:

This code section will be used for aqueous samples only.

Round Identifier:

A two digit round identifier will be used to track the number of aqueous samples (GW, SW, SP) taken from a particular aqueous sample location. The first sample collected from a location will be assigned round identifier 01, the second 02, etc. This applies to both existing and proposed monitoring wells and surface water locations.

Filtered:

Water samples that are field filtered (dissolved analysis) will be identified with an "F" in the last code section. No entry in this segment signifies an unfiltered (total) sample.

Depth Interval, Soil and Sediment only:

The depth code is used to note the depth, below ground surface (bgs), at which a soil or sediment sample is collected. The first two numbers of the four number code specify the top interval and the third and fourth specify the bottom, feet bgs (soil) inches bgs (sediment) of the sample. The depths will be noted in whole numbers only, further detail if needed will be recorded on the sample log sheet, boring log, log book, etc.

Depth (for soils, in feet bgs)

0002 = soil collected from 0 to 2 feet bgs

0204 = soil collected from 2 to 4 feet bgs

0810 = soil collected from 8 to 10 feet bgs

Depth (for sediments, in inches bgs)

0006= sediment collected from 0 to 6 inches bgs

0612= sediment collected from 6 to 12 inches bgs

3.1.1 Examples of Sample Nomenclature

The first ground water sample collected from existing monitoring well 01 at the Ammunition Burning Grounds (SWMU 03) for a filtered sample would be designated as 03GW0101F.

The second ground water sample collected from existing monitoring well C20P2 at the Ammunition Burial Ground for an unfiltered sample would be designated as 03GWC20P202.

The first unfiltered ground water sample collected from new monitoring well MWT01 at the Ammunition Burning Ground would be designated as 03GWT0101.

The second surface water sample collected from point 01 in Little Sulphur Creek for an unfiltered sample would be designated as 03SW0102.

A surface soil sample collected from soil boring 03 at the Burn Pit at the 0 to 2 foot interval would be designated as 03SS030002.

A subsurface soil sample from the same soil boring 3 at an interval of 4 to 5 feet bgs would be designated as 03SB030405.

A sediment sample collected in Little Sulphur Creek from 0 to 6 inches at location 14 would be designated as 035SD03006.

3.2 Field Quality Assurance/Quality Control (QA/QC) Sample Nomenclature

Field QA/QC samples are described in the approved Field Sampling Plan and QAPP. They will be designated using a different coding system. The QC code will consist of a three to four segment alpha-

numeric code that identifies the sample QC type, the date the sample was collected, and the number of this type of QC sample collected on that date.

AA	NNNNNN	NN	F
QC Type	Date	Sequence Number (per day)	Filtered (aqueous only, if needed)

The QC types are identified as:

TB = Trip Blank
RB = Rinsate Blank (Equipment Blank)
FD = Field Duplicate
AB = Ambient Conditions Blank
SB = Source Water Blank

The sampling time recorded on the chain-of-custody form, labels, and tags for duplicate samples will be 0000 so that the samples are "blind" to the laboratory. Notes detailing the sample number, time, date, and type will be recorded on the sample log sheets and will document the location of the duplicate sample (sample log sheets are not provided to the laboratory).

3.2.2 Examples of Field QA/QC Sample Nomenclature

The first duplicate of the day for a filtered ground water sample collected on June 3, 2000 would be designated as FD06030001F.

The third duplicate of the day taken of a subsurface soil sample collected on November 17, 2003 would be designated as FD11170303.

The first Trip Blank associated with samples collected on October 12, 2000 would be designated as TB10120001.

The only Rinsate Blank collected on November 17, 2001 would be designated as RB11170101.

STANDARD OPERATING PROCEDURE
NUMBER CTO126-03

SAMPLE CUSTODY AND DOCUMENTATION OF FIELD ACTIVITIES

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedures for sample custody and documentation of field sampling and field analyses activities.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following logbooks, forms, and labels, are required.

Site Logbook
Field Logbook
Sample label
Chain-of-Custody form
Custody seals
Equipment Calibration Log
Monitoring Well Inspection Form
Water Level Measurement Form
Low-Flow Purge Data Sheet
Ground Water Sample Log Sheet
Surface Water Sample Log Sheet

3.0 PROCEDURES

This section describes custody and documentation procedures. All entries made into the logbooks, custody documents, logs, and log sheets described in this SOP must be made in indelible ink (black is preferred). No erasures are permitted. If an incorrect entry is made, the entry shall be crossed out with a single strike mark, initialed, and dated.

3.1 Site Logbook

The site logbook is a hardbound, paginated, controlled-distribution record book in which all major on-site activities are documented. At a minimum, the following activities/events shall be recorded (daily) in the site logbook:

- All field personnel present
- Arrival/departure of site visitors
- Arrival/departure of equipment
- Start or completion of sampling activities
- Daily on-site activities performed each day
- Sample pickup information
- Health and safety issues
- Weather conditions

The site logbook is initiated at the start of the first on-site activity (e.g., site visit or initial reconnaissance survey). Entries are to be made for every day that on-site activities take place.

The following information must be recorded on the cover of each site logbook:

- Project name
- Project number
- Book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). At the completion of each day's entries, the site logbook must be signed and dated by the Field Operations Leader (FOL).

3.2 Field Logbooks

The Field Logbook is a separate dedicated notebook used by field personnel to document his or her activities in the field. This notebook is hardbound and paginated.

3.3 Sample Labels

Adhesive sample container labels must be completed and applied to every sample container. Information on the label includes the project name, location, sample number, date, time, preservative, analysis, matrix, sampler's initials, and the name of the laboratory performing the analysis.

3.4 Chain-of-Custody Form

The Chain-of-Custody form (COC) is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as it is transferred from person to person. Each COC is numbered. This form must accompany any samples collected for laboratory chemical analysis. A copy of a blank chain-of-custody form is attached at the end of this SOP.

The FOL must include the name of the laboratory in the "Remarks" section to ensure that the samples are forwarded to the correct location. If more than one COC is necessary for any cooler, the FOL will indicate "Page __ of __" on each COC. The original (top) signed copy of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. Once the samples are received at the laboratory, the sample custodian checks the contents of the cooler(s) against the enclosed COC(s). Any problems are noted on the enclosed COC form (bottle breakage, discrepancies between the sample labels, COC form, etc.) and will be resolved through communication between the laboratory point-of-contact and the Task Order Manager (TOM). The COC form is signed and retained by the laboratory and becomes part of the sample's corresponding analytical data package.

3.5 Custody Seal

The Custody Seal is an adhesive-backed label with a number on each seal. It is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transit to the laboratory. The Custody Seals are signed and dated by the samplers and affixed across the opening edges of each cooler (two seals per cooler) containing environmental samples. The laboratory sample custodian will examine the Custody Seal for evidence of tampering and will notify the TOM if evidence of tampering is observed.

3.6 Equipment Calibration Log

The Equipment Calibration Log is used to document calibration of measuring equipment (e.g., multi-parameter water-quality meter) used in the field. The Equipment Calibration Log documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. An Equipment Calibration Log must be maintained for each electronic measuring device requiring calibration. Entries must be made for each day the equipment is used.

3.7 Monitoring Well Inspection Form

The Monitoring Well Inspection Form is used to document the inspection of existing monitoring wells in accordance with SOP CTO126-09.

3.8 Water-Level Measurement Form

The Water Level Measurement Form is used to document the determination of water levels in monitoring wells in accordance with SOP CTO126-18.

3.9 Low-Flow Purge Data Sheet

The Low-Flow Purge Data Sheet is used to document field measurements made while purging wells to stabilization.ccordance with SOP CTO126-16.

3.10 Ground Water Sample Log Sheet

The Ground Water Sample Log Sheet is used to document the samples taken from a monitoring well at the end of low-flow well purging. This sheet is used in conjunction with SOP CTO126-05.

3.11 Surface Water Sample Log Sheet

The Surface Water Sample Log Sheet is used to document the samples collected from surface waters. This sheet is used in conjunction with SOP CTO126-19.

3.12 Soil and Sediment Sample Log Sheet

The Soil and Sediment Sample Log Sheets are used to document the sampling of soils and sediments. This sheet is used in conjunction with SOP CTO126-08 and SOP CTO126-20.

4.0 ATTACHMENTS

1. Chain-of-Custody Record

ATTACHMENT 1
CHAIN-OF-CUSTODY RECORD

TETRA TECH NUS, INC. CHAIN OF CUSTODY | NUMBER | PAGE ____ OF _____

PROJECT NO:	SITE NAME:	PROJECT MANAGER AND PHONE NUMBER	LABORATORY NAME AND CONTACT:
SAMPLERS (SIGNATURE)		FIELD OPERATIONS LEADER AND PHONE NUMBER	ADDRESS
		CARRIER/WAYBILL NUMBER	CITY, STATE

STANDARD TAT ☐
RUSH TAT ☐
☐ 24 hr. ☐ 48 hr. ☐ 72 hr. ☐ 7 day ☐ 14 day

CONTAINER TYPE PLASTIC (P) or GLASS (G)
PRESERVATIVE USED
TYPE OF ANALYSIS

DATE YEAR	TIME	SAMPLE ID	MATRIX	GRAB (G) COMP (C)	No. OF CONTAINERS									COMMENTS

1. RELINQUISHED BY	DATE	TIME	1. RECEIVED BY	DATE	TIME
2. RELINQUISHED BY	DATE	TIME	2. RECEIVED BY	DATE	TIME
3. RELINQUISHED BY	DATE	TIME	3. RECEIVED BY	DATE	TIME

COMMENTS

DISTRIBUTION: WHITE (ACCOMPANIES SAMPLE) YELLOW (FIELD COPY) PINK (FILE COPY)

3/99
FORM NO. TINUS-001

STANDARD OPERATING PROCEDURE
NUMBER CTO126-04

BOREHOLE ADVANCEMENT AND SOIL CORING USING DIRECT PUSH TECHNOLOGY

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the procedures for collecting surface and subsurface soil cores from unconsolidated overburden materials using direct push technology (DPT) for the Jeep Trail at the NSWC Crane facility. For this investigation, a Geoprobe® rig with a Macrocore Sampler will be the type of DPT used.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Cut-resistant Non-latex Impermeable Gloves
Cotton Gloves
Disposable medical-grade gloves (e.g., latex, nitrile)
Writing Utensil
Boring Log Sheets: A copy of this form is included in SOPCTO126-07
Photoionization Detector (PID) (see SOP CTO 126-06)
Geoprobe® or Equivalent DPT Equipment
Geoprobe® Macrocore Sampler or Equivalent
Geoprobe® Sampling Kit or Equivalent
Clear Acetate Liners: one new liner for each soil core
Required Decontamination Materials (see SOP CTO126-17)
Bentonite Pellets

3.0 BOREHOLE ADVANCEMENT AND SOIL SAMPLING USING A GEOPROBE®

Direct Push Technology (DPT) will be employed to collect soil cores. DPT refers to sampling tools and sensors that are driven directly into the ground without the use of conventional rotary drilling equipment. DPT typically utilizes hydraulic pressure and/or percussion hammers to advance the sampling tools. Geoprobe® is a manufacturer of a hydraulically-powered, percussion/probing machine utilizing DPT to

collect subsurface environmental samples. This type of rig with a Macrocore Sampler will be used at the ABG and Jeep Trail to collect soil cores.

3.1 Clear the area to be sampled of any surface debris (herbaceous vegetation, twigs, rocks, litter, etc.).

3.2 Place a new clear acetate liner in the detachable Macrocore core barrel and attach coring device to the Geoprobe® rig.

3.3 Drive macrocore sampler (lined with acetate) into the ground to a depth of 2 feet using hydraulic pressure. The 0 –2 foot depth soil interval is considered to be the surface soil.

3.4 Retract the sampler from the borehole and remove the acetate liner and the soil core from the Macrocore barrel.

3.5 Attach the metal trough from the Geoprobe® Sampling Kit firmly to the tail gate of a vehicle. If a vehicle with a tailgate is not available, secure the trough on another suitable surface.

3.6 Place the acetate liner containing the soil core in the trough.

3.7 While wearing cut-resistant gloves (constructed of non-latex over cotton), cut the acetate liner through its entire length using the double-bladed knife that accompanies the Geoprobe® Sampling Kit. Then remove the strip of acetate from the trough to gain access to the collected soils. CAUTION: Do not attempt to cut the acetate liner while holding it in your hand.

3.8 Scan the entire length of the soil core for VOCs using the PID. Record the specific depth interval and the associated PID reading on the Boring Log Sheet. Collect a soil VOC sample using Encore samplers from the soil interval that had the highest PID reading. If no above-background PID readings were detected, collect the VOC sample from an interval that is discolored or displays other visual signs of being contaminated. If no visual sign of contamination is evident, collect the soil VOC sample from the center of the core interval (i.e., one foot depth). Details for collecting a VOC sample using the Encore sampler are included in SOP CTO126-08.

3.9 Log the soil core on the Boring Log Sheet (see SOP CTO126-07).

3.10 Place the soil core in a stainless steel mixing bowl, homogenize, and collect the remainder of the soil sample aliquots, as described in SOP CTO 126-8.

3.11 Repeat steps 3.2 through 3.11 for the next depth intervals.

3.12 The depth to bedrock should be recorded on the Boring Log and the estimated moisture content of the soil and the presence or absence of water in the boring should be noted.

3.13 If readings from the PID are all at background levels below field screening criteria, then excess soil core materials shall be returned to the hole and tamped. If insufficient soil is available to fill the hole to the ground surface, then bentonite pellets mixed with the soil shall be used to backfill the hole.

3.14 If screening instruments indicate that contaminants may be present in the soil materials, then all excess soil core materials will be placed in a plastic bag (or drum if larger quantities). The bag will be tagged identifying the location and depths from where the soils came from and the date. The bag will then be placed in a 55-gallon drum and stored onsite until laboratory analyses of the soil are completed and classification of the soil waste materials can be determined (see SOP CTO126-15).

3.15 If soil materials from the boring are suspected of being contaminated (see 3.14 above), the soil boring will be backfilled with bentonite pellets up to the ground surface.

3.16 Decontaminate all soil sampling equipment in accordance with SOP CTO126-17 prior to collecting the next sample.

STANDARD OPERATING PROCEDURE
NUMBER CTO126-05

MONITORING WELL SAMPLING

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedure for monitoring well sampling. Low-flow sampling techniques will be used for ground water sampling at the Jeep Trail at the NSWC Crane facility.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following field forms and equipment are required for low-flow sampling of monitoring wells:

Ground Water Sample Log Form: A copy of this form is attached at the end of this SOP

Bound Field Log Book

Chain-of-Custody Form

Bladder Pump

Surgical Gloves

Labeled sample containers: Sample containers are certified clean by the laboratory supplying the sample containers.

Tag for each sample container

Plastic storage bags

Shipping containers with ice

3.0 MONITORING WELL SAMPLING PROCEDURES

3.1 Ground water sampling may be initiated when the monitoring well has been purged and stabilized in accordance with SOP CTO126-16.

3.2 Record the sample start time (using military time) on the Ground Water Sample Log Sheet. Record the field measurements for pH, ORP, specific conductance, temperature, dissolved oxygen, and turbidity.

3.3 With the pump continuing to run, disconnect the flow-through cell from the pump discharge tube and immediately start filling sample bottles directly from the pump discharge. All sample containers will be supplied by the laboratory, and the laboratory will pre-preserve all sample containers, where appropriate.

3.4 Allow the pump discharge to flow gently down the inside of the container with minimal turbulence when filling sample containers. Avoid immersing the discharge tube into the sample as the sample container is being filled. Sample containers for volatile constituents (VOCs) must be completely filled so that no headspace exists in the container. The VOC vials shall be filled to the top so that a convex meniscus is formed. Gently secure the cap, turn the vial upside down, and check to see if any air has been trapped inside the vial. If so, open the cap, reform the meniscus, and attempt again to secure the lid without trapping air in the sample. All other sample containers can have air space included when the container lid is secured.

3.5 Cap each container immediately after filling.

3.6 Record the sample time on the Ground Water Sample Log Form, the sample tag, and on the sample label.

3.7 Secure the associated tag to each sample container.

3.8 Place the tagged sample container into a plastic storage bag and then into a cooler containing ice.

3.9 Enter the proper information on the Chain-of-Custody form for each sample container (see SOP CTO126-03).

3.10 Repeat steps 3.3 through 3.9 for each sample container collected.

3.11 The pump rate should not be adjusted after sampling has commenced. If it becomes necessary to adjust the pump rate, document the change on the Ground Water Sample Log Form.

3.12 All samples will be collected into pre-preserved bottles (if required) supplied by an approved laboratory. Table 4-13 of the QAPP includes information on preservation requirements. All samples will be collected in the following sequence (where applicable):

- Volatile organic compounds (VOCs)
- Other organics
- Appendix IX Metals plus Sn (totals)
- Nitrate
- Nitrite

3.13 If the last turbidity measurement prior to the commencement of sampling showed turbidity to be greater than 10 Nephelometric Turbidity Units (NTUs), then filtered aliquots of ground water will be collected and analyzed for dissolved metals. Without turning off the pump, attach a disposable, inline, 0.45-um filter cartridge at the end of the discharge tube. Fill sample containers marked for "dissolved metals" so that the laboratory knows that these aliquots are distinct sample fractions and that the results should be reported as dissolved analytes.

3.14 Repeat steps 3.5 through 3.9 for the filtered sample containers.

3.15 After completion of sample collection, remove the bladder pump from well and decontaminate following the procedures in SOP CTO126-17.

3.16 Replace the outer protective well cap and lock the well.

3.17 All equipment should be cleaned and packed into the sample vehicle, along with the sample cooler for transport. Disposable gloves and other equipment should be placed in a plastic trash bag and handled as investigation derived waste (SOP CTO126-15).

4.0 ATTACHMENTS

1. Ground Water Sample Log Sheet

ATTACHMENT 1

GROUND WATER SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[] Domestic Well Data
[] Monitoring Well Data
[] Other Well Type: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____
Type of Sample:
[] Low Concentration
[] High Concentration

SAMPLING DATA:

Date:	Color	pH	S.C.	Temp.	Turbidity	DO	TBD	TBD
Time:	Visual	Standard	mS/cm	°C	NTU	mg/l		
Method:								

PURGE DATA:

Date:	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Method:								
Monitor Reading (ppm):								
Well Casing Diameter & Material								
Type:								
Total Well Depth (TD):								
Static Water Level (WL):								
One Casing Volume(gal/L):								
Start Purge (hrs):								
End Purge (hrs):								
Total Purge Time (min):								
Total Vol. Purged (gal/L):								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

Circle if Applicable:		Signature(s):
MS/MSD	Duplicate ID No.:	

TBD: To Be Determined

STANDARD OPERATING PROCEDURE
NUMBER CTO126-06

CALIBRATION AND USE OF PHOTOIONIZATION DETECTOR

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes procedures for the maintenance, calibration, and use of a photoionization detector (PID). The Photovac 2020 Photoionization Air Monitor will be used during the Ammunition Burning Ground, Little Sulphur Creek and Jeep Trail investigation. The procedures for its use are discussed in detail in the following sections.

2.0 GLOSSARY

Electron-volt (eV) - A unit of energy equal to the energy acquired by an electron when it passes through a potential difference of 1 volt in a vacuum.

Intrinsically Safe (I.S.) - Based on wiring, configuration, design, operation, gasketing, construction, this instrument may be employed within locations where flammable gases and/or vapors may exist.

Ionization Potential (I.P.) - The energy required to remove an electron from a molecule yielding a positively charged ion and a negatively charged free electron. The instrument measures this energy level.

Photoionization Detector (PID) - Photoionization detector is employed as the general reference to air monitors of this type. PID's detection method employs ultraviolet (UV) radiation as an energy source. As air and contaminants are drawn through the ionization chamber the UV light source causes the contaminant with ionization potentials equal to or less than the UV source to break into positive and negatively charge ions. The created ions are subjected to an electrostatic field. The voltage difference is measured in proportion to the calibration reference and the concentration of the contaminant.

Ultraviolet Radiation (UV) Lamp - Ultraviolet radiation is the energy source employed by the instrument to ionize collected sample gas streams. The UV lamp source is required to be equal to or greater than the ionization potential of the substance drawn through the instrument in order to create separate ionized species.

3.0 REQUIRED EQUIPMENT

Pen

Equipment Calibration Form

Photoionization Detector

Isobutylene Calibration Gas (i.e., span gas)

Regulator

4.0 PROCEDURES

4.1 Principle of Operation

The Photovac portable photoionizer detects many organic (and a few inorganic) species. The basis for detection of this instrument is the ionization of components in gaseous streams. The incoming gas molecules are subjected to ultraviolet (UV) radiation, which is energetic enough to ionize many compounds associated with industrial activities. Molecules are transformed into charged-ion pairs, creating a current between two electrodes. Each molecule has a characteristic ionization potential, which is the energy required to remove an electron from the molecule, yielding a positively charged ion and a free electron. The instrument measures this energy level.

This instrument measures the concentration of airborne photoionizable gases and vapors and automatically displays and records these concentrations. It does not distinguish between individual substances. Readings displayed represent the total concentration of all photoionizable chemicals present in the sample. This instrument is factory-set to display concentration in units of ppm or mg/m^3. The meter display updates itself once per second.

The 2020 also performs short-term exposure limit (STEL), time-weighted average (TWA) and PEAK calculations. You can view any of these results, but only one mode may be viewed at a time.

The 2020 has 6 keys for alphanumeric entry and for accessing multiple functions. The keys are used to set up and calibrate 2020. They allow you to manipulate the concentration data in various ways.

All information entered with the keys and stored in the 2020's memory is retained when the instrument is switched off. The clock and calendar continue to operate and do not need to be set each time the 2020 is turned on.

4.1.1 Displays

The 2020 has a meter display for reporting detected concentration and a display used for status/ information to guide you through configuration options. All functions of the 2020 will be controlled or reported using one of these displays.

4.1.1.1 Meter Display

The meter display is 4-digits. It will always be used for reporting detected concentration. When the detector and pump are off, the meter display will be blank.

In order to accommodate the range of concentrations the 2020 can detect, the meter reading will be reported using one of 2 resolutions. A resolution of 0.1 will be used for concentrations below 100 ppm, and a resolution of 1 will be used for concentrations above 100 ppm.

4.1.1.2 Status Display

The status display is a 2 line by 16-character display. The top line is used to display status/information and prompts you for your inputs. The bottom line is used for soft key names. Up to 3 names can be displayed for the 3 soft keys. If a name does not appear for a soft key, then the soft key has no associated function.

4.1.2 Keys

4.1.2.1 Fixed Keys

The three round keys below the soft keys each have a fixed function. The first key is the ON/OFF key, the middle key is the EXIT key, and the last key is the ENTER key.

The ON/OFF key is used to both turn power on and off. To turn on the 2020, press the ON/OFF key. To turn the power off, press the ON/OFF key and hold it down for 2 seconds, and then release it. This is done to prevent accidental power off.

The EXIT key provides a way of returning to the default display. In the functional map, the soft keys allow you to advance and the EXIT key provides a way to go back. If you are at the initial entry of the menu, EXIT will return you to the default display.

The ENTER key has a context sensitive function. When you are operating or navigating through the function map, the ENTER key is used to exit the functions and return you to the default display. When entering data such as a name, number, date, or time, ENTER is used to confirm the entry.

4.1.2.2 Soft Keys

The three soft keys on the 2020 are located directly below the status display. Each key has varying functions for configuring the 2020, editing the data logger, and controlling the display. Because only three soft keys are available, each function is broken down into a path.

4.1.2.3 Entering Text With the Soft Keys

For all information that you must enter, the left, center, and right soft keys correspond to the up, down, and right arrow.

The up and down arrows are used to change the character highlighted by the cursor. The right arrow is used to advance the cursor to the next character on the right. When the cursor is advanced past the right most character, it wraps around to the first character again. To accept the changes, press the ENTER key. To ignore the change, press EXIT.

Formatting characters, such as the colon (:) in the time, the decimal (.) in a concentration, and the slash (/) in the date are skipped when advancing the cursor.

All inputs are an 8-character input, which is displayed on the right side of the top line of the status display. The prompt, describing the input, occupies the left half of the top line. The soft keys are defined on the bottom line of the status display.

4.2 Default Display

The meter display shows the detected concentration. The resolution of the display changes with the magnitude of the reading. A reading of 0 to 99.9 will be displayed with a resolution of 0.1 ppm. A reading greater than 99.9 will be shown with a resolution of 1 ppm or 1 mg/m^3. The meter will display concentrations up to 2000 ppm or 2(99) mg/m^3.

The status display is used to display the instrument status, date, time, units, and active soft keys.

The default display provides the following information: instrument status, current detected concentration, time, date, and measurement units. The status display toggles between showing time and units and then the date.

When the display mode is MAX, the date and time correspond to the date and time the MAX concentration was recorded. In TWA mode, the time represents the number of hours and minutes during which the TWA has been accumulating. For PEAK and STEL monitoring, the date and time correspond to the current date and time.

4.3 Monitoring

4.3.1 Instrument Status

The instrument status is shown on the left of the first line of the status display and on the Table and Graph outputs. Each status has a priority assigned to it. If more than one status is in effect, then the status with the highest priority is displayed until the condition is corrected or until the option is turned off.

4.3.2 Alarms

While operating the instrument, any one of three alarm conditions can occur. To accurately identify the source of the alarm, each type of alarm has been given a unique status.

In addition to the status, the 2020 also has an audible alarm and a visual alarm LED. To conserve power, the 2020 alternates between these two alarm indicators, rather than operating both concurrently. Different alarms are identified by the frequency at which the 2020 alternates as follows: PEAK alarm-5 times per second; STEL alarm-2.5 times per second; and TWA alarm-1.25 times per second.

The left soft key is used for acknowledging alarms, and is labeled "Ack." If no alarm exists, then the "Ack" key is not shown. To clear the alarm, press the "Ack" key. Once acknowledged, the alarm indicators are cleared. The alarm status will remain until the alarm condition clears.

The 2020 updates the peak concentration once every second. Following every update, the peak concentration is compared to the peak alarm level, and if exceeded, an alarm is triggered.

If a 15-minute average concentration exceeds the selected STEL, a STEL alarm is generated.

The TWA alarm is generated when the current average concentration over an 8-hour period, since the TWA was last cleared, has exceeded the TWA exposure limit.

During calibration, all alarms are disabled. Once the calibration is complete the alarms are re-enabled.

4.4 STEL, TWA, MAX, and PEAK Operation

The 2020's meter display can be configured to show one of four values: STEL, TWA, PEAK, and MAX.

4.4.1 Short-term Exposure Limit Mode

The STEL mode displays the concentration as a 15-minute moving average. The 2020 maintains 15 samples, each representing a one-minute averaging interval.

Once every minute, the oldest of the 15 samples is replaced with a new one-minute average. This moving average provides a 15-minute average of the last 15 minutes with a one-minute update rate. Because the average is calculated using 15 one-minute averages, the meter display will only update once every minute.

The STEL is set to zero each time the instrument is turned on. Because STEL is a 15-minute moving average, there is no need to clear, or reset the STEL.

STEL calculations are always being performed by the 2020. You can display the results of the calculations by selecting "STEL" as the Display mode.

4.4.2 Time-weighted Average (TWA) Mode

The TWA accumulator sums concentrations every second until 8 hours of data have been combined. If this value exceeds the TWA alarm setting, a TWA alarm is generated. The TWA is not calculated using a moving average. Once 8 hours of data have been summed, the accumulation stops. In order to reset the TWA accumulator, press the "Clr" key.

This sum will only be complete after 8 hours, so the meter displays the current sum divided by 8 hours. While you are in TWA mode, the time on the status display will show the number of minutes and hours of data that TWA has accumulated. When this reaches 8 hours, the 2020 stops accumulating data and the TWA is complete.

TWA calculations are always being performed by the 2020. You can display the results of the calculations by selecting TWA as the Display mode.

4.4.3 MAX Mode

The MAX mode displays the maximum signal, with the date and time that it was recorded. The 2020 continues to log data according to the selected averaging interval, but only the maximum detected concentration is displayed on the meter display.

The right soft key is used to clear the meter when displaying MAX. The "Clr" key only affects the reading that the meter is displaying. For example, if you display the MAX reading, and you press "Clr," only the MAX value is cleared. The TWA is still accumulating in the background.

4.4.4 PEAK Mode

The PEAK mode displays the current detected concentration. The reading is updated once a second. In the background, the 2020 data logger is sampling the concentration and measuring minimum, maximum, and average concentrations for the selected averaging interval. At the end of every interval, one entry is placed in the data logger until the data logger is full. For CTO 126, the instrument should be operated in this mode. Operation within the other specialized modes are the responsibility of the SSO.

4.5 Set Functions

Set functions are used to setup the 2020. There are three functions which can be set on the 2020: Pump, Clock, and Calibration.

4.5.1 Pump

The Pump function is used to control the pump. After selecting "Set Pump", the 2020 responds by displaying the new pump status.

The detector is also turned off when you turn the pump off. This prevents the detector from being damaged when there is no sample flowing through the detector.

When the pump and the detector are off, the meter display will be blank. Turn the pump and detector off when concentration measurements are not necessary, and the 2020 will only be used for reviewing data or generating reports. By operating the instrument with the pump and detector off when you do not need them, you will conserve the lives of the battery and ultraviolet (UV) lamp.

To set the pump:

1. Press the ENTER key. The top line of the status display changes to "Select?". The bottom line displays 3 soft key names: "Set," "Log," and "Disp."

2. Press the soft key below "Set."

3. The names of the soft keys change to reflect the Set options. The display now shows 3 devices which can be set: "Clock," "Pump," and "Cal." Press the "Pump" key.

4. The 2020 turns the pump off. If the pump was off, pressing "Pump" will turn the pump on.

5. A message will be displayed to show you the status of the pump. The 2020 reverts back to the previous menu after a few seconds.

6. To return to the default display, press the ENTER key.

4.5.2 Clock

The Clock function is used to set both the current date and time.

To set the clock:

1. Press the ENTER key.

2. Press the "Set" key.

3. When the names of the soft keys change, press the "Clock" key.

   The up and down arrows are used to change the character underlined by the cursor. The right arrow is used to advance the cursor to the next character on the right. When the cursor is advanced past the right-most character, it wraps around to the first character again.

   Formatting characters, such as the colon (:) in the time and the slash (/) in the date are skipped when advancing the cursor.

4. Use the "arrow keys" to enter the correct time. The time is formatted as Hour:Minute:Second.

5. Press the ENTER key to confirm the time and move to the date option.

6. When setting the date, the 2020 prompts you for the current date formatted as Year/Month/Day. Use the "arrow keys" to enter the correct date.

7. Press the ENTER key to confirm the date and return to the Set options. You can wait for the display to timeout or press ENTER to return to the default display.

4.5.3 Calibration (Cal)

"Cal" allows you to setup and calibrate the 2020. There are three options under the Cal function: "Zero," "Span," and "Mem."

A calibration memory consists of a name, a response factor, and PEAK, TWA, and STEL alarm levels.

The "Zero" and "Span" keys are covered in detail in the manufacturer's operations manual for the instrument.

To edit the calibration memory, select "Mem" and then "Chng." The 2020 prompts you with two new soft keys: "User" and "Lib."

4.5.4 Library (Lib)

Library selections simplify Cal Memory programming, and provide standard response factors for approximately 70 applications. "Lib" allows you to select an entry from a pre-programmed library. The name, response factor, and three alarm levels are all set from the library. To select a library entry to program the selected Cal Memory:

1. Select "Set," "Cal," "Mem," "Chng," and "Lib."
2. Use the "Next" and "Prev" keys to scroll through the list. See the manufacturer's manual Appendix 8.7 for a list of the library entries.

4.6 Preparing for Field Operation of the Photovac 2020

Turning The 2020 On

1. Turn the 2020 on by pressing the ON/OFF key.

2. The 2020 will display the software version number. Wait for the 2020 to proceed to the default display.

3. Allow 10 minutes for the instrument to warm up and stabilize.

4. Press the Enter Key. The default display will provide 3 soft key selection "Set," "Log," and "Display."

5. Press "Set." From this option, 3 other soft key selections will be offered: "Pump," "Clock," and "Cal."

6. Press "Cal." This will begin the calibration sequence. The first selection is to Zero the instrument.

7. Press Enter, zeroing will begin. (Note: When employing zero gas attach and activate zero gas supply at this time.)

8. The next selection offered will be Span. Press Enter at which time the concentration will be requested. The isobutylene calibration gas employed under general service will be marked on the side of the container. Use the soft keys to toggle into position and to log the concentration. Once the concentration is logged press "Enter." The direction on the status display will indicate spanning. At this time hook up the span gas with a regulator to the Photovac 2020, and open it to supply enough flow to elevate the flow rate indicator to the green indicator line (1/8" from the rest position).

9. Once spanning is complete, the alarms, which have been disabled during calibration, will activate indicating that calibration is complete.

10. Document this calibration procedure using a Document of Calibration form (included in Appendix A).

This instrument is ready for general purpose application.

Calibration is to be performed daily or prior to each use in accordance with this section.

4.7 Maintenance and Calibration Schedule

Function	Frequency
Routine Calibration	Prior to each use
Factory Inspection and Calibration	Once a year, or when malfunctioning
Wipe Down the Outer Casing of the Unit	After each use
Clean UV Light Source	Every 24 hours of operation
Sample Inlet Filter	Change on a weekly basis or as required by level of use
Battery charging	After each use
Clean ionization chamber	Monthly

4.7.1 Cleaning the UV Light Source Window

1. Turn the FUNCTION switch to the OFF position. Use the 2020 multi-tool and remove the lamp housing cover. CAUTION: The UV lamp is delicate and expensive-handle carefully.

2. Tilt the lamp housing with one hand over the opening, slide the lamp out of the housing.

3. The lamp window may now be cleaned with any of the following compounds using lens paper:
   a. 11.7 eV Lamp - Dry Aluminum Oxide Powder (3.0 micron powder)
   b. All other lamps-HPLC Grade Methanol

4. Following cleaning, reassemble by first sliding the lamp back into the lamp housing. Replace the o-ring as necessary, reinstall the lamp housing cover, and tighten it using the 2020 multi-tool. (Do not over tighten).

5. Recalibrate the instrument as per Section 4.6.

4.7.2 Cleaning the Ionization Chamber

1. Turn the FUNCTION switch to the OFF position and remove the lamp housing cover and lamp as per Section 4.7.1.

2. Using a gentle jet of compressed air, gently blow out any dust or dirt.

3. Following cleaning, reassemble by first sliding the lamp back into the lamp housing. Replace the o-ring as necessary, reinstall the lamp housing cover, and tighten it using the 2020 multi-tool. (Do not over tighten).

4. Recalibrate the instrument as per Section 4.6.

4.8 Instrument Advantages

The Photovac 2020 is easy to use in comparison to many other types of monitoring instrumentation. Its detection limit range is in the low parts-per-million range. Response rapidly reaches 90 percent scale of the indicated concentration (less than 3 seconds for benzene). This instrument's automated performance covers multiple monitoring functions simultaneously, incorporating data logging capabilities.

4.9 Limitations of the Photovac 2020 Photoionization Monitor

- Because the 2020 is a nonspecific total gas/vapor detector, it cannot be used to identify unknown chemicals; it can only quantitate them in relationship to a calibration standard (relative response ratio).

- For appropriate application of the 2020, ionization potentials of suspected contaminants must be known.

- Because the types of compounds that the 2020 can potentially detect are only a fraction of the chemicals possibly present at a hazardous waste site or incident, a background or zero reading on this instrument does not necessarily signify the absence of air contaminants.

- The 2020 instrument can only monitor certain vapors and gases in air. Many nonvolatile liquids, toxic solids, particulates, and other toxic gases and vapors cannot be detected.

- PID's are generally not specific. Their response to different compounds is relative to the calibration gas used. This is referred to as relative response ratio. Instrument readings may be higher or lower than the true concentration. This can be an especially serious problem when monitoring for total contaminant concentrations if several different compounds are being detected at once.

- The 2020 is a small, portable instrument which cannot be expected to yield results as accurately as laboratory instruments.

4.9.1 Variables Affecting Monitoring Data

Monitoring a hazardous waste site environment can pose a significant challenge in assessing airborne concentrations and the potential threats to site personnel. Several variables may influence both dispersion and the instrument's ability to detect actual concentrations. Some of the variables, which may impact these conditions, are as follows:

- Temperature - changes in temperature or pressure will influence volatization, and affect airborne concentrations. Additionally, an increase or decrease in temperature ranges may have an adverse effect on the instrument's ability to detect airborne concentrations.

- Humidity - excessive levels of humidity may interfere with the accuracy of monitoring results.

- Rainfall - through increased barometric pressure and water, may influence dispersion pathways affecting airborne emissions.

- Electromagnetic interference - high voltage sources, generators, other electrical equipment may interfere with the operation and accuracy of direct-reading monitoring instruments.

5.0 TROUBLESHOOTING

5.1 Fault Messages

When the "Fault" status is displayed, the 2020's operation is compromised.

Fault 1: Signal from zero gas is too high.

Cause: If another fault occurred while the 2020 was setting its zero point, then this fault is displayed.
Action: Ensure no faults are occurring and calibrate the 2020 again.

Cause: Contamination of sample line, sample probe, or fittings before the detector.

Action: Clean or replace the sample line, sample probe, or the inlet filter.

Cause: Span gas and zero air are switched.

Action: Ensure clean air is used to zero the 2020. If you are using gas bags, mark the calibration and zero gas bags clearly.

Cause: Ambient air is contaminated.

Action: If you are unsure about the quality of ambient air, use a supply of commercial zero grade air to zero the 2020.

Fault 2: Signal from span gas is too small.

Cause: Operator may have switched the span gas and zero air.

Action: Ensure clean air is used to zero the 2020. If you are using gas bags, mark the calibration and zero gas bags clearly.

Action: Ensure the span gas is of a reliable concentration.

Cause: UV lamp window is dirty.

Note: Do not remove the detector lamp in a hazardous location.

Action: Clean the UV lamp window.

Cause: UV lamp is failing.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: Install a new UV lamp.

Cause: Incompatible application.

Action: The concentration and sample gas are incompatible for use with the 2020.

Fault 3: UV lamp fault. UV lamp has not started.

Cause: The UV lamp has not started immediately.

Action: This fault may be seen momentarily when 2020 is first turned on. Allow 30 to 60 seconds for the UV lamp to start and the fault to clear.

Cause: The UV lamp serial number label is blocking the photocell.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: If you have a UV lamp with a white serial number label, it is possible that the label is blocking the photocell. Rotate the lamp approximately 90 degrees and then try to start the 2020 again. If the fault persists, replace the lamp.

Cause: the UV lamp is not installed.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: Install a UV lamp.

Cause: The UV lamp has failed.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: Install a new UV lamp.

Cause: Electronic problem.

Action: If a new UV lamp still generates this fault, then contact the Photovac Service Department.

Fault 4: Pump current too low or too high.

Cause: If the pump sounds labored, then the pump is operating beyond normal operating parameters.

Action: Check for an obstruction in the sample line. Make sure sample line, sample probe or inlet filter are not plugged.

Note: Do not replace the inlet filter in a hazardous location.

Action: Replace the inlet filter.

Action: Ensure the sample outlet, located on the underside of the 2020, is not obstructed.

Cause: The UV lamp is too wide, causing flow to be restricted.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: If you have a UV lamp with a white serial number label, it is possible that the lamp is too wide for the lampholder. Contact the TtNUS Equipment Manager.

Cause: The 2020 has been exposed to a solvent that can pass through the inlet filter and liquid has been aspirated.

Action: Contact the TtNUS Equipment Manager.

Cause: The pump has failed.

Action: Contact the TtNUS Equipment Manager.

5.2 Specific Problems

Problem: Very low or no instrument response detected, yet compounds are known to be present.

Cause: The 2020 has not been calibrated properly.

Action: Ensure the calibration gas is of a reliable concentration and then calibrate the instrument as outlined in Section 4.6 of the User's Manual. After the instrument has been calibrated, sample the bag of calibration gas. A reading equivalent to the calibration gas should be displayed. If not, contact the TtNUS Equipment Manager.

Note: Do not remove or recharge the battery pack in a hazardous location.

Action: Disconnect the battery charger before calibrating the 2020.

Cause: Calibration Memories have not been programmed correctly.

Action: Program all the calibration memories you require for your application. You must use the correct calibration gas and concentration for each Cal Memory.

Cause: The response factor has been set to zero.

Action: Enter the correct response factor. Refer to Appendix 8.6 for a list of response factors. If the compound is not listed in Appendix 8.6 or you are measuring gas mixtures, then enter a value of 1.0. See User's Manual provided by the manufacturer.

Cause: You are not using the correct Cal Memory.

Action: Select the correct Cal Memory for your application.

Note: It does not matter which Cal Memory is selected or which response factor is entered. The 2020's response is not specific to any one compound. The reading displayed represents the total concentration of all ionizable compounds in the sample.

Cause: Detector is leaking. A decrease in sensitivity may be due to a leak in the detector.

Note: Do not remove or replace the detection lamp in a hazardous location.

Action: Ensure the UV lamp has been installed correctly.

Action: Ensure the lamp cover has been tightened down. Do not overtighten the cover.

Action: Ensure the o-ring seal on the lamp cover is positioned correctly.

Cause: The UV lamp is too long, causing flow to be restricted.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: If you have a UV lamp with a white serial number label, it is possible that the lamp is too long for the lampholder. Replace the lamp and contact the TtNUS Equipment Manager.

Cause: UV lamp is too wide, causing flow to be restricted.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: If you have a UV lamp with a white serial number label, it is possible that the lamp is too wide for the lampholder. Contact the TtNUS Equipment Manager.

Cause: The sampling environment is extremely humid.

Action: Water vapor is not ionized by the PID, but it does scatter and absorb the light and results in a lower reading. The 2020 detector has been designed to operate under high humidity conditions. Under extreme conditions you may notice decreased response due to humidity.

Cause: The UV lamp is failing.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: High concentration of non-ionizable compounds. Chemical compounds, such as methane, with IPs greater than the 10.6 eV scatter and absorb the UV light. Sensitivity may be decreased significantly. Application with high backgrounds of such materials, may be incompatible with the 2020. Contact the Photovac Applications Group for more information.

Problem: Erroneously high readings.

Cause: Sampling environment is extremely humid.

Action: Water vapor may contain mineral salts, which carry a charge. The water vapor becomes an electrolytic solution, which becomes ionized when it enters the detector. Atmospheric water in areas around the sea or stagnant water may produce a response in the absence of contaminants. The same effect may be seen when conducting ground water investigations in areas where the water is hard because it contains a significant concentration of minerals.

Cause: The 2020 has not been calibrated properly.

Action: Ensure the calibration gas is of a reliable concentration and then calibrate the instrument as outlined in Section 4.6. After the instrument has been calibrated, sample the bag of calibration gas. A reading equivalent to the calibration gas should be displayed. If not contact the TtNUS Equipment Manager.

Cause: Cal Memories have not been programmed correctly.

Action: Program all the Cal Memories you require for your application. You must use the correct calibration gas and concentration for each Cal Memory. See Section 3.4, of the User's Manual.

Cause: You are not using the correct Cal Memory.

Action: Select the correct Cal Memory for your application. See Section 3.2.2 or 3.3.2, of the User's Manual.

Note: It does not matter which Cal Memory is selected or which response factor is entered. The 2020's response is not specific to any one compound. The reading displayed represents the total concentration of all ionizable compounds in the sample.

Cause: The Detector has been short circuited by foreign matter in the detector cell.

Note: Do not service the 2020 in a hazardous location.

Action: Do not touch the wire grid inside the detector cell. Use a gentle jet of compressed air to remove any dust in the detector cell.

Warning: Do not insert any object, other than the UV lamp, into the lampholder.

Cause: There is an undetermined problem.

Action: Contact the TtNUS Equipment Manager.

Problem: Date and time settings are not retained.

Cause: The battery pack has been removed before the 2020 was turned off.

Note: Do not remove or recharge the battery pack in a hazardous location.

Action: Replace the battery pack and reset the time and date. Ensure that the 2020 has been turned off before removing the battery pack.

Cause: The 2020 has not been used for 3 months or more and the internal battery (not the external battery pack) has discharged.

Note: Do not remove or recharge the battery pack in a hazardous location.

Action: Connect the 2020 to the AC adapter and turn the 2020 on. Turn the pump off. While the 2020 is running the internal battery is charging. Leave the instrument running for approximately 24 hours.

Problem: Instrument status shows "Over."

Cause: High concentrations of gases and vapors will cause a rapid change in signal level. The detector and associated electronics may become temporarily saturated.

Action: Wait a few seconds for the status to return to normal. PIDs are designed to detect relatively low concentrations of gases and vapors. Exposure to very high concentrations may result in a very high or maximum response.

Cause: The detector has become saturated.

Action: Move the 2020 to a location where it can sample clean air. Sample clean air until the reading stabilizes around 0.

Cause: Detector has been short circuited by foreign matter in the detector cell.

Note: Do not service the 2020 in a hazardous location.

Action: Do not touch the wire grid inside the detector cell. Use a gentle jet of compressed air to remove any dust or dirt in the detector cell.

Warning: Do not insert any object, other than the UV lamp, into the lampholder.

Cause: There is an undetermined problem.

Action: Contact the TtNUS Equipment Manager.

Problem: Display is blank.

Cause: Battery pack is critically low.

Note: Do not remove or recharge the battery pack in a hazardous location.

Action: Replace the battery pack or connect the 2020 to the AC adapter.

Cause: The battery pack is not connected to the instrument correctly.

Action: Ensure the battery pack connector is securely attached to the connector on the 2020.

Cause: There is an undetermined problem.

Action: Reset the 2020. You must leave the instrument on while you disconnect the battery pack. This will reset the instrument. Reconnect the battery pack and close the battery hatch. Turn on the 2020, set the time and date and program all the calibration memories that you are using.

Action: Contact the TtNUS Equipment Manager.

Problem: Sample flow rate is less than 300 ml/min.

Cause: The inlet filter is plugged.

Note: Do not replace the inlet filter in a hazardous location.

Action: Replace the inlet filter.

Cause: The inlet filter has not been installed properly.

Action: Ensure that the inlet filter has been installed correctly.

Cause: The UV lamp is too long, causing flow to be restricted.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: If you have a UV lamp with a white serial number label, it is possible that the lamp is too long for the lampholder. Replace the lamp and contact the TtNUS Equipment Manager.

Cause: The UV lamp is too wide, causing flow to be restricted.

Action: If you have a UV lamp with a white serial number label, it is possible that the lamp is too wide for the lampholder. Contact the TtNUS Equipment Manager.

Cause: The 2020 has been exposed to a solvent that can pass through the inlet filter and liquid has been aspirated.

Action: Contact the TtNUS Equipment Manager.

Cause: Sample outlet is obstructed.

Action: Ensure the sample outlet is not obstructed in any way.

Cause: Pump has been damaged.

Action: Contact the TtNUS Equipment Manager.

Problem: Liquid has been aspirated.

Cause: The 2020 has been exposed to a solvent that can pass through the inlet filter.

Action: Contact the TtNUS Equipment Manager.

Problem: Corrosive gases and vapors have been sampled.

Cause: The 2020 has been exposed to corrosive gases and vapors.

Action: Corrosive gases and vapors can affect the electrodes within the detector as well as the lamp window. Prolonged exposure to corrosive materials may result in permanent fogging or etching

of the window. If the 2020 is exposed to corrosive material, contact the TtNUS Equipment Manager.

6.0 SHIPPING

The Photovac may be shipped as cargo or carried on as luggage providing there is no calibration gas cylinder accompanying the kit. When shipping or transporting the calibration gas, a Hazardous Airbill must be completed.

7.0 REFERENCES

Photovac 2020 Photoionization Monitor User's Manual, 1995.

8.0 ATTACHMENTS

1. Equipment Calibration Log

ATTACHMENT 1
EQUIPMENT CALIBRATION LOG

Tetra Tech NUS, Inc.

EQUIPMENT CALIBRATION LOG

PROJECT NAME : ____________________ INSTRUMENT NAME/MODEL: ____________________

SITE NAME: ____________________ MANUFACTURER: ____________________

PROJECT No.: ____________________ SERIAL NUMBER: ____________________

Date of Calibration	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot No.)	Remarks and Comments
			Pre-calibration	Post-calibration	Pre-calibration	Post-calibration		

STANDARD OPERATING PROCEDURE
NUMBER CTO126-07

BOREHOLE AND SOIL SAMPLE LOGGING

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the standard procedures and technical guidance on the logging of soil cores collected at the Jeep Trail, at the NSWC Crane facility.

2.0 FIELD FORMS AND EQUIPMENT

Knife
Ruler (marked in tenths and hundredths of feet)
Boring Log: An example of this form is attached.
Photoionization Detector (PID) (see SOP 126-06)
Writing Utensil

3.0 RESPONSIBILITIES

A field geologist/engineer is responsible for supervising all boring activities and assuring that each borehole is properly and completely logged.

4.0 PROCEDURES FOR BOREHOLE AND SAMPLE LOGGING

To maintain a consistent classification of soil, it is imperative that the field geologist understands and accurately uses the field classification system described in this SOP. This identification is based on visual examination and manual tests.

4.1 USCS Classification

Soils are to be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Figure 1 (attached to this SOP).

This method of classification identifies soil types on the basis of grain size and cohesiveness.

Fine-grained soils, or fines, are smaller than the No. 200 sieve and are of two types: silt (M) and clay (C). Some classification systems define size ranges for these soil particles, but for field classification purposes, they are identified by their respective behaviors. Organic material (O) is a common component of soil but has no distinguishable size range; it is recognized by its composition. The careful study of the USCS will aid in developing the competence and consistency necessary for the classification of soils.

Coarse-grained soils shall be divided into categories: rock fragments, sand, or gravel. The terms sand and gravel not only refer to the size of the soil particles but also to their depositional history. To insure accuracy in description, the term rock fragments shall be used to indicate angular granular materials resulting from the breakup of rock. The sharp edges typically observed indicate little or no transport from their source area, and therefore the term provides additional information in reconstructing the depositional environment of the soils encountered. When the term "rock fragments" is used it shall be followed by a size designation such as "(1/4 inchΦ-1/2 inchΦ)" or "coarse-sand size" either immediately after the entry or in the remarks column. The USCS classification would not be affected by this variation in terms.

4.2 Color

Soil colors shall be described utilizing a single color descriptor preceded, when necessary, by a modifier to denote variations in shade or color mixtures. A soil could therefore be referred to as "gray" or "light gray" or "blue-gray.". Because color can be utilized in correlating units between sampling locations, it is important for color descriptions to be consistent from one boring to another.

Colors must be described while the sample is still moist. Soil samples shall be broken or split vertically to describe colors. Samplers tend to smear the sample surface creating color variations between the sample interior and exterior.

The term "mottled" shall be used to indicate soils irregularly marked with spots of different colors. Mottling in soils usually indicates poor aeration and lack of good drainage.

4.3 Relative Density and Consistency

To classify the relative density and/or consistency of a soil, the geologist is to first identify the soil type. Granular soils contain predominantly sands and gravels. They are noncohesive (particles do not adhere well when compressed). Finer-grained soils (silts and clays) are cohesive (particles will adhere together when compressed).

Granular soils are given the USCS classifications GW, GP, GM, SW, SP, SM, GC, or SC (see Figure 1).

The consistency of cohesive soils is determined by performing field tests and identifying the consistency as shown in the following table.

CONSISTENCY FOR COHESIVE SOILS

Consistency	Standard Penetration Resistance (Blows per Foot)	Unconfined Compressive Strength (Tons/Sq. Foot by pocket penetration)	Field Identification
Very soft	0 to 2	Less than 0.25	Easily penetrated several inches by fist
Soft	2 to 4	0.25 to 0.50	Easily penetrated several inches by thumb
Medium stiff	4 to 8	0.50 to 1.0	Can be penetrated several inches by thumb with moderate effort
Stiff	8 to 15	1.0 to 2.0	Readily indented by thumb but penetrated only with great effort
Very stiff	15 to 30	2.0 to 4.0	Readily indented by thumbnail
Hard	Over 30	More than 4.0	Indented with difficulty by thumbnail

Cohesive soils are given the USCS classifications ML, MH, CL, CH, OL, or OH (see Figure 1).

The consistency of cohesive soils is determined by hand by determining the resistance to penetration by the thumb. The thumb determination methods are conducted on a selected sample of the soil, preferably the lowest 0.5 foot of the sample. The sample shall be broken in half and the thumb pushed into the end of the sample to determine the consistency. Do not determine consistency by attempting to penetrate a rock fragment. If the sample is decomposed rock, it is classified as a soft decomposed rock rather than a hard soil. One of the other methods shall be used in conjunction with it. The designations used to describe the consistency of cohesive soils are shown in the above-listed table.

4.4 Weight Percentages

In nature, soils are comprised of particles of varying size and shape, and are combinations of the various grain types. The following terms are useful in the description of soil:

Terms of Identifying Proportion of the Component	Defining Range of Percentages by Weight
Trace	0 - 10 percent
Some	11 - 30 percent
Adjective form of the soil type (e.g., "sandy")	31 - 50 percent

Examples:

- Silty fine sand: 50 to 69 percent fine sand, 31 to 50 percent silt.
- Medium to coarse sand, some silt: 70 to 80 percent medium to coarse sand, 11 to 30 percent silt.
- Fine sandy silt, trace clay: 50 to 68 percent silt, 31 to 49 percent fine sand, 1 to 10 percent clay.
- Clayey silt, some coarse sand: 70 to 89 percent clayey silt, 11 to 30 percent coarse sand.

4.5 Moisture

Moisture content is estimated in the field according to four categories: dry, moist, wet, and saturated. In dry soil, there appears to be little or no water. Saturated samples obviously have all the water they can hold. Moist and wet classifications are somewhat subjective and often are determined by the individual's judgment. A suggested parameter for this would be calling a soil wet if rolling it in the gloved hand or on a porous surface liberates water, i.e., dirties or muddies the surface. Whatever method is adopted for describing moisture, it is important that the method used by an individual remains consistent throughout an entire field activity.

4.6 Classification of Soil Grain Size for Chemical Analysis

To determine the gross grain size classification (e.g., clay, silt, and sand) from the USCS classification described above, the following table shall be used.

Gross Soil Grain Size Classification	USCS Abbreviation	Description
Clay	CL	inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays,
	CH	inorganic clays of high plasticity, fat clays
	OH	organic clays of medium to high plasticity, organic silts
Silt	ML	inorganic silts and very fine sands, rock four, silty or clayey fine sands with slight plasticity
	OL	organic silts and organic silty clays of low plasticity
	MH	inorganic silts, micaceous or diatomaceous fine sand or silty soils

Gross Soil Grain Size Classification	USCS Abbreviation	Description
Sand	SW	well graded sands, gravelly sands, little or no fines
	SP	poorly graded sands, gravelly sands, little or no fines
	SM	silty sands, sand-silt mixtures
	SC	clayey sands, sand-clay mixtures

4.7 Summary of Soil Classification

In summary, soils shall be classified in a similar manner by each geologist/engineer at a project site. The hierarchy of classification is as follows:

- Density and/or consistency
- Color
- Plasticity (Optional)
- Soil types
- Moisture content
- Other distinguishing features
- Grain size
- Depositional environment

4.0 ATTACHMENTS

1. Figure 1 - Unified Soil Classification System
2. Boring Log

ATTACHMENT 1

FIGURE 1 - UNIFIED SOIL CLASSIFICATION SYSTEM

FIGURE 1

UNIFIED SOIL CLASSIFICATION (USCS)

FIELD IDENTIFICATIONPROCEDURES
(Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights

COARSE-GRAINED SOILS More Than Half of Material is LARGER Than No. 200 Sieve Sizes			GROUP SYMBOL	TYPICAL NAMES
GRAVELS (50%(+)>1/4"Ø)	CLEAN GRAVELS (Low % Fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Well graded gravels, gravel-sand mixtures, little or no fines.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.
	GRAVELS W/FINES (High % Fines)	Non-plastic fines (for identification procedures, see ML)	GM	Silty gravels, poorly graded gravel-sand-silt mixtures.
		Plastic fines (for identification procedures, see CL)	GC	Clayey gravels, poorly graded gravel-sand-clay mixtures.
SANDS 50%(+)<1/4"Ø)	CLEAN SANDS (Low % Fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	SW	Well graded sand, gravelly sands, little or no fines.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines.
	SANDS W/FINES (High % Fines)	Non-plastic fines (for identification procedures, see MCL)	SM	Silty sands, poorly graded sand-silt mixtures.
		Plastic fines (for identification procedures, see CL)	SC	Clayey sands, poorly graded sand-clay mixtures.

FINE-GRAINED SOILS More Than Half of Material is SMALLER Than No. 200 Sieve Size	FIELD IDENTIFICATION PROCEDURES (Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights) Identification Procedures on Fraction Smaller than No. 40 Sieve Size				GROUP SYMBOL	TYPICAL NAMES
		DAY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)		
SILTS AND CLAYS Liquid Limit <50	None to Slight	Quick to Slow	None		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity
	Medium to High	None to Very Slow	Medium		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
	Slight to Medium	Slow	Slight		OL	Organic silts and organic silt-clays of low plasticity.
SILTS AND CLAYS Liquid Limit >50	Slight to Medium	Slow to None	Slight to Medium		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
	High to Very High	None	High		CH	Inorganic clays of high plasticity, fat clays.
	Medium to High	None to Very Slow	Slight to Medium		OH	Organic clays of medium to high plasticity.
HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture.				Pt	Peat and other organic soils

Boundary classifications: Soils possessing characteristics of two groups are designated by combining group symbols. For example, GW-GC, well graded gravel-sand mixture with clay binder.
All sieve sizes on this chart are U.S. Standard.

DENSITY OF GRANULAR SOILS

DESIGNATION	STANDARD PENETRATION RESISTANCE-BLOWS/FOOT
Very Loose	0-4
Loose	5-10
Medium Loose	11-30
Dense	31-50
Very Dense	Over 50

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNC COMPRESSIVE STRENGTH (TONS/SQ. FT.)	STANDARD PENETRATION RESISTANCE-BLOWS/FOOT	FIELD IDENTIFICATION METHODS
Very Soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb.
Medium Stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb.
Stiff	1.0 to 2.0	8 to 15	Readily indented by thumb.
Very Stiff	2.0 to 4.0	15 to 30	Readily indented by thumbnail.
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail.

Tetra Tech NUS, Inc.

ATTACHMENT 2

BORING LOG

PROJECT NAME: _____ BORING No.: _____
PROJECT NUMBER: _____ DATE: _____
DRILLING COMPANY: _____ GEOLOGIST: _____
DRILLING RIG: _____ DRILLER: _____

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm): [ ]

Remarks: _____

Converted to Well: Yes _____ No _____ Well I.D. #: _____

STANDARD OPERATING PROCEDURE
NUMBER CTO126-08

SURFACE AND SUBSURFACE SOIL SAMPLING

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the procedures to be used for surface and subsurface soil sampling using direct push technology (DPT) or split-barrel samplers during field activities at the Jeep Trail at the NSWC Crane facility. This procedure also describes the collection of samples for analysis of volatile organic compounds (VOCs) using EnCore samplers, and the use of field screening (i.e., photoionization detector [PID]) to select the most appropriate subsurface soil interval for VOC sampling.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Writing utensil with indelible ink

Disposable medical-grade gloves (i.e. latex, nitrile)

Boring log

Soil sample logsheets

Stainless-steel mixing bowls

Stainless-steel trowel or soup spoon

EnCore handle and samplers

Required sample containers: All sample containers including shipping coolers for analysis by fix-based laboratories will be supplied and deemed certified clean by the laboratory.

Required decontamination materials

Chain-of-custody records

Required personnel protective equipment (PPE)

Photoionization detector (PID) (see SOP 126-06)

Wooden stakes or pin flags

Sealable polyethylene bags

Heavy-duty cooler

Ice

Razor knife

Geoprobe and sampling equipment

Sample labels and tags

3.0 COLLECTION OF SOIL SAMPLES FOR VOLATILE ORGANIC COMPOUNDS (VOCs)

When soil cores are collected using DPT such as Geoprobe, 2-foot soil intervals will be collected in clear acetate tubes, which can be extracted from the Geoprobe core barrel (see SOP CTO126-04) upon retrieval at the surface.

3.1 Slit the acetate liner lengthwise with a razor knife, remove a section of the liner, and expose the length of the soil interval (see SOP CTO126-04).

3.2 Scan the soil core interval with a PID, slowly moving the intake nozzle along the length of the core where the acetate liner has been slit open. Note on the Boring Log what the range of PID readings are detected, and the specific location(s) along the sample interval where above-background readings are encountered. If elevated volatile organics are measured via the PID, collect the VOC samples from the specific interval where the highest PID reading is measured. If no above-background PID readings are measured, then the VOC sample will be collected from a specific interval where visual signs of contamination (staining, etc.) are observed. If no above-background PID reading is measured, and no discoloration or odor in the soil core indicate potential contamination, then collect the VOC sample from near the center of a core.

3.3 The 0-2 feet core interval will be collected as a "surface soil" sample. Determine where in this core interval the highest PID reading was encountered. Soil samples collected for volatile organics will be obtained directly from soil cores using four EnCore samplers for each VOC sample. These samples are to be collected by pushing the EnCore samplers directly into the soil core where the highest PID readings were measured, ensuring that the sampler is packed tight with soil, and leaving no headspace between cap and container. All four EnCore sample containers will be collected as close to each other as possible. Make sure that all caps are securely fastened to the samplers and locked in place with both clips (see instructions that come with samplers). Write the sample ID on the strip labels that come with the samplers and place a label on each of the four samplers.

3.4 Place the four EnCore samplers in the ziplock pouches that come with the samplers and fill in appropriate information, including sample ID, date, time, and other information on the label. Place the four pouches in a plastic bag and place the tag on the bag, identifying the sample ID and other necessary information (see SOP CTO126-01).

3.5 Once the samples are properly labeled, bagged, and tagged, place the sample into the cooler containing ice and a trip blank. It should be kept at 4°C and shipped to the analytical laboratory for preservation or extraction within 48 hours.

3.6 Fill in the required information on the Soil Sample Log Sheet (attached at the end of this SOP) and fill in the required information on the Chain-of-Custody (COC) form.

3.7 Up to two additional subsurface soil samples will be collected from each boring. For these subsurface soil samples, the collected cores will be scanned with the PID before a specific depth is selected for VOC sampling. Choose the specific location within the collected cores that had the highest PID reading and proceed to collect four EnCore samples, as described above in 3.2 through 3.6. If readings are not elevated, samples will be collected from the center of each cored interval using the default sample depths identified in the QAPP. Place the samples in the cooler containing ice, once they have been properly labeled, bagged, and tagged.

4.0 COLLECTION OF OTHER SOIL SAMPLE ALIQUOTS

Note: A surface soil sample is collected from the 0-2 feet depth (i.e., one core length). Additional subsurface soil samples each consist of two 2-foot core segments.

4.1 After the VOC sample has been collected for the soil interval of interest (see 3.0 above), the remainder of the soil interval shall be composited and used to fill the remainder of the sample containers. Any surface debris (e.g., herbaceous vegetation, twigs, rocks, litter, etc.) should first be removed from the top of the surface soil core. For other core intervals, the top 2 inches of each core should be discarded because it often contains material scraped from the side of the borehole and not fresh material from the bottom of the borehole.

4.2 Slide the remaining core material out of the acetate liner and into a clean, decontaminated stainless steel mixing bowl. Mix the soil thoroughly with a stainless steel spoon and remove gravel, large pebbles, and other coarse materials. Fill the required sample containers in the following order:

- Containers for organic analyses
- Container for metals
- Container for Nitrate
- Container for Nitrite

The containers (number, size, and type) required for each type of laboratory analysis are listed in Table 4-12 of the QAPP.

4.3 Complete all required information on the sample labels (see SOP CTO126-01).

4.4 Fill in all required information on the sample tag and secure the tag to the sample container.

4.5 Place the sample container in a ziplock plastic bag and seal shut. Place the bag in a cooler containing ice and cool to 4 $\pm$ 2°C.

4.6 Record the required information on the Soil Sample Log Sheet and the COC form.

5.0 PACKAGING AND SHIPPING OF SAMPLES

Samples will be packaged and shipped according to SOP CTO126-04.

6.0 ATTACHMENTS

1. Soil and Sediment Sample Log Sheet

ATTACHMENT 1

Tetra Tech NUS, Inc.

SOIL & SEDIMENT SAMPLE LOG SHEET

Page___ ___

Project Site Name: _____
Project No.: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____

[] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other: _____
[] QA Sample Type: _____

Type of Sample:
[] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date:			
Time:			
Method:			
Monitor Reading (ppm):			

COMPOSITE SAMPLE DATA:

Date:	Time	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Method:				
Monitor Readings				
(Range in ppm):				

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:

MAP:

Circle If Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

STANDARD OPERATING PROCEDURE
NUMBER CTO126-09

INSPECTION OF EXISTING MONITORING WELLS

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes procedures for the inspection and repair of existing monitoring wells at the Jeep Trail, at the NSWC Crane facility.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following equipment and field forms are required for inspection of existing monitoring wells.

Monitoring well inspection form: A copy of the monitoring well inspection form is attached.
Writing utensil with indelible ink
Bound field log book
Well keys
Disposable medical-grade gloves (e.g., latex, nitrile)
Photoionization detector (PID)
Electronic water-level indicator
Steel rod (about 1-inch diameter with eye bolt at one end)
100 feet of nylon rope
Internal pipe cutter
File, v notch

3.0 INSPECTION PROCEDURES

3.1 Record the well identification information (ID), date, and time on the Monitoring Well Inspection Form.

3.2 Record the condition of the well ID tag. Is the tag in place and legible? If not, note the discrepancies on the Monitoring Well Inspection Form.

3.3 Record the condition of the protective casing, caps, and lock. Has the casing, cap, and/or lock been tampered with or damaged? Has the well been damaged in any way or does it show signs of deterioration?

3.4 Record the condition of the concrete or gravel pads, if a pad is present. Check the condition of the pad (or the area around the well if no pad exists) and note any abnormalities. Are concrete pads cracking or heaving? If a gravel pad is present, is there any erosion or plant growth in the pad area?

3.5 Record the condition of the cement seal surrounding the protective casing. Has the seal cracked or pulled away from the protective casing? Record any visible signs of deterioration in the area of the seal.

3.6 Record the presence of depressions and/or standing water around the casing or pad.

3.7 Unlock the well cap and open the protective cover, if one exists.

3.8 Inspect and record the condition of the PVC riser pipe and the surveyed reference point. The surveyed reference point is a V-notch on the top of the PVC riser pipe.

3.9 Measure the height of the protective casing and riser pipe above the ground surface. Record these readings on the inspection form to the nearest 0.01-foot.

3.10 Check Table 4-4 of the QAPP to verify the total original depth of the monitoring well being inspected.

3.11 Open the well cap and use the PID to screen the air within the well opening to determine whether above-background levels of VOCs are present within the well. Refer to the HASP for procedures to follow for the presence of VOCS in a well.

3.12 Lower the electronic water-level indicator probe down the well casing. If an obstruction is encountered, record the depth of the obstruction, and whether the obstruction is partial or complete.

3.13 If no obstruction is encountered, continue lowering the water-level indicator down the well casing until ground water is encountered. Measure the depth to water to the nearest 0.01 feet (see SOP CTO131-18), and record the depth on the Inspection Log.

3.14 Continue lowering the indicator probe down the casing until a solid bottom is reached or an obstruction is encountered. Record the depth to bottom of well (from top of casing) on the Inspection Log.

3.15 If an obstruction is encountered in the casing before the well bottom is reached, record the depth of obstruction on the Inspection Log, and whether the obstruction is partial or complete.

3.16 Remove the water-level indicator from the well.

3.17 If an obstruction was encountered during steps 3.12 or 3.14, lower a heavy steel rod slowly down the well casing until the obstruction is encountered. Attempt to loosen the obstruction by raising and dropping the steel rod, letting it hit the obstruction with gradually increasing force. Record whether the obstruction could be loosened.

3.18 If step 3.17 is performed, remove the steel rod from the well and remeasure the depth to the obstruction. If the obstruction has been knocked loose and settles to the bottom, then the well may still be used as a piezometer, but will not be used for ground water sampling.

3.19 Close the well cap and lock, if lock is present.

3.20 Decontaminate the water-level indicator and steel rod, if used, per SOP CTO126-17.

3.21 Make recommendations on the Inspection Log, if necessary, for repair of the monitoring well. Replace lock, if needed, as soon as possible.

3.22 Perform repair of well as soon as possible.

4.0 Field Repairs to Monitoring Wells

Field repairs to monitoring wells, for the most part, will be limited to the repair of the PVC riser (inter case). If a monitoring well is damaged beyond the repair capabilities of the field crew, the NSWC Crane Environmental Department will be notified and a decision will be made to repair or replace the well using a drilling contractor.

4.1 Remove a short section of the top of the PVC riser, that is broken, using an inside pipe cutter. Prior to cutting the riser, a clean rag will be inserted into the riser to just below the cut, this will prevent cuttings from entering the well. Insert the cutter just below the damaged area and remove only the damaged section of riser. Carefully remove the rag, measure and record the length of riser removed, mark the top of the riser for water level measurement (filing a V notch is the preferred method).

4.2 If the riser damage indicates that a riser must be added, a section of PVC may be attached to the existing riser. After removing the damaged riser (see 4.1 above), cut a new section of riser to the needed length and attach a slip coupler to one end. In most cases, the coupler will fit securely to the pipe without the need for mechanical fasteners (pop-rivets/screws). If needed, fasteners may be used, but in no case will glue be used to attach the coupler. Attach the new coupler and PVC pipe to the existing riser, mark the top for measurement purposes and document the length of pipe added. All new materials (pipe and couplers) will be decontaminated prior to installation.

5.0 ATTACHMENTS

1. Monitoring Well Inspection Sheet

ATTACHMENT 1
MONITORING WELL INSPECTION SHEET

MONITORING WELL INSPECTION SHEET

Well ID: _____

Time: _____ **Date:** _____ **Inspector's Name:** _____

Inspection Item	Types of Problems	Status		Observation
		S	U	
Well Tag	Is it in-place, legible			
Well security	Condition protective case, cap, lock			
Well pad	Concrete or gravel & condition			
Well seal	Condition of…			
Area Immediately around well pad	Record any evidence of/or standing water in area of well			
Dedicated sampling equipment	Condition of…			
PVC Riser	Condition of riser & survey reference point			

Comments:

Signature(s)_____

Note: S= Satisfactory, U= Unsatisfactory
Check one, if unsatisfactory explain

STANDARD OPERATING PROCEDURE
NUMBER CTO126-10

MONITORING WELL DEVELOPMENT

1.0 PURPOSE

This procedure provides general guidance and information pertaining to proper development of new and existing monitoring wells. The methods described herein are specific for monitoring wells located at the Jeep Trail at the NSWC Crane facility. Guidelines by South Division, Naval Facilities Engineering Command, (SOUTHDIV NAVFAC, 1997) and the State of Indiana regulatory requirements in Article 16 Water Well Drillers of Chapter 310 of the Indiana Annotated Codes (310 IAC 16) should be consulted.

2.0 RESPONSIBILITIES

The drilling contractor will provide adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force capable of performing the development of monitoring wells. The drilling contractor personnel must have all of the health and safety training required to perform the work, as specified in the Health and Safety Plan.

3.0 REQUIRED EQUIPMENT/ITEMS

The following list includes equipment and items required for monitoring well installation:

Health and safety equipment as required by the HASP and the Site Safety Officer.

Well development equipment with associated materials (typically supplied by the driller).

Hydrogeologic equipment (weighted engineer's tape, water level indicator, retractable engineers rule, electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, and a field notebook).

4.0 WELL DEVELOPMENT METHODS

The development of new wells shall not occur until at least 48 hours after the well has been installed and grouted. This time is required so that the grout in the annulus can set and harden. The purpose of well development is to stabilize and increase the permeability of the sand pack and the well screen, and to restore the permeability of the formation which may have been reduced by drilling operations. Wells are typically developed until all fine material and drilling water, if any, is removed from the well.

Sequential measurements of pH, specific conductance, turbidity, and temperature taken during development yield information (stabilized values) that sufficient development is reached. Development should proceed until criteria are met as stated in Navy Guidelines.

A surge plunger (also called a surge block) that is approximately the same diameter as the well casing will be used to agitate the water, causing it to move in and out of the screens. This movement of water pulls fine materials into the well, where they may be removed by any of several methods, and prevents bridging of sand particles in the gravel pack. There are two basic types of surge plungers; solid and valved surge plungers. Site-specific conditions will dictate which type will be used. In formations with low yields, a valved surge plunger may be preferred, as solid plungers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers are designed to produce a greater inflow than outflow of water during surging.

Development should proceed until the following criteria are met:

- The well water is clear to the unaided eye AND-

- A minimum removal of five times the standing water volume in the well (to include the well screen and casing plus saturated borehole annulus, assuming 30% annular porosity) OR

- When pH measurements remain constant within 0.1 Standard Units and specific conductance and temperature vary no more than plus or minus 3% for at least three consecutive readings. Turbidity should also show stabilization and ideally be below 10 Nephelometric Turbidity Units (NTUs).

If for any reason the above criteria cannot be met, the site geologist should document the event in writing and consult with the TOM regarding an alternate plan of action.

Well development must be completed at least 24 hours before well sampling. The intent of this hiatus is to provide time for the newly installed well and backfill materials to sufficiently equilibrate to their new environment and for the new environment to re-stabilize after the disturbance of drilling.

5.0 ATTACHMENTS

1. Monitoring Well Development Record

ATTACHMENT 1
MONITORING WELL DEVELOPMENT RECORD

Tetra Tech NUS, Inc.

MONITORING WELL DEVELOPMENT RECORD

Page ___ of ____

Well: _____ Depth to Bottom (ft.): _____ Responsible Personnel: _____
Site: _____ Static Water Level Before (ft.): _____ Drilling Co.: _____
Date Installed: _____ Static Water Level After (ft.): _____ Project Name: _____
Date Developed: _____ Screen Length (ft.): _____ Project Number: _____
Dev. Method: _____ Specific Capacity: _____
Pump Type: _____ Casing ID (in.): _____

Time	Estimated Sediment Thickness (Ft.)	Cumulative Water Volume (Gal.)	Water Level Readings (Ft. below TOC)	Temperature (Degrees C)	pH	Specific Conductance (Units _____)	Turbidity (NTU)	Remarks (odor, color, etc.)

STANDARD OPERATING PROCEDURE
NUMBER CTO126-11

DRILLING AND GEOLOGIC LOGGING OF BOREHOLES IN ROCK

1.0 PURPOSE

This procedure describes the methods and equipment necessary to drill rock borings and identify the equipment, sequence of events, and appropriate methods necessary to obtain rock cores and prepare boring logs during drilling activities. Up to four types of drilling activities and equipment will be used to drill holes and install monitoring wells at the Jeep Trail at the NSWC Crane facility:

- Auger drilling will be used to drill through the overburden material.

- Diamond coring equipment will be used to core through the bedrock in well borings 03MWT10 and 03MWT12. NX or similar size diamond core barrels will be used to collect 2 to 3 inch diameter continuous rock core. These cores will be used to describe the lithologic characteristics and fracture distributions in the bedrock. Diamond coring is relatively slow and more expensive compared to the air rotary method of drilling, so only two holes are being cored.

- Air-rotary drilling will be used to ream out to a larger diameter in the two diamond-core holes mentioned above, and to drill the other two deep well borings described in the QAPP. The holes need to be a minimum of 5 inches in diameter in order to install 2-inch diameter monitoring wells. Air rotary may also be used to deepen well borings in the event bedrock is encountered prior to reaching the desired well boring depth.

- Rotary drilling with a roller bit and water wash may be used to complete well borings in the event that bedrock is encountered prior to reaching the desired well boring depth.

2.0 RESPONSIBILITIES

Field Operations Leader (FOL) - The FOL is responsible for coordinating all on-site personnel and for providing technical assistance, when required. The FOL, or designee, will coordinate and lead all activities and will ensure the availability and maintenance of all materials/equipment. The FOL is responsible for the completion of all field activities, field and chain-of-custody documentation; will assume

custody of all samples; and will ensure the proper handling and shipping of samples. The FOL is a highly experienced environmental professional who will report directly to the TtNUS TOM. Specific FOL responsibilities include the following:

- Function as a communications link between field staff members, the Site QA/QC Advisor, Site Safety Officer, the Site Manager, and the TOM.
- Oversee the mobilization and demobilization of all field equipment and subcontractors.
- Coordinate and manage the Field Technical Staff.
- Adhere to the work schedules provided by the TOM.
- Maintain the site logbook and field record keeping.
- Initiate field task modification requests, when necessary.
- Identify and resolve problems in the field, resolve difficulties in consultation with the NSWC Crane Site Manager, implement and document corrective action procedures, and provide communication between the field team and upper management.

Field Geologist - The field geologist is responsible for ensuring that standard and approved drilling procedures are followed. The field geologist will generate a detailed boring log for each borehole. This log shall include a description of geologic materials, samples (if any), method of sampling, and other pertinent information and observations that may be obtained during drilling.

Determination of the exact location for borings is the responsibility of the field geologist. The final location for drilling must be properly documented on the boring log. The general area in which the borings are to be located will be shown on a site map included in the QAPP.

Drilling Subcontractor - Operates under the supervision of the FOL. Responsible for obtaining all drilling permits and clearances, and supplying all services (including labor), equipment and material required to perform the drilling, testing, and well installation program, as well as maintenance and quality control of such required equipment except as stated in signed and approved subcontracts.

The driller must report any major technical problems encountered in the field to the FOL within 24 hours of determination, and must provide advance written notification of any changes in field procedures, describing and justifying such changes. No such changes shall be made unless requested and authorized in writing by the FOL (with the concurrence of the Project Manager). Depending on the subcontract, the Project Manager may need to obtain written authorization from appropriate administrative personnel before approving any changes.

The drilling subcontractor is responsible for following decontamination procedures specified for drilling and coring equipment specified in the project plan documents. The FOL will oversee the in-field equipment decontamination procedures to confirm compliance with the appropriate SOP and specific requirements of the NSWC Crane Environmental Department. Upon completion of the work, the driller is responsible for demobilizing all equipment, cleaning up any materials deposited on site during drilling operations, and properly backfilling any open borings.

3.0 PROCEDURES

3.1 General

The purpose of drilling boreholes is:

- To determine the type, thickness, and certain physical and chemical properties of the soil, water and rock strata which underlie the site, and
- To install monitoring wells or piezometers.

All drilling and sampling equipment will be cleaned between samples and borings using appropriate decontamination procedures as outlined in SOP CTO126-17. Unless otherwise specified, it is generally advisable to drill borings at "clean" locations first, and at the most contaminated locations last, to reduce the risk of spreading contamination between locations. All borings must be logged by the site geologist as they proceed.

3.2 Rock Coring

Drilling is done by rotating and applying downward pressure to the drill rods and drill bit. The drill bit is a circular, hollow, diamond-studded bit attached to the outer core barrel in a double-tube core barrel. The use of single-tube core barrels is not recommended, as the rotation of the barrel erodes the sample and limits its use for detailed geological evaluation. Water or air is circulated down through the drill rods and annular space between the core barrel tubes to cool the bit and remove the cuttings. The bit cuts a core

out of the rock which rises into an inner barrel mounted inside the outer barrel. The inner core barrel and rock core are removed by lowering a wire line with a coupling into the drill rods, latching onto the inner barrel and withdrawing the inner barrel. A less efficient variation of this method utilizes a core barrel that cannot be removed without pulling all of the drill rods. This variation is practical only if less than 50 feet of core is required. When coring rock, the speed of the drill and the drilling pressure, amount and pressure of water, and length of run can be varied to give the maximum recovery from the rock being drilled.

Advantages of core drilling include:

- Undisturbed rock cores can be recovered for examination and/or testing.
- In formations in which the cored hole will remain open without casing, water from the rock fractures may be recovered from the well without the installation of a well screen and gravel pack.
- Formation logging is extremely accurate.
- Drill rigs are relatively small and mobile.

Disadvantages include:

- Water or air is needed for drilling.
- Coring is slower than rotary drilling (and more expensive).
- Depth to water cannot accurately be determined if water is used for drilling.
- The size of the borehole is limited.

This drilling method is useful if accurate determinations of rock lithology are desired or if open wells are to be installed into bedrock. To install monitoring wells in coreholes, the hole will be reamed out to the proper size after boring, using air rotary drilling methods. Rock coring enables a detailed assessment of borehole conditions to be made, showing precisely all lithologic changes and characteristics. Because coring is an expensive drilling method, it is commonly used for shallow studies of 500 feet or less, or for specific intervals in the drill hole that require detailed logging and/or analyzing. Rock coring can, however, proceed for thousands of feet continuously, depending on the size of the drill rig, and yields better quality data than air-rotary drilling, although at a substantially reduced drilling rate.

Borehole diameter can be drilled to various sizes, depending on the information needed. NX, or a similar size (2 to 3 inch diameter core recovery), will be used for Jeep Trail investigation.

Begin the core drilling using a double-tube swivel-core barrel of the desired size. After drilling no more than 10 feet (3 meters), remove the core barrel from the hole and take out the core. If the core blocks the flow of the drilling fluid during drilling, remove the core barrel immediately.

Since rock structures and the occurrence of bedding planes, porosity type/distribution, and fracture patterns are among the most important items to be detected and described, take special care to obtain and record these features. If such broken zones or cavities prevent further advance of the boring, one of the following three steps shall be taken: (1) cement the hole; (2) ream and case; or (3) case and advance with the next smaller size core barrel, as conditions warrant.

3.3 Rock Core Management and Labeling

Once the core barrel has been recovered, the rock core shall be carefully removed from the barrel, placed in a core tray (previously labeled "top" and "bottom" to avoid confusion), classified, and measured for percentage of recovery as well as the rock quality designation (RQD). Each core shall be described, classified, and logged using a uniform system (Section 3.5 of this SOP).

Rock cores shall be placed in the sequence of recovery in well-constructed wooden or cardboard boxes provided by the drilling contractor. Rock cores from two different borings shall not be placed in the same core box. The core boxes shall be constructed to accommodate at least 20 linear feet of core in rows of approximately 5 feet each. Wood partitions shall be placed at the end of each core run. The depth from the surface of the boring to the top and bottom of the drill run and run number shall be marked on the wooden partitions with indelible ink. These blocks will serve to separate successive core runs and indicate depth intervals for each run. The order of placing cores shall be the same in all core boxes. Rock core shall be placed in the box so that, when the box is open, with the inside of the lid facing the observer, the top of the cored interval contained within the box is in the upper left corner of the box, and the bottom of the cored interval is in the lower right corner of the box. The top and bottom of each core obtained and its true depth shall be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movement of the core in the box. Similarly, an empty space in a row shall be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box.

The inside and outside of the core-box lid shall be marked by indelible ink to show all pertinent data on the box's contents. At a minimum, the following information shall be included:

- Project name
- Project number
- Boring number
- Run numbers
- Footage (depths)
- Recovery
- RQD (%)
- Box number and total number of boxes for that boring (Example: Box 5 of 7)
- Contact person's name and telephone number.

For easy retrieval when core boxes are stacked, the sides and ends of the box shall also be labeled and include project number, boring number, top and bottom depths of core and box number.

Prior to final closing of the core box, a photograph of the recovered core and the labeling on the inside cover shall be taken. If moisture content is not critical, the core shall be wetted and wiped clean for the photograph. (This will help to show true colors and bedding features in the cores).

3.4 Air Rotary Drilling

Air-rotary drilling is a method of drilling where the drill rig simultaneously turns and exerts a downward pressure on the drilling rods and bit while circulating compressed air down the inside of the drill rods, around the bit, and out the annulus of the borehole. Air circulation serves to both cool the bit and remove the cuttings from the borehole.

Advantages of this method include:

- The drilling rate is high (even in rock)
- The cost per foot of drilling is relatively low
- Air-rotary rigs are common in most areas
- No drilling fluid is required (except when water is injected to keep down dust)
- The borehole diameter is large, to allow room for proper well installation procedures

Disadvantages to using this method include:

- Formations must be logged from the cuttings that are blown to the surface and thus the depths of materials logged are approximate
- Air blown into the formation during drilling may "bind" the formation and impede well development and natural groundwater flow
- In-situ samples cannot be taken, unless the hole is cased
- Air-rotary drill rigs are large and heavy
- Large amounts of Investigation Derived Waste (IDW) may be generated which may require containerization, sampling, and off-site disposal.

4.0 GEOLOGIC DESCRIPTION OF BOREHOLES IN ROCK

These procedures provide descriptions of the standard techniques for borehole and sample logging. These logging techniques shall be used for each boring to provide consistent descriptions of subsurface lithology. While experience is the only method to develop confidence and accuracy in the description of soil and rock, the field geologist/engineer can do a good job of classification by careful, thoughtful observation and by being consistent throughout the classification procedure.

The classification of soil and rocks is one of the most important jobs of the field geologist/engineer. To maintain a consistent flow of information, it is imperative that the field geologist/engineer understand and accurately use the field classification system described in this SOP. This identification is based on visual examination and manual tests.

4.1 Required Field Forms and Equipment

When logging soil and rock samples, the geologist or engineer should be equipped with the following:

Rock hammer
Knife
Camera
10% Dilute hydrochloric acid (HCl)
Ruler (marked in tenths and hundredths of feet)
Hand lens
Writing utensil with indelible ink
Field logbook
Disposable medical-grade gloves (e.g., latex, nitrile)
Soil/rock classification sheets

4.2 Classification of Rocks

Claystone - Very fine-grained rock made up of particle less than 1/256 mm in diameter. Fractures irregularly. Very smooth to touch. Generally has irregularly spaced pitting on surface of drilled cores.

Shale - A fissile very fine-grained rock with particles less than 1/256 mm in diameter. Fractures along bedding planes.

Limestone - Rock made up predominantly of calcite ($CaCO_3$, which is mainly fossilized animal and plant debris). Effervesces strongly upon the application of dilute hydrochloric acid.

Coal – A very dark colored rock consisting mainly of organic (mainly fossilized plant debris) remains.

Others - Numerous other sedimentary rock types are present in lesser amounts in the stratigraphic record.

The local abundance of any of these rock types is dependent upon the depositional history of the area. Conglomerate, halite, gypsum, dolomite, anhydrite, lignite, etc. are some of the rock types found in lesser amounts.

In classifying a sedimentary rock the following hierarchy shall be noted: Rocks are grouped into three main divisions: sedimentary, igneous and metamorphic. Sedimentary rocks are by far the predominant type exposed at the earth's surface and are the only type present at NSWC Crane. The following basic names are applied to the types of rocks found in sedimentary sequences:

Sandstone - Made up predominantly of granular materials ranging between 1/16 to 2 mm in diameter.

Siltstone - Made up of granular materials between 1/16 to 1/256 mm in diameter. Fractures irregularly. Medium thick to thick bedded.

4.2.1 Rock Type

As described above, there are numerous types of sedimentary rocks. In most cases, a rock will be a combination of several grain types, therefore, a modifier such as a sandy siltstone, or a silty sandstone

can be used. The modifier indicates that a significant portion of the rock type is composed of the modifier. Other modifiers can include carbonaceous, calcareous, siliceous, fossiliferous, etc.

Grain size is the basis for the classification of clastic (sandstones, siltstones, and shales) sedimentary rocks. The Udden-Wentworth classification will be assigned to sedimentary rocks (shown below). The individual boundaries are slightly different than the USCS subdivision for soil classification. For field determination of grain sizes, a scale can be used for the coarse grained rocks. Alternatively, the division between siltstone and shale may be measurable in the field by the use of a hand lens. If the grains cannot be seen with the naked eye but are distinguishable with a hand lens, the rock is a siltstone. If the grains are not distinguishable with a hand lens, the rock is a shale.

GRAIN SIZE CLASSIFICATION FOR ROCKS

Particle Name	Grain Size Diameter
Cobbles	> 64 mm
Pebbles	4 - 64 mm
Granules	2 - 4 mm
Very Coarse Sand	1 - 2 mm
Coarse Sand	0.5 - 1 mm
Medium Sand	0.25 - 0.5 mm
Fine Sand	0.125 - 0.25 mm
Very Fine Sand	0.0625 - 0.125 mm
Silt	0.0039 - 0.0625 mm
After Wentworth, 1922	

4.2.2 Color

The color of a rock can be determined in a similar manner as for soil samples. Rock core samples shall be classified while wet, when possible, and air cored samples shall be scraped clean of cuttings prior to color classifications. Soil colors shall be described utilizing a single color descriptor preceded, when necessary, by a modifier to denote variations in shade or color mixtures. A soil could therefore be referred to as "gray" or "light gray" or "blue-gray." Since color can be utilized in correlating units between sampling locations, it is important for color descriptions to be consistent from one boring to another.

4.2.3 Bedding Thickness

The bedding thickness designations listed below will also be used for rock classification.

BEDDING THICKNESS CLASSIFICATION

Thickness (metric)	Thickness (Approximate English Equivalent)	Classification
> 1.0 meter	> 3.3'	Massive
30 cm - 1 meter	1.0' - 3.3'	Thick Bedded
10 cm - 30 cm	4" - 1.0'	Medium Bedded
3 cm - 10 cm	1" - 4"	Thin Bedded
1 cm - 3 cm	2/5" - 1"	Very Thin Bedded
3 mm - 1 cm	1/8" - 2/5"	Laminated
1 mm - 3 mm	1/32" - 1/8"	Thinly Laminated
< 1 mm	<1/32"	Micro Laminated

(Weir, 1973; Ingram, 1954)

4.2.4 Hardness

The hardness of a rock is a function of the compaction, cementation, and mineralogical composition of the rock. A relative scale for sedimentary rock hardness is as follows:

Soft - Weathered, considerable erosion of core, easily gouged by screwdriver, scratched by fingernail. Soft rock crushes or deforms under pressure of a pressed hammer. This term is always used for the hardness of the saprolite (decomposed rock which occupies the zone between the lowest soil horizon and firm bedrock).

Medium soft - Slight erosion of core, slightly gouged by screwdriver, or breaks with crumbly edges from single hammer blow.

Medium hard - No core erosion, easily scratched by screwdriver, or breaks with sharp edges from single hammer blow.

Hard - Requires several hammer blows to break and has sharp conchoidal breaks. Cannot be scratched with screwdriver.

Note the difference in usage of the words "scratch" and "gouge." A scratch shall be considered a slight depression in the rock (do not mistake the scraping off of rock flour from drilling with a scratch in the rock itself), while a gouge is much deeper.

4.2.5 Fracturing

Method of Calculating RQD
(After Deere, 1964)

Fractures should also be noted.

$$RQD\ \% = r/l \times 100$$

r = Total length of all pieces of the lithologic unit being measured, which are greater than 4 inches in length, and have resulted from natural breaks. Natural breaks include slickensides, joints, compaction slicks, bedding plane partings (not caused by drilling), friable zones, etc.

l = Total length of the coring run.

4.2.6 Weathering

The degree of weathering is a significant parameter that is important in determining weathering profiles and is also useful in engineering designs. The following terms can be applied to distinguish the degree of weathering:

Fresh - Rock shows little or no weathering effect. Fractures or joints have little or no staining and rock has a bright appearance.

Slight - Rock has some staining which may penetrate several centimeters into the rock. Clay filling of joints may occur. Feldspar grains may show some alteration. Oxidation and weathering may be the degree of fracturing or brokenness of a rock is described by measuring the fractures or joint spacing. After eliminating drilling breaks, the average spacing is calculated and the fracturing is described by the following terms:

Very broken (V. BR.) - Less than 2-inch spacing between fractures
Broken (BR.) - 2-inch to 1-foot spacing between fractures
Blocky (BL.) - 1- to 3-foot spacing between fractures
Massive (M.) - 3 to 10-foot spacing between fractures

The structural integrity of the rock can be approximated by calculating the Rock Quality Designation (RQD) of cores recovered. The RQD is determined by adding the total lengths of all pieces exceeding 4 inches and dividing by the total length of the coring run, to obtain a percentage. .

Moderate - Most of the rock, with exception of quartz grains, is stained. Rock is weakened due to weathering and can be easily broken with hammer.

Severe - All rock including quartz grains is stained. Some of the rock is weathered to the extent of becoming a soil. Rock is very weak.

4.2.7 Other Characteristics

The following items shall be included in the rock description:

Description of contact between two rock units. These can be sharp or gradational.

- Stratification (parallel, cross stratified).
- Description of any filled cavities or vugs.
- Cementation (calcareous, siliceous, hematitic).
- Description of any joints or open fractures.
- Observation of the presence of fossils.
- Notation of joints with depth, approximate angle to horizontal, any mineral filling or coating, and degree of weathering.

All information shown on the boring logs shall be neat to the point where it can be reproduced on a copy machine for report presentation. The data shall be kept current to provide control of the drilling program and to indicate various areas requiring special consideration and sampling.

4.2.8 Additional Terms Used in the Description of Rock

The following terms are used to further identify rocks:

Seam - Thin (12 inches or less), probably continuous layer.

Some - Indicates significant (15 to 40 percent) amounts of the accessory material. For example, rock composed of seams of sandstone (70 percent) and shale (30 percent) would be "sandstone -- some shale seams."

Few - Indicates insignificant (0 to 15 percent) amounts of the accessory material. For example, rock composed of seam of sandstone (90 percent) and shale (10 percent) would be "sandstone -- few shale seams."

Interbedded - Used to indicate thin or very thin alternating seams of material occurring in approximately equal amounts. For example, rock composed of thin alternating seams of sandstone (50 percent) and shale (50 percent) would be "interbedded sandstone and shale."

Interlayered - Used to indicate thick alternating seams of material occurring in approximately equal amounts.

4.2.9 Abbreviations

Abbreviations may be used in the description of a rock. However, they shall be kept at a minimum. Following are some of the abbreviations that may be used:

C - Coarse	Lt - Light	Yl - Yellow
Med - Medium	BR - Broken	Or - Orange
F - Fine	BL - Blocky	SS - Sandstone
V - Very	M - Massive	Sh - Shale
Sl - Slight	Br - Brown	LS - Limestone
Occ - Occasional	Bl - Black	Fgr - Fine-grained
Tr - Trace		

5.0 BORING LOGS AND DOCUMENTATION

This section describes in more detail the procedures to be used in completing boring logs in the field. Information obtained from the preceding sections shall be used to complete the logs. A sample boring log is attached at the end of this SOP.

The field geologist/engineer shall use this example as a guide in completing each boring log. Each boring log shall be fully described by the geologist/engineer as the boring is being drilled. Every sheet contains space for 25 feet of log. Information regarding classification details is provided either on the back of the

boring log or on a separate sheet, for field use. All data shall be written directly on the boring log. Additional notes may be entered in a field notebook if more space is needed.

5.1 Remarks Column

The following information shall be entered under the "Remarks" column and shall include, but is not limited to, the following:

- Moisture - estimate moisture content using the following terms - dry, moist, wet and saturated. These terms are determined by the individual. Whatever method is used to determine moisture, be consistent throughout the log.

- Angularity - describe angularity of coarse grained particles using the terms angular, subangular, subrounded, or rounded. Refer to ASTM D 2488 or Earth Manual for criteria for these terms.

- Particle shape - flat, elongated, or flat and elongated.

- Maximum particle size or dimension.

- Water level observations.

- Reaction with HCl - none, weak, or strong.

Additional comments:

- Indicate presence of mica, caving of hole, when water was encountered, difficulty in drilling, loss or gain of water.

- Indicate odor and Photoionization Detector (PID) readings.

- Indicate any change in lithology by drawing a line through the lithology change column and indicate the depth. This will help when cross-sections are subsequently constructed.

- At the bottom of the page indicate type of rig, drilling method, hammer size and drop, and any other useful information (i.e., borehole size, casing set, changes in drilling method).

- Vertical lines shall be drawn in the Material Description column from the bottom of each sample to the top of the next sample to indicate consistency of material from sample to sample, if the material is consistent. Horizontal lines shall be drawn if there is a change in lithology, then vertical lines drawn to that point.

- Indicate screened interval of well, as needed, in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.2 Rock Classification

Indicate depth at which coring began by drawing a line at the appropriate depth. Indicate core run depths by drawing coring run lines (as shown) under the first and fourth columns on the log sheet. Indicate core run number, RQD percent, and core recovery under the appropriate columns.

Indicate lithology change by drawing a line at the appropriate depth as explained above.

Rock hardness is entered under designated column using terms as described on the back of the log or as explained earlier in this section.

Enter color as determined while the core sample is wet; if the sample is cored by air, the core shall be scraped clean prior to describing color.

Enter rock type based on sedimentary, igneous or metamorphic. For sedimentary rocks use terms as described in Section 5.3. Again, be consistent in classification. Use modifiers and additional terms as needed. For igneous and metamorphic rock types use terms as described in Sections 5.3.8.

Enter brokenness of rock or degree of fracturing under the appropriate column using symbols VBR, BR, BL, or M as explained in Section 5.3.5 and as noted on the back of the Boring Log.

The following information shall be entered under the remarks column. Items shall include but are not limited to the following:

- Indicate depths of joints, fractures and breaks and also approximate to horizontal angle (such as high, low), i.e., 70° angle from horizontal, high angle.

- Indicate calcareous zones, description of any cavities or vugs.
- Indicate any loss or gain of drill water.
- Indicate drop of drill tools or change in color of drill water.

Remarks at the bottom of Boring Log shall include:

- Type and size of core obtained.
- Depth casing was set.
- Type of rig used.

As a final check the boring log shall include the following:

- Vertical lines shall be drawn as explained for soil classification to indicate consistency of bedrock material.

- If applicable, indicate screened interval in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.3 Classification of Soil and Rock from Drill Cuttings

The previous sections describe procedures for classifying rock samples when cores are obtained. However, some drilling methods (air/mud rotary) may require classification and borehole logging based on identifying drill cuttings removed from the borehole. Such cuttings provide only general information on subsurface lithology. Some procedures that shall be followed when logging cuttings are:

- Obtain cutting samples at approximately 5-foot intervals, sieve the cuttings (if mud rotary drilling) to obtain a cleaner sample, place the sample into a small sample bottle or "zip lock" bag for future reference, and label the jar or bag (i.e. hole number, depth, date, etc.). Cuttings shall be closely examined to determine general lithology.

- Note any change in color of drilling fluid or cuttings, to estimate changes in lithology.

- Note drop or chattering of drilling tools or a change in the rate of drilling, to determine fracture locations or lithologic changes.

- Observe loss or gain of drilling fluids or air (if air rotary methods are used), to identify potential fracture zones.

- Record this and any other useful information onto the boring log.

This logging provides a general description of subsurface lithology and adequate information can be obtained through careful observation of the drilling process. It is recommended that split-barrel and rock core sampling methods be used at selected boring locations during the field investigation to provide detailed information to supplement the less-detailed data generated through borings drilled using air/mud rotary methods.

5.4 Review

Upon completion of the borings logs, copies shall be made and reviewed. Items to be reviewed include:

Checking for consistency of all logs.
Checking for conformance to the guideline.
Checking to see that all information is entered in their respective columns and spaces.

Originals of the boring logs shall be retained in the project files.

7.0 ATTACHMENTS

1. Boring Log

ATTACHMENT 1

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: _____ BORING No.: _____
PROJECT NUMBER: _____ DATE: _____
DRILLING COMPANY: _____ GEOLOGIST: _____
DRILLING RIG: _____ DRILLER: _____

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm): [ ]

Remarks: _____

Converted to Well: Yes _____ No _____ Well I.D. #: _____

STANDARD OPERATING PROCEDURE
NUMBER CTO126-12

MONITORING WELL INSTALLATION

1.0 PURPOSE

This procedure provides general guidance and information pertaining to proper design and installation of ground water monitoring wells. The methods described herein are specific for monitoring well construction at the Jeep Trail, at the NSWC Crane facility. Guidelines by South Division, Naval Facilities Engineering Command, (South Div NavFac, 1997) and the State of Indiana regulatory requirements in Article 16 Water Well Drillers of Chapter 310 of the Indiana Annotated Codes (310 IAC 16) should be consulted.

2.0 RESPONSIBILITIES

Driller - The driller provides adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force capable of performing all phases of proper monitoring well installation and construction. The drilling contractor personnel must have all of the health and safety training required to perform the work, as specified in the Health and Safety Plan. The driller is also responsible for obtaining, in advance, any required permits for drilling and monitoring well installation and construction.

Field Geologist - The field geologist supervises and documents well installation and construction performed by the driller, and insures that the screen interval for each monitoring well is properly placed to provide representative groundwater data from the monitored interval. Geotechnical engineers, field technicians, or other suitable trained personnel may also serve in this capacity.

Site Safety Officer – The Site Safety Officer is responsible for clearing the drill site for underground and overhead utilities, or other potentially hazardous obstructions.

3.0 REQUIRED EQUIPMENT/ITEMS

The following list includes equipment and items required for monitoring well installation:

Health and safety equipment as required by the HASP and the Site Safety Officer.

Well drilling and installation equipment with associated materials (typically supplied by the driller).

Hydrogeologic equipment (weighted engineer's tape, water level indicator, retractable engineer's rule, electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, boring logs, soil sample log forms, chain-of-custody records, sample coolers with ice, and a field notebook).

4.0 WELL DESIGN AND CONSTRUCTION

All nine shallow well borings will be drilled using minimum 4-inch inside diameter hollow-stem augers to the desired depth of each well boring. Rotary drilling with a roller bit and water wash or air rotary drilling can be used to extend the shallow well borings, in the event that bedrock comprised of aquifer material is encountered prior to reaching the desired well depth. In no cases, will the elwren shale be completely penetrated unless a steel casing is installed and grouted in place at the top of the elwren shale.

Two of the deep monitoring well borings (03MWT10 and 03MWT12) will be drilled using hollow-stem auger or rotary drilling techniques until the bedrock of the elwren shale is reached. A six-inch diameter steel casing will be installed to the top of the elwren shale and will be grouted with a cement-bentonite slurry in a manner to ensure that the entire annulus between the casing and borehole is sealed. Diamond coring (NX) will be initiated after the grout is allowed to cure for a minimum of 24 hours. For each well, the coring will proceed from the bottom of the casing to the full depth as shown on Table 4-5 of the QAPP. Once the coring has been completed and the core has been logged (see SOP CTO126-11), then the hole will be reamed out with a minimum 5-inch-diameter air rotary bit. The air rotary equipment must have a filter on the compressed air line going to the borehole to prevent oil and other organics from being introduced. Once the hole has been cleaned out using the compressed air of the rig, packer testing of the hole can proceed (see SOP CTO126-13). Installation of the monitoring well follows the packer testing. Note: all drilling and packer testing equipment must be decontaminated before it is placed in a borehole.

The two additional deep monitoring well borings (03MWT11 and 03MWT13) will be drilled in the same manner as the initial deep well borings, however, no coring will be performed. The boring will be logged using the rock chips and dust blown up the boring by the return air of the drill bit (see SOP CTO126-11). The borehole will then be cleaned out using compressed air from the drill bit.

All monitoring wells will be constructed of schedule-40, flush-joint threaded, 2-inch inside diameter PVC riser pipe and flush joint threaded, factory slotted well screen with a threaded end cap. The well screens will be factory slotted to 0.020-inch size. Each section of well casing and screen shall be National Sanitation Foundation (NSF) approved. Well screens will be 10-feet long, but may be longer or shorter based on the subsurface conditions encountered. A PVC cap will be placed on the bottom and will also be flush-threaded. Other means of joining casings using glue, gaskets, pop rivets or screws are not allowed. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material.

Monitoring wells will be installed immediately upon completion of drilling or packer testing, if performed. A well screen section with bottom cap and the proper amount of riser pipe will be assembled and lowered down the borehole. Centralizers will be used as necessary to ensure that the casing and screen are centered and are aligned straight. The sand pack will be extended from 0.5 feet below the well screen to 2.0 feet above the top of the well screen. Clean silica sand of U.S. Standard Sieve Size No. 20 to 40 will be used.

A minimum 3-foot-thick bentonite pellet seal will be installed above the filter pack and allowed to hydrate for a minimum of 3 hours before grout is added above the seal. Only 100-percent, certified pure, sodium bentonite will be used for well construction. The depths of backfill materials will be constantly monitored during well installation using a weighted stainless steel or fiberglass tape measure.

The remaining annulus above the hydrated bentonite seal will be backfilled to the surface using a tremie pipe, with a 20:1 cement/bentonite grout. A maximum of 10 gallons of water per 94-pound bag of Type-1 cement will be used. The grout mixture should be blended in an above-ground rigid container or mixer to produce a thick lump-free mixture. This grout mixture shall also be used for placement of steel casings in deep wells.

Bentonite expands by absorbing water and provides a seal between the screened interval and the overlying portion of the annular space and formation. Cement-bentonite grout is placed on top of the bentonite pellets extending to the surface. The grout effectively seals the well and eliminates the possibility for surface infiltration reaching the screened interval. Grouting also replaces material removed during drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used to introduce grout from the bottom of the hole upward, to prevent bridging, and to provide a better seal. However, in shallow boreholes that don't collapse, it may be more practical to pour the grout from the surface without a tremie pipe.

When the well is completed and grouted to the surface, a protective steel surface casing is placed over the top of the riser pipe. The finished well casing shall extend at least 2 feet above the ground level. This casing will have a cap that can be locked to prevent vandalism. A vent hole shall be provided in the cap to allow venting of gases and maintain atmospheric pressure as water levels rise or fall in the well. The protective casing has a larger diameter than the riser pipe and is set into the wet cement grout over the well upon completion or can be placed between the steel casing and the riser pipe in the case of deep monitoring well borings. In addition, one hole is drilled just above the cement collar through the protective casing which acts as a weep hole for the flow of water which may enter the annulus during well development, purging, or sampling.

5.0 DOCUMENTATION OF FIELD ACTIVITIES

A critical part of monitoring well installation is recording of significant details and events in the site logbook, on field forms, and a field logbook. Details of borehole logging are contained in SOP CTO126-11.

6.0 ATTACHMENTS

1. Bedrock Monitoring Well Sheet
2. Overburden Monitoring Well Sheet

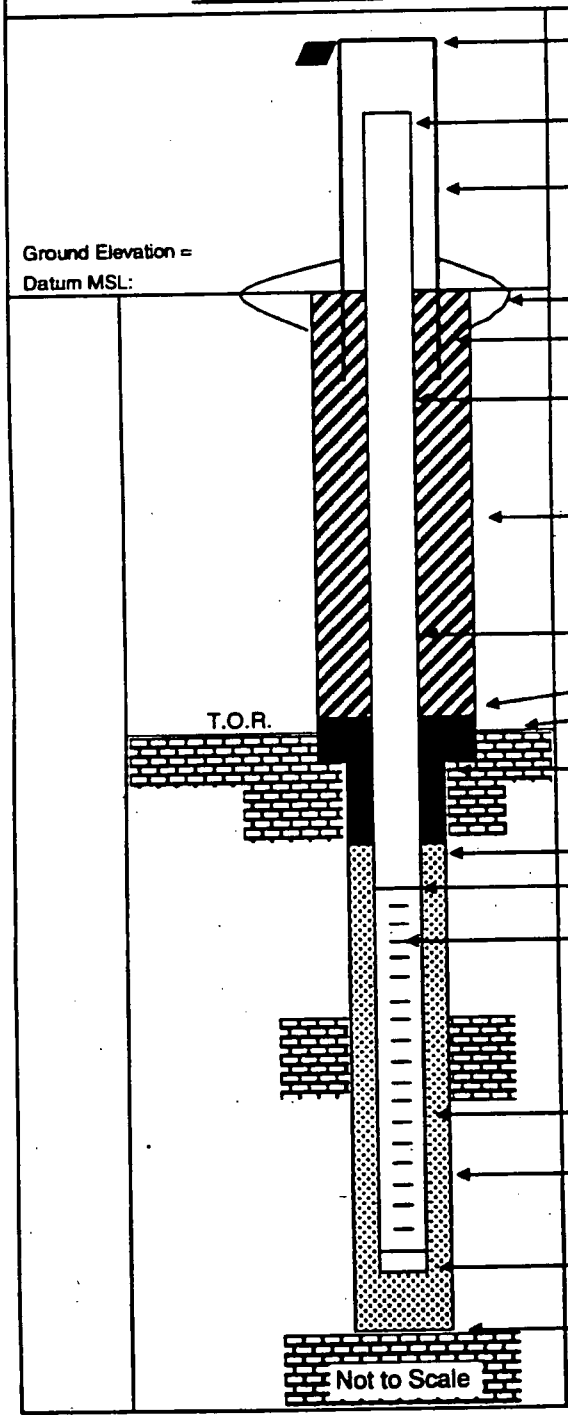
ATTACHMENT 1
BEDROCK MONITORING WELL SHEET

Tetra Tech NUS, Inc.

BEDROCK
MONITORING WELL SHEET

WELL No.: _____
PERMIT No:

PROJECT:	_____	DRILLING Co.:	_____	BORING No.:	_____
PROJECT No.:	_____	DRILLER:	_____	DATE COMPLETED:	_____
SITE:	_____	DRILLING METHOD:	_____	NORTHING:	_____
GEOLOGIST:	_____	DEV. METHOD:	_____	EASTING:	_____



Elevation of Top of Casing: _____

Stick Up of Casing Above Ground Surface: _____
Elevation of Top of Riser: _____

I.D. of Surface Casing: _____

Type of Surface Casing: _____

Type of Surface Seal: _____

I.D. of Permanent Casing: _____

I.D. of Riser: _____

Type of Riser: _____

Borehole Diameter: _____

Type of Backfill: _____

Elevation / Depth Top of Seal: _____ / _____
Elevation / Depth Top of Bedrock: _____ / _____

Type of Seal: _____

Elevation / Depth of Top of Fine Sand: _____ / _____
Elevation / Depth of Top of Filter Pack: _____ / _____
Elevation / Depth of Top of Screen: _____ / _____

Type of Screen: _____

Slot Size x Length: _____

I.D. of Screen: _____

Type of Filter Pack: _____

Diameter of Hole in Bedrock:
Core / Ream: _____

Elevation / Depth of Bottom of Screen: _____ / _____

Elevation / Total Depth of Borehole: _____ / _____

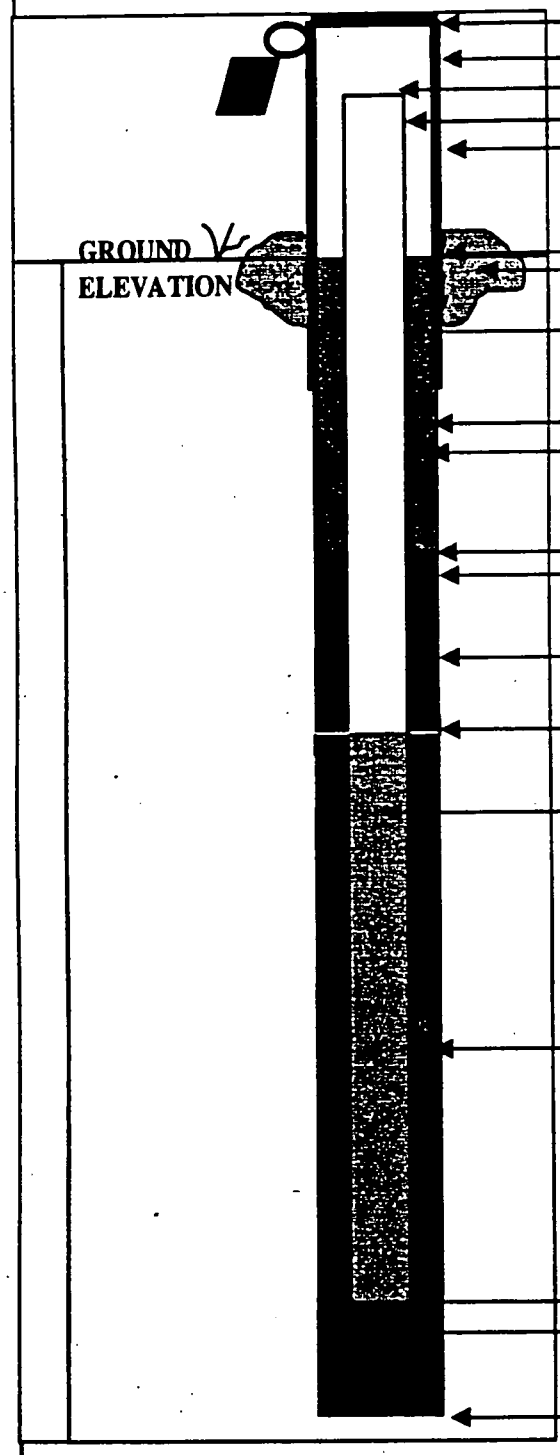
ATTACHMENT 2

OVERBURDEN MONITORING WELL SHEET

BORING NO.: _____

Tetra Tech NUS, Inc. **OVERBURDEN MONITORING WELL SHEET**

PROJECT:		DRILLING Co.:		BORING No.:	
PROJECT No.:		DRILLER:		DATE COMPLETED:	
SITE:		DRILLING METHOD:		NORTHING:	
GEOLOGIST:		DEV. METHOD:		EASTING:	



ELEVATION OF TOP OF SURFACE CASING: _____
STICK -UP TOP OF SURFACE CASING: _____
ELEVATION OF TOP OF RISER PIPE: _____
RISER STICK-UP ABOVE GROUND SURFACE: _____
I.D. OF SURFACE CASING: _____
TYPE OF SURFACE CASING: _____

GROUND ELEVATION: _____
TYPE OF SURFACE SEAL: _____

RISER PIPE I.D.: _____
TYPE OF RISER PIPE: _____

BOREHOLE DIAMETER: _____
TYPE OF SEAL: _____

ELEVATION / DEPTH OF SEAL: _____ / _____
TYPE OF SEAL: _____

ELEVATION / DEPTH TOP OF FILTER PACK: _____ / _____

ELEVATION / DEPTH TOP OF SCREEN: _____ / _____

TYPE OF SCREEN: _____

SLOT SIZE X LENGTH: _____

I.D. OF SCREEN: _____

TYPE OF FILTER PACK: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: _____ / _____
ELEVATION / DEPTH BOTTOM OF FILTER PACK: _____ / _____
TYPE OF BACKFILL BELOW WELL: _____
ELEVATION / DEPTH OF BOREHOLE: _____ / _____

STANDARD OPERATING PROCEDURE
NUMBER CTO126-13

PACKER TESTING OF UNCASED BOREHOLES

1.0 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) delineates protocols for performing packer tests in open holes in bedrock at the Jeep Trail at the NSWC Crane facility. These tests will allow hydraulic properties of rock to be determined and ground water samples to be collected, if needed, from specific depth intervals.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Submersible pump with 0.5-10 gpm capacity
Inflatable packers
Drill rig and associated equipment
Teflon-coated drop tube
Stainless-steel cable
Pressure transducer and data recorder
Photoionization Detector (PID)
Water quality meter
High pressure steel tubing

3.0 PROCEDURE

3.1 Determine depth intervals of the open borehole to be tested.

3.2 Lower the decontaminated packer assembly down to the first desired interval to be tested.

3.3 Pack off the top and bottom of the test interval with inflatable packers which are attached to high-pressure steel tubing.

3.4 Monitor the hydraulic pressure in the test section, until the pressure reaches a constant value (i.e., steady-state). Record times and pressure values on data logger.

3.5 Once the pressure has reached steady state, turn on the pump, which will produce water at a rate of about one gpm.

3.6 Monitor the hydraulic pressure during pumping. Do not let the water level drop below the top packer elevation (i.e., do not let the packed interval become dewatered).

3.7 If the water level drops quickly, reduce the pumping rate to the lowest steady level and continue to record the water pressure.

3.8 Monitor water quality parameters (pH, ORP, temperature, D.O., turbidity, and specific conductance) in accordance with SOP CTO126-16 in-line in the pump discharge line during the test. Record values every two to three minutes.

3.9 Monitor the flow rates during the test and record every two minutes. Any time the pump rate is intentionally reduced, record this information.

3.10 After approximately 15 minutes of pumping and when the ground water elevation has stabilized and is still well above the top packer elevation, a step increase in pumping rate may be achievable. Increase the pumping rate to about 5 gpm and repeat steps 3.6 through 3.9.

3.11 If, after about 15 minutes, the ground water elevation has stabilized, attempt to increase the pumping rate to 10 gpm. **Do not let the water level drop below the top of the packer assembly.** If the water pressure drops quickly, cut the pumping rate down to 7 or 8 gpm, or stop pumping altogether.

3.12 Record water pressures and water quality parameters every 2 to 3 minutes. When the pressure transducer readings have stabilized (i.e., remained constant over a 5 minute period), the test is completed.

3.13 Turn off the pump and deflate the packers.

3.14 Lower the pump and the packer assembly to the next interval selected for testing.

3.15 Repeat steps 3.3 through 3.13 for next test interval.

3.16 When testing is completed, remove the packer assembly, pump, and other equipment from the hole. Decontaminate all equipment as described in SOP CTO126-17.

3.17 Contain all water produced during testing. Transport the IDW water to the central storage area per SOP CTO126-15.

STANDARD OPERATING PROCEDURE
NUMBER CTO126-14

CALIBRATION AND CARE OF WATER QUALITY METER

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedures for the calibration and maintenance of field instruments used to measure water quality, and for the proper documentation of calibration and maintenance. The YSI 6-Series Environmental Monitoring System will be used to measure pH, temperature, oxidation-reduction potential (ORP), specific conductance (SC), dissolved oxygen (DO), and turbidity in water. The YSI meter has a multiprobe sensor, which can be used in conjunction with a flow-through cell attached to a pump discharge tube to measure water quality parameters in a ground water discharge, or can be immersed in a surface water body such as a stream, pond, or drainage ditch.

2.0 FIELD FORMS AND EQUIPMENT LIST

The following log books, forms, equipment and supplies are required.

Site log book
Equipment calibration log sheet
YSI Model 610-D and Sonde: multi-parameter water quality meter with flow through cell
Equipment manual
Calibration kit
Deionized water, paper towels, spray bottle etc.
Disposable medical-grade gloves (e.g., latex, nitrile)

3.0 PROCEDURES

This section describes the calibration procedure for the YSI Model 610-D. The meter is supplied with an instruction manual. Sections of this manual are reproduced in this SOP. The manual will be on-site and used as the calibration guidance document for the meter's calibration (page 29, Section 2.6 of the manual

starts the calibration procedure). This procedure will list requirements for frequency of calibration and checks to be performed on the meter.

The YSI Model 610-D and Sonde is a multi-parameter, water quality meter that may be used to measure open water bodies (streams, ponds, springs, etc.) with the probe guard installed. With the flow through cell attached, the meter has the ability to measure water quality parameters in ground water via a pump discharge line. By performing the measurements in the discharge line coming directly from the well, the parameters are measured prior to the ground water coming in contact with the atmosphere. The parameters measured by the YSI for this field effort are:

- Dissolved Oxygen (DO)
- Specific Conductance (SC)
- Temperature
- pH
- Oxidation-Reduction Potential (ORP)
- Turbidity

3.1 Documentation

The Equipment Calibration Log is used to document calibration of measuring equipment used in the field. The Equipment Calibration Log documents that the manufacturer's instructions were followed for calibration of the equipment, including the frequency of calibration, type of standards used, and checks performed on calibration during the course of using the equipment. An Equipment Calibration Log must be maintained for each measuring device that requires calibration. Entries must be made for each day the equipment is used. A blank Equipment Calibration Log form is attached at the end of this SOP.

3.2 Calibration

All the parameters listed in Section 3.0 must be calibrated prior to the start of each field effort. After this initial calibration, the YSI will be checked each day that it is used. If the check shows any out-of-spec readings, the specific probe will be recalibrated. Meter specifications can be found in the equipment manual, starting on page 248. Calibration and calibration checks will be documented in the Field Logbook and on the Equipment Calibration Log. The name, lot number, and expiration date for all calibration buffers and standards used will be recorded on the Equipment Calibration Log. The meter's model, serial number, and name of rental company will also be recorded on the equipment calibration form.

3.3 Tips for Good Calibration

- The DO calibration is a water-saturated air calibration. Make certain to loosen the calibration cup seal to allow pressure to equilibrate before calibrating.
- Make certain that sensors are completely submersed in solution and readings are stable when calibration values are entered.
- Use a small amount of calibration solution (previously used solution may be used, then discarded for this purpose) to pre-rinse the sonde.
- Fill a bucket with ambient temperature water to rinse the sonde between calibration solutions.
- Make sure to rinse and dry the probe between calibration solutions. This will reduce carry-over contamination and increase the accuracy of the calibration.

4.0 MAINTENANCE

The YSI Meter will be rented for the duration of each brief field effort. Therefore, little field maintenance will be required. For any maintenance other than the routine cleaning, calibrating, or battery charging, the instrument should be returned to the vendor and a replacement sent immediately to the job site.

4.1 Meter Storage

For this field effort, the meter storage will be short term, i.e. over-night or between work shifts (4-day break). During these breaks the meter shall be placed on charge. One-half inch of tap or distilled water shall be placed in the meter calibration cup and the cup threaded onto the sonde. The key for short-term storage of probes is to use a minimal amount of water so that the calibration cup will remain at 100% humidity. The water level must be low enough so that none of the probes are actually immersed. Proper storage of the sonde between usage will extend its life and will also ensure that the unit is ready for use as quickly as possible for the next application.

Multi-parameter short term storage key points:

- Use enough water to provide humidity, but not enough to cover the probe surfaces.
- Make sure the storage vessel is sealed to minimize evaporation.

- Check periodically to make certain that water is still present.

4.2 Probe Cleaning

- Rinse the probe thoroughly with potable water.
- Wash the probe in a mild solution of Liquinox and water and wipe with paper towels and/or cotton swabs.
- Rinse and soak the probe in deionized water.
- If stronger cleaning is required, consult Section 2.10 on page 89 of the equipment manual.

Note: Reagents that are used to calibrate and check the YSI may be hazardous. Review the Health and Safety Plan, Appendix A of the equipment manual, and MSDS's, all of which are on file in the field trailer.

5.0 ATTACHMENTS

1. Equipment Calibration Log

ATTACHMENT 1
EQUIPMENT CALIBRATION LOG

Tetra Tech NUS, Inc.

EQUIPMENT CALIBRATION LOG

PROJECT NAME : _____ INSTRUMENT NAME/MODEL: _____

SITE NAME: _____ MANUFACTURER: _____

PROJECT No.: _____ SERIAL NUMBER: _____

Date of Calibration	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot No.)	Remarks and Comments
			Pre-calibration	Post-calibration	Pre-calibration	Post-calibration		

STANDARD OPERATING PROCEDURE
NUMBER CTO126-15

MANAGEMENT OF INVESTIGATION DERIVED WASTE

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes how investigation derived waste (IDW) will be collected, segregated, classified, and managed during the field investigations at the Ammunition Burning Ground (ABG), Little Sulphur Creek and Jeep Trail, at the NSWC Crane facility. The following types of IDW will be generated during this investigation:

- Excess soil and rock materials remaining from subsurface drilling activities
- Well development water and purge water related to monitoring well installation and sampling
- Decontamination solutions
- Personal protective equipment and clothing (PPE)
- Miscellaneous trash and incidental items

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Health and safety equipment (with PPE)
Decontamination equipment
Field logbook and indelible ink pen
Plastic sheeting and/or tarps
55-gallon drums with sealable lids
IDW labels for drums
Waste water container tanks
Plastic garbage bags

3.0 PROCEDURES

Management of IDW includes: the collection, segregation, temporary storage, classification, final disposal, and documentation of the waste handling activities.

3.1 Liquid Wastes

Liquid wastes that will be generated during the site activities include well development water, well purge water (collected during low-flow sampling), and decontamination solutions from drilling and sampling equipment. As they are collected, these wastewaters will be placed in a 300-gallon (or smaller) portable tank attached to a truck. Whenever the portable tank approaches full, it will be transported to a central location at NSWC Crane adjacent to a Crane-designated sanitary sewer manhole). The water in the portable tank will be discharged to the sewer by gravity draining.

An accurate record will be kept by the FOL of all wastewaters that have been placed in the large holding tank. At a minimum, this information will include:

- the location and type of each water that has been placed in the tank (e.g., purge water from well 03MW47),
- the quantity of water from each source,
- the date the waste water was generated,
- the date and time the waste water was placed in the tank,
- the person(s) present when the wastewaters were discharged to the sewer.

3.2 Drill Cuttings and Cores

As cuttings are removed from borings, they will be screened for VOCs. If these results do not show above-background levels of VOCs, the cuttings materials will be mixed with bentonite and returned to the borehole when sampling activities in the hole are completed or spread on the ground in the area of the borehole. The backfill materials will be tamped as they are placed in the hole to increase density and reduce permeability of the backfill material.

If any soil materials from a screened borehole interval shows evidence of contamination (based on the field screening results), then the soil material from the screened interval will be placed in a plastic trash bag (or directly in a drum if a larger quantity) and the bag will be tagged. Information included on the tag will consist of the hole from which the material came, the depth interval from which the material came, the date, and the name of the person filling out the tag. The bag will then be placed in a 55-gallon drum and sealed (more than one bag may be placed in a drum). The waste drums will be stored at the Jeep Trail temporarily until laboratory results have been received concerning the soil samples that were collected from the suspect borehole. If the results indicate that no contamination is present in the soil samples. then the soils will be disposed of at the Jeep Trail site. If the levels of contamination of any of the

samples from a borehole exceed TCLP limits (using the total soil concentrations), then all excess soil from the borehole will be considered as RCRA-hazardous and disposed of offsite in accordance with RCRA waste disposal regulations. Alternatively the toxicity characteristic leaching procedure may be conducted for any constituent which could exceed the TC limits based on total concentrations.

Cuttings from well borings will be handled in the same manner as soil boring cuttings.

3.3 PPE, Pump Discharge Tubing, DPT Sample Liners and Incidental Trash

All PPE wastes, pump discharge tubes, DPT sample liners and incidental trash materials (e.g., wrapping or packing materials from supply cartons, waste paper) will be decontaminated (if contaminated) double-bagged, securely tied shut, and placed in a designated waste receptacle at NSWC Crane.

STANDARD OPERATING PROCEDURE
NUMBER CTO126-16

LOW-FLOW WELL PURGING AND STABILIZATION

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedure for well purging and stabilization utilizing low-flow techniques.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following field forms and equipment are required for low-flow purging.

Low-Flow Purge Data Sheet: A copy of this form is attached at the end of this SOP.
Ground Water Sample Log Sheet: A copy of this form and instructions for its completion are included in SOP CTO126-05.
Bound Field Log Book
Writing Utensil
Photoionization detector (PID): The procedures for the operation of the PID are found in the Health and Safety Plan and SOP CTO126-06.
Well key
Electronic water level indicator: The water level indicator must have a cable of sufficient length to reach the water surface and be capable of measurements of 0.01-feet (see SOP CTO126-18).
Electronic Programmable Controller, model 400: This controller regulates air flow in a bladder pump.
Cylinder of compressed nitrogen with regulator: Compressed gas serves as the power source for the bladder pump.
Multiple parameter water quality meter: This unit measures and displays field parameters measured in the field including pH, dissolved oxygen, oxidation-reduction potential (ORP), temperature, and specific conductance (see SOP CTO126-14).
Flow-through cell adapter for water quality meter
LaMotte Turbidity Meter: Used to measure turbidity (see SOP CTO126-14).
Purge water containers
Graduated cylinder and stopwatch: Used to calculate flow rate.

Decontamination supplies: SOP CTO126-17 describes required decontamination supplies.

Disposable medical-grade gloves (e.g., latex, nitrile)

3.0 PROCEDURES FOR WELL PURGING

3.1 Prior to mobilizing to the site, clean, check for proper operation, and calibrate as per manufacturer requirements above equipment as necessary.

3.2 Follow the steps outlined in SOP CTO126-18 to obtain a static water level measurement of the well to be purged. Record the information on the Ground Water Sample Log Sheet and the Low-Flow Purge Data Sheet. Leave the water level meter suspended in the well casing.

3.3 Calculate one well casing volume as follows:

1. Obtain the total depth of the well from Table 4-4 of this QAPP.

2. Using the static water level determined in Step 3.2 of this SOP and the total depth of the well, calculate the well casing volume using the following formula:

$$V = (0.163)(T)(r^2)$$

where:

V	=	Static casing volume of well (in gallons).
T	=	Vertical height of water column (linear feet of water).
0.163	=	A constant conversion factor which compensates for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and pi.
r	=	Inside radius of the well casing (in inches).

Note: For wells of 1-inch radius (2-inch diameter) V = 0.163 gallons per foot of water column.

3.4 Connect the pump controller to the well pump air supply (at the well cap) by following the instructions in the pump control manual. The pump controller must be turned off when being connected.

3.5 Connect the nitrogen cylinder to the pump controller. The nitrogen cylinder valve must be closed and the regulator line pressure set at zero pounds per square inch (psi) when being connected.

3.6 Following the instructions found in the water quality meter manual, connect the flow-through cell to the pump discharge line (at the well cap).

3.7 Place the discharge tubing from the flow-through cell to direct the purge water discharge into the graduated cylinder or purge-water container.

3.8 Following the instructions in the pump controller manual, start pumping water from the well.

3.9 Start with the initial pump rate set at approximately 0.1 liters/minute. Use the graduated cylinder and stopwatch to measure the pumping rate. Adjust pumping rates as necessary to prevent drawdown from exceeding 0.3 feet during purging. If no drawdown is noted, the pump rate may be increased (to a max of 0.4 liters/minute) to expedite the purging and sampling event. The pump rate will be reduced if turbidity is greater than 10 NTUs after all other field parameters have stabilized. If ground water is drawn down below the top of the well screen, purging will cease and the well will be allowed to recover before purging continues. Slow recovering wells will be identified and purged at the beginning of the workday. If possible, samples will be collected from these wells within the same 8-hour workday and no later than 24 hours after the start of purging.

The time to sample any given well will vary greatly due to the many variables associated with low flow purging and sampling; i.e.,

- Stabilization of parameters
- Possible draw down
- Analytical changes from quarter to quarter
- Varying QA sample requirements from quarter to quarter
- Variable pump rates

Normally, the time from the start of purging to the end of sampling will be between 1 and 4 hours.

3.10 Measure the well water level using the water level meter every five minutes. Record the well water level on the Low-Flow Purge Data Form (attached at the end of this SOP.

3.11 Record on the Low-Flow Purge Data Form every five to ten minutes the water quality parameters (pH, specific conductance, temperature, turbidity, oxidation-reduction potential, and dissolved oxygen) measured by the water quality meter and turbidity meter. If the cell needs to be cleaned during purging operations, continue pumping (allow the pump to discharge into a container) and disconnect the cell. Rinse the cell with distilled water. After cleaning is completed, reconnect the flow-through cell and continue purging. Document the cell cleaning on the Low-Flow Purge Data Form.

3.12 Measure the flow rate using a graduated cylinder. Remeasure the flow rate any time the pump rate is adjusted.

3.13 During purging, check for the presence of bubbles in the flow-through cell. The presence of bubbles is an indication that connections are not tight. If bubbles are observed, check for loose connections.

3.14 Stabilization is achieved and sampling can begin when a minimum of one casing volume has been removed and three consecutive readings, taken at 5 to 10 minute intervals, are within the following limits:

- pH ± 0.1 standard units
- Specific conduct ± 5%
- Temperature ± 5%
- Turbidity less than 10 NTUs
- Dissolved oxygen ± 10%

If the above conditions have still not been met after the well has been purged for four hours, purging will be considered complete and sampling can begin. Record the final well stabilization parameters from the Low-Flow Purge Data From onto the Ground Water Sample Log Form.

If there is a need to leave a well during purging, there are two options:

- One, if the sampler must move for 30 minutes or less but still has a clear line of sight to the well, the sampler may leave the pump running and watch the well until the sampler is able to return to the well.

- Two, if for whatever reason, the sampler must stop purging for an extended period of time or a clear line of sight cannot be maintained, the pump and cell will be shut-down. All equipment and supplies will be loaded into the sample vehicle, and the well will be secured before departing.

In both cases, the time purging was stopped and restarted will be noted on the Low-Flow Purge Data Form.

3.15 Rinse the flow-through cell, the water quality meter probes, and the turbidity cell with analyte-free water and pack the cell and meters for transport.

4.0 ATTACHMENTS

1. Low-Flow Purge Data Sheet

Tetra Tech NUS, Inc.

LOW FLOW PURGE DATA SHEET

PROJECT SITE NAME: _____ **WELL ID.:** _____

PROJECT NUMBER: _____ **DATE:** _____

Time (Hrs.)	Water Level (Ft. below TOC)	Flow (mL/Min.)	pH (S.U.)	Cond. (mS/cm)	Turb. (NTU)	DO (mg/L)	Temp. (Celsius)	Salinity (%)	ORP (mV)	Comments (Cumulative Vol. & Color)

SIGNATURE(S): _____

PAGE___OF___

ATTACHMENT 1
LOW-FLOW PURGE DATA SHEET

STANDARD OPERATING PROCEDURE
NUMBER CTO126-17

DECONTAMINATION OF FIELD SAMPLING EQUIPMENT

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedures to be followed when decontaminating non-dedicated field sampling equipment during the field investigations at the Ammunition Burning Ground (ABG), Little Sulfur Creek and Jeep Trail, at the NSWC Crane facility.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Waterproof pens
Non-latex rubber or plastic gloves
Cotton gloves
Field log book
Potable water
Deionized water
LiquiNox detergent
Brushes, spray bottles, paper towels, etc.
55-gallon drum or other container to collect and transport decontamination fluids

3.0 DECONTAMINATION PROCEDURES

3.1 Don non-latex and/or cotton gloves and decontaminate sampling equipment (in accordance with the following steps) prior to field sampling and between samples.

3.2 Rinse the equipment with potable water. Rinsing may be conducted by spraying with water from a spray bottle or by dipping. Collect the potable water rinsate into a container.

3.3 Wash the equipment with a solution of LiquiNox detergent. Prepare the LiquiNox wash solution in accordance with the instructions on the LiquiNox container. Collect the LiquiNox wash solution into a container. Use brushes or sprays as appropriate for the equipment. If oily residue has

accumulated on the sampling equipment, remove the residue with a isopropanol wash and repeat the Liquinox wash.

3.4 Rinse the equipment with potable water. Rinsing may be conducted by spraying with water from a spray bottle or by dipping. Collect the potable water rinsate into a container.

3.5 Rinse the equipment with deionized water. Rinsing may be conducted by spraying with water from a spray bottle or by dipping. Collect the deionized water rinsate into a container.

3.6 Remove excess water by air drying, shaking, or by wiping with paper towels as necessary.

3.7 Document decontamination by recording it in the Field Logbook.

3.8 Containerized decontamination solutions will be managed in accordance with the procedures described in SOP CTO126-15 and Section 4.11 of the QAPP.

STANDARD OPERATING PROCEDURE
NUMBER CTO126-18

MEASUREMENT OF WATER LEVELS IN MONITORING WELLS

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes procedures for determining water levels in monitoring wells.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following equipment and field forms are required for determining water levels in monitoring wells.

Ground Water Level Measurement Form: A copy of the Ground Water Level Measurement Form is attached.
Bound Field Log Book
Photoionization detector (PID): Operation and calibration of the PID is discussed in SOP CTO126-06.
Well key
Writing utensil
Electronic Water-Level Indicator: The water level indicator must have a cable of sufficient length to reach the water surface and be capable of measurements of 0.01 feet.
Decontamination supplies: SOP CTO126-17 describes decontamination procedures including decontamination supplies.

3.0 WATER-LEVEL MEASUREMENT PROCEDURES

3.1 Check the operation of the electronic water level indicator or interface meter.

3.2 Record the well identification (ID), date, and time (using military time) on the Ground Water-Level Measurement Form.

3.3 Unlock the well and remove the well cap.

3.4 Place the well cap on a clean piece of plastic.

3.5 Check the well for the presence of organic vapors in the 2-inch PVC riser pipe as follows:

1. Calibration of the PID shall be done in accordance with the calibration procedures described in SOP CTO126-06. Calibration of the PID shall be done at the field office prior to entering the field.

2 Insert the PID sample inlet straw approximately three inches into the riser pipe.

3 Record the PID reading on the Ground Water Level Measurement Form. If the reading is less than concentrations specified in the site-specific HASP, proceed to step 3.6. If the reading is greater than the concentration specified in the HASP, measure the concentration in the breathing zone. If the concentration in the breathing zone is less than the concentration specified in the HASP, proceed to Step 3.6. If the reading is greater than the specified concentration, allow the riser pipe to ventilate for ten minutes and repeat the measurement of breathing zone concentrations until the concentrations fall below the level specified in the HASP before proceeding to step 3.6.

3.6 Ensure that the water level indicator probe has been decontaminated before use in accordance with the procedures outlined in SOP CTO126-17.

3.7 Slowly lower the probe into the well riser pipe until an audible and/or visible signal is produced, indicating contact with the water surface.

3.8 Read the ground water level measurement from the top of the inner casing at the surveyed reference point to the nearest 0.01-foot.

3.9 Record the water level measurement on the Ground Water Level Measurement Form.

3.10 Wind the meter cable measuring tape back onto the spool.

3.11 Replace the well cap and lock.

3.12 Decontaminate the meter's probe and cable following the procedures outlined in SOP CTO126-17.

3.13 Containerize any decontamination fluids and PPE in accordance with the procedures described in SOP CTO126-15.

4.0 ATTACHMENTS

1. Ground Water Level Measurement Sheet

Tetra Tech NUS, Inc.

GROUNDWATER LEVEL MEASUREMENT SHEET

Project Name: _____ **Project No.:** _____

Location: _____ **Personnel:** _____

Weather Conditions: _____ **Measuring Device:** _____

Tidally Influenced: Yes ___ No ___ **Remarks:** _____

Well or Piezometer Number	Date	Time	Elevation of Reference Point (feet)*	Total Well Depth (feet)*	Water Level Indicator Reading (feet)*	Thickness of Free Product (feet)*	Groundwater Elevation (feet)*	Comments

* All measurements to the nearest 0.01 foot

Page ___ of ___

STANDARD OPERATING PROCEDURE
NUMBER CTO126-19

SURFACE WATER SAMPLING

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedure for collecting surface water samples in Little Sulphur Creek at the NSWC Crane facility.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Surface Water Sample Log Sheet: A copy of this form is attached at the end of this SOP.

Field Logbook

Writing utensil

Multi-parameter water-quality meter: The water-quality meter is used for the measurement of dissolved oxygen, pH, specific conductance, temperature, oxidation-reduction potential, and turbidity (see SOP CTO126-14).

LaMotte Turbidity Meter: Used to measure turbidity in the field.

Disposable sample containers: disposable sample containers are used to fill sample containers and transport sample(s) to a pump for filtering.

Labeled sample containers: Prelabeled, certified-clean sample containers will be provided by the laboratory that performs the analyses.

Sample tags: One tag is to be completed and attached to each sample container.

0.45-micron filter assembly: These are single-use filter cartridges used to filter samples scheduled for dissolved metals or dissolved thorium isotope analyses. The filters become investigation-derived waste (IDW) after one use.

Peristaltic pump

Silicon tubing

Ziploc-type plastic storage bags

Shipping containers (coolers)

Trip Blank Sample (if VOC samples are being collected)

Temperature Blank

3.0 SURFACE WATER SAMPLING PROCEDURES

3.1 The same methods will be used to collect surface water and seep samples. Sampling will start at the downstream end of a stream and proceed to the farthest upstream location. The surface water sample locations are shown on Figure 4-2 and discussed in Section 4.4.3 of the QAPP.

3.2 While standing downstream or from the bank gently remove any floating leaves or twigs that may be present in a sample pool area in a manner that will not disturb the bottom sediment.

3.3 While standing downstream or from the bank place the sample container in the water at the sampling location at a 45-degree angle and lower it to approximately half the sample pool depth. With the mouth of the container facing upstream, fill the container with water, being careful not to disturb the sediment.

3.4 All samples will be collected into certified-clean, pre-preserved bottles (if preservation is required for the analysis to be performed) supplied by the laboratory performing the analyses. Table 4-13 of the QAPP includes information on the preservative requirements for each type of analysis. Sample containers for volatile constituents (VOCs) must be completely filled, so that no headspace exists in the container. Other sample containers should <u>not</u> be filled completely; a small amount of air should be left at the top. Sample containers will be collected in the following sequence:

Volatile organic compounds (VOCs)
Other Organics
Total metals
Nitrate
Nitrite
Total suspended solids (TSS)
Dissolved metals

3.5 Record the date and time that the sample containers are filled on the Surface Water Sample Log Sheet, the sample labels, the sample tags, and the Chain-of-Custody form.

3.6 After the sample label and sample tag are completed and checked, place the sample container into a ziploc-type plastic storage bag and place the plastic storage bag holding the sample container into a cooler containing ice.

3.7 Repeat steps 3.3 through 3.6 until all the sample bottles containing unfiltered samples have been filled.

3.8 Fill two 1-liter unpreserved polyethylene bottles. Use these bottles to transfer the sample for field filtering. Set up a peristaltic pump for filtering of the dissolved metals samples. Using new, clean, disposable silicone tubing and a 0.45-micron filter, place the intake tubing from the pump into the transfer bottle with the filter attached to the discharge end and start the pump. Pre-rinse the filter with approximately 50-mL of sample water prior to filling the sample containers.

3.9 Using the discharge from the filter cartridge, fill one 1-liter polyethylene sample bottle for dissolved metals (see Table 4-13 in the QAPP). Repeat steps 3.8 and 3.9 for these sample containers.

3.10 Obtain measurements of dissolved oxygen, pH, specific conductance, temperature, turbidity, and oxidation-reduction potential using the multi-parameter water-quality meter and LaMotte Turbidity Meter (see SOP CTO126-14). Record the readings in the appropriate fields on the Surface Water Sample Log Sheet.

3.11 Estimate the flow rate of the stream or spring as per SOP CTO126-21. This is an estimate only. Round the flow rate to the nearest 5 gallons and record this number on the Surface Water Sample Log Sheet.

3.12 Decontaminate all equipment and load the equipment and the sample cooler in the sample vehicle for transport.

4.0 ATTACHMENTS

1. Surface Water Sample Log Sheet

Tetra Tech NUS, Inc.

SURFACE WATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[] Stream
[] Spring
[] Pond
[] Lake
[] Other: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____

Type of Sample:
[] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Date:	Visual	Standard	mS/cm	Degrees C	NTU	mg/l	%	NA
Time:								
Depth:								
Method:								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

STANDARD OPERATING PROCEDURE
NUMBER CTO126-20

SEDIMENT SAMPLING

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedure for sediment sampling in Little Sulphur Creek at the NSWC Crane facility.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following field forms and equipment are required for sediment sampling.

Sediment Sample Log Forms: A copy of this form is attached at the end of this SOP.
Bound Field Log Book
Tags for each sample container
Disposable plastic trowels
Survey stakes and flagging: Used to mark sampling locations after completion of sampling.
Labeled sample containers: See SOP CTO126-01 for sample identification procedures. Sample containers are certified clean by the laboratory supplying the containers.
Plastic storage bags
Shipping containers (containing ice)
Surgical gloves
Indelible marker
Chain-of-Custody Form

3.0 SEDIMENT SAMPLE LOCATION SELECTION

The general locations where the sediment samples should be collected in Little Sulphur Creek are shown on Figure 4-2 of this QAPP. At many of the locations, surface water is seldom flowing. Therefore, sediment samples will be collected from areas of sediment accumulation.

In general, sediments composed of fine-grained materials with greater surface area available for adsorption, are more desirable for sample selection. The fined-grained materials may act as a sink or

reservoir for adsorbing heavy metals and organic contaminants even if surface runoff concentrations are below detection limits. Therefore, it is important to locate the specific sampling points where the sediment has the greatest percentage of fine particles. The sampling personnel will determine specific sampling locations with these goals in mind.

3.0 SEDIMENT SAMPLING PROCEDURES

3.1 The sampler will wear clean, disposable, surgical gloves. Clear vegetative matter or debris, if present, from the sample location using a disposable sampling trowel or spoon. Use the trowel to dig up and homogenize the sediment in an 18-inch diameter circular area that is 6 inches deep. Stir the sediment within the circular area; do not move the sediment outside of the circle. Also, do not dig or stir sediment that is deeper than 6 inches below the ground surface, until the next depth interval is sampled.

3.2 Use the same trowel to scoop the homogenized sediment into the requisite labeled sample containers. Table 4-12 of the QAPP includes the bottle requirements for each type of sediment analysis. All sample jars will be filled in the following sequence:

- Volatile organics
- Other organics
- TAL metals plus and Sn (total)
- Nitrate
- Nitrite
- TOC
- pH
- Geotechnical parameters

3.3 Record the sample time (using military time) on the Sediment Sample Log Form and sample container labels and tags. Record all other information required on the labels and tags as specified by SOP CTO126-01.

3.4 Secure the tag to the neck of the sample container using a wire tie.

3.5 Place the tagged sample container into a plastic storage bag and then place the plastic storage bag holding the sample container into a cooler containing ice.

3.6 Record date, sampling site, site conditions, location map, and other information (e.g., presence and flow rate of water in channel) on the Sediment Collection Log Sheet. Enter the sample information onto the Chain-of-Custody form per SOP CTO126-03.

3.7 Using an indelible marker, write the sample ID on a survey stake, drive the stake into the ground at the sample location. Tack on a piece of brightly colored flagging to the stake. In addition, tie a piece of flagging to an overhead tree branch or other eye-level object to improve the ability to relocate the sampling site in the future.

4.0 ATTACHMENTS

1. Soil and Sediment Sample Log Sheet

ATTACHMENT 1

Tetra Tech NUS, Inc.

SOIL & SEDIMENT SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

- [] Surface Soil
- [] Subsurface Soil
- [] Sediment
- [] Other: _____
- [] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____

Type of Sample:
- [] Low Concentration
- [] High Concentration

GRAB SAMPLE DATA:

	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date:			
Time:			
Method:			
Monitor Reading (ppm):			

COMPOSITE SAMPLE DATA:

Date:	Time	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Method:				
Monitor Readings				
(Range in ppm):				

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

STANDARD OPERATING PROCEDURE
NUMBER CTO126-21

ESTIMATING FLOW IN SMALL STREAMS

1.0 PURPOSE

This Standard Operating Procedure (SOP) provides technical guidance on the measurement of stream channel cross-section and flow in a small stream. Stream flow measurements will be obtained to evaluate the migration potential of contaminants in a stream channel. This method is applicable for free flowing streams with uniform flow and widths greater than 3 feet and depths greater than about 6 inches. Flow in the unnamed tributaries adjacent to the Ammunition Burning Ground (ABG), Little Sulphur Creek and Jeep Trail, at the NSWC Crane facility, are expected to be low when surface water samples are collected. Stream flow rates will be measured at the same time when water level measurements are collected.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Measuring rod or yardstick
Measuring tape
Waders or rubber boots
Colored flagging tape
2x2 inch wooden stakes
Bound Field Log Book
Waterproof pen
Orange or apple
Surface Water Sample Log Sheet
Indelible marker
Stopwatch

3.0 PROCEDURES

3.1 Establish a transect across the stream, along a straight reach where the stream is relatively narrow and velocity across the stream is relatively uniform. Orient the transect perpendicular to the flow.

3.2 Mark both ends of the transect with colored plastic flagging tape. Tie the flagging to a tree branch or other elevated (about eye level) object. Drive wooden stakes into the ground at both ends of transect and tack a short piece of brightly colored flagging to the stakes. Use a black marker to identify the transect number, which will be the same as the surface water sample location.

3.3 Measure the total distance across the stream with a measuring tape and record the stream width (in feet) in the field logbook.

3.4 Measure the depth of water in the stream at three or four points across the stream. Record these measurements and calculate an average depth. Record the average depth (in feet) in the field logbook.

3.5 Measure a distance of 20 feet upstream of the transect. Tie a piece of flagging on a tree branch or other visable location above the stream.

3.6 Go another 20 feet upstream and place the orange or apple in the center of the stream or where the water current is fastest.

3.7 Using a watch with a timer or a stopwatch, measure the length of time it takes the orange (or apple) to travel from the first marker flag to the transect location (distance of 20 feet). Record the time.

3.8 Repeat step 3.7 two more times. Record the readings and calculate an average time.

3.9 Calculate approximate flow rate in the stream channel by multiplying the stream width (from step 3.3) times the average depth (from step 3.4) times the average velocity (from step 3.8). Record the estimated flow rate (in ft^3/s) in the field logbook and on the Surface Water Sample Collection Log Sheet.

STANDARD OPERATING PROCEDURE
NUMBER CTO126-22

HYDRAULIC CONDUCTIVITY TESTING

1.0 PURPOSE

This Standard Operating Procedure (SOP) provides technical guidance for the performance and evaluation of a in-situ hydraulic conductivity testing (slug testing) in monitoring wells at the Jeep Trail, at the NSWC Crane facility.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Solid Slug
Pressure transducers and data recorder, including instruction manual
Manual water level indicator
Hydraulic Conductivity Testing Data Sheet
Watch
Decontamination equipment and supplies
Field Log Book
Measuring tape

3.0 PROCEDURES

Slug tests are short-term tests designed to provide approximate hydraulic conductivity values for the portion of a formation immediately surrounding the screened/open interval of a well or boring. These tests are much less accurate than pumping tests, as a much more localized area is involved. Therefore, a number of slug tests are typically performed and averaged to determine a representative hydraulic conductivity value for the formation tested. Performance of slug tests may be preferable to pumping tests in situations where handling of large volumes of contaminated water is a concern or when time/budget constraints preclude the more expensive and time-consuming setup and performance of a pumping test.

The procedure is summarized below:

3.1 Determine the total depth of the well using a weighted tape or other measuring device. A pressure transducer attached to a data logger shall be placed in the well approximately one foot from the bottom of the well. The transducer will be positioned so that it is about 5 to 10 feet lower than the slug.

3.2 Record the well number, the transducer probe identification number being used, the PSI rating for each probe, the depth below top of casing where each probe is positioned, the static water level in the well, and any other information relative to the setup and performance of the slug test. Data and information should be recorded in a bound field notebook and on the Pumping Test Data Sheet.

3.3 A falling-head test can be performed where the slug is lowered into the well and the rate of water-level fall with respect to time is recorded until equilibrium is reached. A rising-head test can be performed where a slug is lowered into the well and the water is allowed to equilibrate, then the slug is removed and the rate of water-level rise is measured with respect to time. Falling head slug tests should only be performed in wells with fully submerged screens, while rising head slug tests can be performed in wells with either partially or fully submerged screens/open intervals.

3.4 Remove or insert the slug and immediately start the data logger. Record the starting time for the data logger on the form sheet.

3.5 Manually measure the depth to water with a water depth indicator to estimate the rate of recovery while the data logger is in the sleep mode. Enter the reading onto the form sheet, along with the corresponding transducer reading from the same time.

3.6 Observe the water-level readings once the data logger can be read. Record the times and the readings on the form sheet.

3.7 Rate of recovery measurements shall be obtained from time zero (maximum change in water level) until water level recovery exceeds 90 percent of the initial change in water level. In low permeability formations, the test may be cut-off short of 90 percent recovery due to time constraints. Time intervals between water level readings will vary according to the rate of recovery of the well. For a moderately fast recovering well, water level readings at 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.75, 1.0, 1.25, 1.5, 2.0, 2.5, 3.0, 4.0, . . . minutes may be required. With practice, readings at down to 0.05-minute (3 seconds) time intervals can be obtained with reasonable accuracy, using a pressure transducer and hand held readout. For wells which recover very fast,

the pressure transducer and data logger can be set on a logarithmic recording interval. Time intervals between measurements can be extended for slow recovering wells. A typical schedule for measurements for a slow recovering well would be 0, 0.25, 0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0, 8.0, 10.0, 15.0, 20.0, 30.0, . . . minutes from the beginning the test. Measurements shall be taken from the top of the well casing.

3.8 Stop the test once equilibrium is reached and repeat as necessary to ensure reproducibility.

3.9 Remove the pressure transducer, the slug, and the cables from the well and thoroughly decontaminate, per SOP CTO126-17.

3.10 Check all field notes, copy, and place into one file for each test. Download the data recorder as soon as possible and check data. Make an electronic file and paper file of all data and place with the file for evaluation later. Confirm that the data is usable for the intended analysis prior to leaving the field. Time/recovery should be field-plotted on semilog graph paper to determine the data quality. The data set should plot along a sloped, straight line. If excessive data scatter is observed, the test should be rerun until acceptable results are obtained.

4.0 PERSONNEL

A qualified geologist or hydrogeologist, having experience with these test procedures and equipment, will be needed for each sampling team to carry out the Hydraulic Conductivity tests.

5.0 ATTACHMENTS

1. Hydraulic Conductivity Testing Data Sheet

ATTACHMENT A

HYDRAULIC CONDUCTIVITY TESTING DATA SHEET

PROJECT NAME: ..... WELL/BORING NO

PROJECT NO.: ..... GEOLOGIST: .....

WELL DIAMETER: ..... SCREEN LENGTH/DEPTH: ..... TEST NO.: .....

STATIC WATER LEVEL (Depth/Elevation): ..... DATE: .....

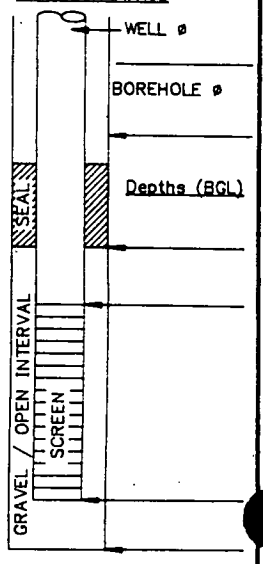
TEST TYPE (Rising/Falling/Constant Head): ..... CHECKED: .....

METHOD OF INDUCING WATER LEVEL CHANGE: ..... PAGE ..... OF .....

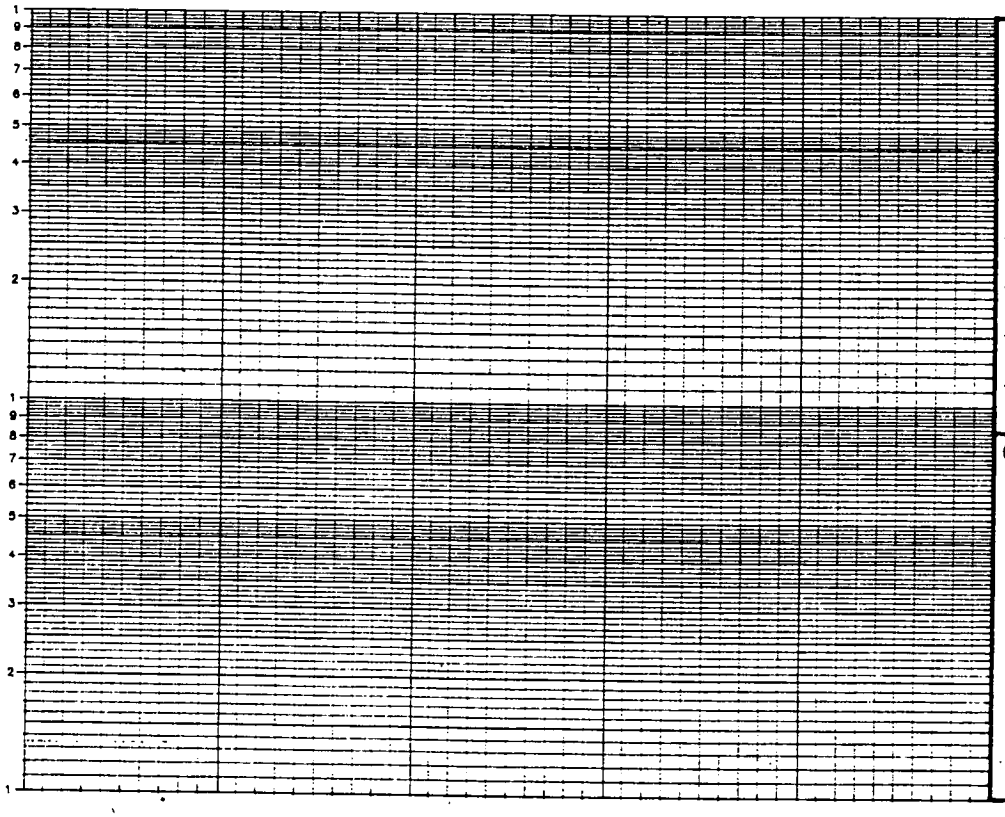
REFERENCE PT. FOR WL MEAS. (Top of Casing, Transducer, etc.): .....

ELAPSED TIME (min. or sec.)	MEASURED WATER LEVEL (feet)	DRAWDOWN OR HEAD (ΔH) (feet)	ELAPSED TIME (min. or sec.)	MEASURED WATER LEVEL (feet)	DRAWDOWN OR HEAD (ΔH) (feet)

WELL SCHEMATIC



Indicate SWL Depth on Drawing



REMARKS:

CALCS,SKETCH MAPS, ETC.:

STANDARD OPERATING PROCEDURE
NUMBER CTO126-23

TRACER TESTS

1.0 PURPOSE

This Standard Operating Procedure (SOP) provides technical guidance for the operation and maintenance of a quantitative tracer test in the Jeep Trail Site, at the NSWC Crane facility. This type of test is performed under natural hydraulic gradient conditions. Thus, there shall be no pumping of wells in the area during this test. Information about the hydraulic properties of geologic materials will be generated by this type of test, and is necessary because the hydraulic properties of the geologic materials control the movement of ground water and contaminants at the site.

2.0 REQUIRED FIELD EQUIPMENT

Submersible or surface (capable of low flow) pump (12 volt DC recommended)
In-line valves to control pump flow rate
Pump cables and hoses
Specific conductivity transducers and data recorder, including instruction manual
Manual water level indicator
Power generator (if pump is AC volt operated) 12 volt DC pump use automobile power source
Gas tank (if power generator is needed)
55-Gallon drum or other suitable container(s) to hold tracer solution
Field Log Book
Writing utensil
23.5 kilograms reagent grade sodium bromide
Ion-selective electrode (ISE) probe for bromide (with calibration fluids) with meter
40-gallons deionized water
1.6 kilograms of Rhodamine WT (20%) dye

3.0 PROCEDURES

Selected monitoring points, including wells installed at the site during the 1980s, newly installed wells, and springs (surface seeps), shall be part of the tracer study network which will be monitored for the

presence of the bromide ion and Rhodamine dye. The specific conductivity of the water at each well and spring will be measured using a conductivity transducer and automatic recording data logger to record water conductivity before, during, and after the injection of a sodium bromide slug into a well. When the specific conductivity begins to increase or dye is visually detected, an ISE probe shall be used to confirm the presence of the bromide ion and grab samples will be collected and sent to a fixed based laboratory for chemical analysis. Notes and other data related to the tests will be entered into a table format in the field notebook. The procedures are as follows:

3.1 Perform a synoptic round of water level measurement at all site wells.

3.2 Set up of tranducers: Determine the total depth of the well using a weighted tape or other measuring device. A specific conductivity transducer attached to a data logger shall be placed in the well approximately 1 foot from the bottom of the well, and another carefully placed into the spring, being sure not to submerge the probe into the sediment. Record the well number, the transducer probe identification number being used, the PSI rating for each probe, the depth below top of casing where each probe is positioned, and the static water level in the well. Data and information should be recorded in the field notebook.

3.3 Collect water samples from all monitoring wells and springs, and measure and record the bromide ion concentration using a calibrated ion-specific electrode.

3.4 Set the data logger(s) on the linear reading frequency of one measurement per 30 minutes and start recording data. Record the starting time for the data logger in the field notebook.

3.5 Dissolve approximately 23.5 kilograms of sodium bromide and 1.6 kilograms of Rhodamine WT (20%) dye into 40 gallons of deionized water in a 55 gallon drum. This 40-gallon mixture is called the bromide ion slug.

3.6 Inject the bromide ion slug using a pump and running the pump output hose into the designated injection well. Turn the pump on and set flow rate to approximately 100 mL/minute. Record the time the pump was started. While monitoring the water level in the injection well, adjust the flow as needed to prevent overflow at the well head and to obtain a maximum flow rate (injection rate). Record the time the slug injection is completed in the field notebook.

3.7 At 2-hour intervals check the data loggers measuring specific conductivity at all of the monitoring points (break through points). When break through is achieved (i.e. when the conductivity

increases above background or the Rhodamine dye is visually detected) begin to collect samples and measure and record the bromide ion concentration with the ISE probe. Continue to record and measure using the ISE probe at 1-hour intervals for approximately 2 hours (2 readings) at each break through point. This will confirm the presence of the bromide ion. Once it is confirmed that the bromide ion is present, water samples will be collected at 1-hour intervals for approximately 4 to 8 hours. Up to 20 of the samples collected will be submitted for laboratory analysis. Break through may occur at different times at different locations. Therefore it is important to continue to check the data loggers at the prescribed interval at the other monitoring points. If there is an increase in the specific conductivity but no bromide ion is measured, recalibrate the ISE probe, and try again. If there is still no bromide measured, continue to measure using the data loggers until the specific conductivity further increases, then proceed using the ISE probe as described above to confirm the occurrence of the bromine ion.

3.8 If break through has occurred and the presence of the bromide ion is confirmed, continue to run the data loggers for at least 4 hours after the specific conductivity returns to the background level.

4.0 PERSONNEL

Two qualified geologists or hydrogeologists, having experience with the monitoring equipment will be needed for the duration of the test.