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Quality Assurance Project Plan
for
RCRA Facility Investigation
at
Building 106 Pond (SWMU 8)
Roads and Grounds Area (SWMU 15)

AND

Environmental Indicator Investigation
for
SWMU 18 (Load and Fill Area Buildings), SWMU 19 (Pyrotechnic Test Area), SWMU 20 (Crane Army Ammunition Activity Quality Assurance/Quality Control Test Area), and the Old Gun Tub Storage Lot

Naval Surface Warfare Center Crane
Crane, Indiana

NAVFAC
Naval Facilities Engineering Command

Southern Division
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888
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QUALITY ASSURANCE PROJECT PLAN FOR RCRA FACILITY INVESTIGATION AT SWMUs 8 (BUILDING 106 POND) AND 15 (ROADS AND GROUNDS AREA) AND ENVIRONMENTAL INDICATOR INVESTIGATION FOR SWMUs 18 (LOAD AND FILL AREA BUILDINGS), 19 (PYROTECHNIC TEST AREA), AND 20 (CRANE ARMY AMMUNITION ACTIVITY QUALITY ASSURANCE/QUALITY CONTROL TEST AREA) AND THE OLD GUN TUB STORAGE LOT

NAVAL SURFACE WARFARE CENTER
CRANE DIVISION, CRANE, INDIANA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY CONTRACT

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ACRONYMS

°F	degrees Fahrenheit
ac	acre(s)
ALPEC	Ammunition Loading and Production Engineering Center
amsl	above mean sea level
ANOVA	Analysis of Variance
AOC	area of concern
ASCO	Ammunition Supply Control Office
AST	aboveground storage tank
AWQC	Ambient Water Quality Criterion
BERA	baseline ecological risk assessment
bgs	below ground surface
BOD	biological oxygen demand
CAAA	Crane Army Ammunition Activity
CADD	Computer-Aided Design and Drafting
CEC	cation exchange capacity
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
CMS	Corrective Measure Study
CN	alpha-chloroacetophenone
COC	chain-of-custody
COD	chemical oxygen demand
COPC	chemical of potential concern
CTO	Contract Task Order
DO	dissolved oxygen
DPT	direct push technology
DQO	data quality objective
EDQL	ecological data quality level
EI	Environmental Indicator
EP	Extraction Procedure
EPC	exposure point concentration
ERA	ecological risk assessment
ESM	Environmental Site Manager
EU	exposure unit

FDSA	Former Drum Storage Area
FOL	Field Operations Leader
FTMR	Field Task Modification Request
GIS	Geographic Information System
gpd	gallons per day
HSA	hollow-stem auger
HASP	Health and Safety Plan
HCl	hydrochloric acid
HHRA	Human Health Risk Assessment
HI	Hazard Index
HMS	Health and Safety Manager
HMX	octahydro 1,3,5,7 tetranitro 1,2,5,7-tetrazocine or cyclotetramethylene tetranitramine
IDEM	Indiana Department of Environmental Management
IDL	instrument detection limit
IDW	investigation-derived waste
in	Inches
Li	lithium
MCL	Maximum Contaminant Level
MDL	method detection limit
MEK	methyl ethyl ketone
MNA	monitored natural attenuation
MS	matrix spike
MSD	matrix spike duplicate
MTBE	methyl tertiary butyl ether
N	North
NAD	Naval Ammunition Depot
NAVD	North American Vertical Datum
NAVFAC EFD SOUTH	Naval Facilities Engineering Field Division South
NFEC	Naval Facilities Engineering Command
NFESC	Naval Facilities Engineering Service Center
NSWC	Naval Surface Warfare Center
NTU	Nephelometric turbidity unit
NWSC	Naval Weapons Station Crane
O&G	oil and grease
OGTSL	Old Gun Tub Storage Lot

ORP	oxidation-reduction potential
OSHA	Occupational Safety and Health Admnistration
OTA	Ordnance Test Area
PAHs	polynuclear aromatic hydrocarbons
PCB	polychlorinated biphenyl
PCP	pentachlorophenol
PID	photoionization detector
PM	Project Manager
PPE	personal protective equipment
PRG	Preliminary Remediation Goals
PQL	practical quantitation limit
PTA	Pyrotechnic Test Area
PVC	polyvinyl chloride
QA	quality assurance
QAM	Quality Assurance Manager
QAPP	Quality Assurance Project Plan
QC	quality control
RAGS	Risk Assessment Guidance for Superfund
RBSL	risk-based screening level
RBTL	risk-based target level
RCRA	Resource Conservation and Recovery Act
RCRIS	RCRA Conservation and Recovery Information System
RDX	hexahydro 1,3,5 trinitro 1,3,5 triazine; cyclo-trimethyl-trinitramine; or "cyclonite"
RFI	RCRA Facility Investigation
RISC	Risk-Integrated System of Closure
RL	reporting limit
RQAC	RCRA Quality Assurance Coordinator
SAP	Sampling and Analysis Plan
SERA	screening-level ecological risk assessment
SIM	selected ion monitorin
Sn	tin
SOP	standard operating procedure
SOUTHDIV	Southern Division Naval Facilities Engineering Command
SOWs	statements of work
Sr	strontium
SSL	Soil Screening Level

SSO	Site Safety Officer
SVOC	semivolatile organic compound
SWMU 15	Roads and Ground Area
SWMU 18	Loading and Fill Area Buildings
SWMU 19	Pyrotechnic Test Area
SWMU 20	CAAA QA/QC Test Area
SWMU 8	Loading and Fill Area Building 106 Pond
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TCE	trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
TDS	total dissolved solids
TNT	2,4,6-trinitrotoluene
TOC	total organic carbon
TOM	Task Order Manager
TPH	total petroleum hydrocarbons
TSS	total suspended solids
TtNUS	Tetra Tech NUS, Inc.
TV	threshold value
U.S. EPA	United States Environmental Protection Agency
U.S.	United States
USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
USDA	United States Department of Agriculture
UST	underground storage tank
UXO	unexploded ordnance
VOC	volatile organic compound
WES	Waterways Experiment Station
WRS	Wilcoxon Rank-Sum
WWII	World War II
WWTP	wastewater treatment plant
ZnB	Zanesville-Udorthents

1.0 PROJECT DESCRIPTION

This Quality Assurance Project Plan (QAPP) is being prepared as part of the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Phase III work plan. This 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 October 18, 2001 [Indiana Department of Environmental Management (IDEM, 2001b)]. This investigation will provide data on select organic and inorganic chemical concentrations in surface soils, subsurface soils, sediment, surface water, and ground water at Solid Waste Management Unit (SWMU) 8 (Building 106 Pond) and SWMU 15 (Roads and Grounds Area). In addition, the investigations described in this QAPP will provide information for completion of the United States Environmental Protection Agency (U.S. EPA) Region 5 RCRA Conservation and Recovery Information System (RCRIS) code Environmental Indicators (EIs) Forms (Form CA725) for SWMU 18 (Load and Fill Area Buildings), SWMU 19 [Pyrotechnic Test Area (PTA)], SWMU 20 [Crane Army Ammunition Activity (CAAA) Quality Assurance/Quality Control (QA/QC) Test Area], and the Old Gun Tub Storage Lot (OGTSL). Figure 1-1 shows the locations of the five SWMUs and the OGTSL within NSWC Crane.

For SWMUs 8 and 15, this QAPP will govern data collection and development of an RFI Report that will include a Human Health Risk Assessment (HHRA) and an Ecological Risk Assessment (ERA).

For SWMUs 18, 19, and 20 and the OGTSL, this QAPP will govern the focused data collection associated with an EI determination regarding worker exposure. The collected data will be provided to U.S. EPA Region 5 for completion of the Form CA725.

SWMU 8, Building 106 Pond Area

SWMU 8 is located in the Load and Fill Area on the west-central side of NSWC Crane (Figure 1-1), west of Boggs Creek. The area of concern (AOC) at SWMU 8 is the Building 106 Pond, which is an unlined surface impoundment between 40 and 60 feet in diameter. The Building 106 Pond received discharges from floor drains and process wastewaters that were generated in Buildings 106 and 107. Additionally, the Building 106 Pond has received surface water runoff from the area immediately surrounding Buildings 106 and 107. Historical contaminant releases are described in Section 1.3.2.

SWMU 15, Roads and Grounds Area

SWMU 15 is located west of Turkey Creek in the northern half of NSWC Crane (Figure 1-1). SWMU 15 includes the following:

- A former aboveground storage tank (AST) for waste oil.
- A former underground storage tank (UST) for fuel oil.
- A former asphalt batch plant.
- A former salt dome.
- Two wash racks near Building 2716.
- Buildings 2716, 2717, 2718, 2727, and 2801.
- The vegetated hillside south of Building 2801.
- A backfilled and graded area that was formerly a ravine that ran along the road east of Building 2718.

Historical contaminant releases are described in Section 1.3.3.

SWMU 18, Load and Fill Area Buildings

SWMU 18 is located in west-central NSWC Crane, northeast of Boggs Creek (Figure 1-1). SWMU 18 includes various buildings used in munitions load and fill operations. The AOC for SWMU 18 includes the four buildings (Buildings 104, 105, 198, and 200) targeted for U.S. EPA Form CA725 human health assessments. No information is available as to whether contamination has been released as a result of operations at these buildings.

SWMU 19, Ordnance Test Area

SWMU 19 consists of three physically separate areas [Ordnance Test Area (OTA), PTA Annex, and Rocket Range] where related functions are performed. In general, these areas consist of large, open fields and concrete buildings that were used for QA test burning of pyrotechnic devices, and QA of submarine batteries and rocket motors. Boggs Creek flows through the center of the SWMU. Most of SWMU 19 is within the Boggs Creek 100-year flood plain.

The OTA is an active site that comprises several different test locations where various types of devices are tested. Functional testing of flares, signals, and other marking devices has been performed at this location for about 40 years. The tested devices range from hand-held marine and aerial devices such as

personnel distress signal flares to ground illumination signals, decoy flares, location marker flares, smoke pots, tear gas, riot and smoke grenades, and similar devices.

The PTA Annex is an active site where explosive testing is conducted. The PTA Annex also includes a control room, air launch building, two test chambers, two gun turrets, a metal platform, and a wooden wall.

The Rocket Range is an active site where smoke warhead and 5-inch rocket testing is conducted in operational ordnance test chambers (former gun turrets). The Rocket Range pyrotechnics are either fired down range from the launch site or are tested in one of the facilities. A sand pit is located at the impact area. A wave tank is used to test marine markers and signal flares.

Past operations at the Rocket Range involved the testing of live ordnance and rocket motors as well as the testing of rocket motors containing dummy loads. During the 1950s and 1960s, a dye test tank was located at the Rocket Range.

Historical contaminant releases at the OTA, PTA Annex, and the Rocket Range are described in Section 1.3.5.

Previously, a QAPP was prepared for the RFI investigation of SWMU 19 (TtNUS, 2003). To date, the investigation has not been conducted. A subset of sampling locations described in that QAPP will be sampled to provide data for the EIs.

SWMU 20, CAAA QA/QC Test Area

SWMU 20 is located in north-central NSWC Crane (Figure 1-1). Operations include QA/QC testing of explosives and pyrotechnics devices; however, information is not available as to whether contaminants have been released as a result of these operations.

Old Gun Tub Storage Lot

The OGTSL is located in the north-central portion of NSWC Crane (Figure 1-1) and consists of a relatively flat area covered by gravel at which gun tubs from ships were stored outdoors and exposed to the elements.

PROJECT PROBLEM STATEMENT

SWMUs 8 and 15

Because of known or suspected operationally related chemical releases at SWMUs 8 and 15 (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 re-suspension of dust or release of volatile chemicals) are anticipated.

The degree of risk to a human or ecological receptor is 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 SWMUs identified as exhibiting unacceptable levels of contamination. The extent of contamination at SWMUs 8 and 15 will be established, and a risk evaluation will be conducted for human and ecological receptors in contaminated areas of SWMUs 8 and 15 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.

SWMUs 18, 19, and 20 and the OGTSL

The U.S. EPA has developed a variety of EIs to summarize site environmental conditions. The U.S. EPA utilizes these EIs to determine whether site human health conditions are under control. These include RCRA Corrective Action EI Form CA725. Site specific data are required to complete this form.

NSWC Crane will provide the U.S. EPA with data that establish contamination concentrations at SWMUs 18, 19, and 20 and the OGTSL. The U.S. EPA will utilize these data to complete the CA725 forms and to evaluate whether, under the current industrial land use, human exposure (e.g., worker exposure) is under control at SWMUs 18, 19, and 20 and the OGTSL.

1.1 INTRODUCTION

NSWC Crane is a United States Navy installation located within the State of Indiana. Tetra Tech NUS, Inc. (TtNUS) has prepared this QAPP on behalf of the Naval Facilities Engineering Field Division South (NAVFAC EFD SOUTH) and NSWC Crane to comply with IDEM Risk-Integrated System of Closure (RISC) requirements and guidance. Those requirements and guidance, described in Section 1.1.3, govern all aspects of RCRA environmental investigations. The investigations described in this QAPP are considered non-default scenarios as defined in the RISC guidance. In accordance with RISC

requirements and guidance, project planning followed the U.S. EPA data quality objectives (DQO) process (U.S. EPA 1999a). 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. The process culminates in a specification of decision rules and in a sampling and analysis plan (SAP) designed to solve the stated problem.

This QAPP presents the project organization, objectives, planned activities, and specific QA/QC procedures associated with sample collection and analysis for the investigation. Specific protocols for sample collection, sample handling and storage, chain-of-custody (COC), 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 Comprehensive Long-Term Environmental Action Navy (CLEAN) III Contract Number N62467-94-D-0888, Contract Task Order (CTO) Number 0331.

1.1.1 Project Objectives and Decision Statement

SWMUs 8 and 15

The purpose of the field investigation is to collect enough of the appropriate data to assess the nature and extent of contamination and to conduct a baseline HHRA and an ERA to evaluate the risks posed by contaminants in various media. If contamination is detected that poses unacceptable levels of human health or ecological risk, these data will also be used to evaluate options for remedial action to reduce the risk to acceptable levels.

For risk assessments, the overall objective of the data collection is to develop representative exposure point concentrations (EPCs) for the defined human and ecological receptors and exposure models. EPCs will be developed for those site-related constituents identified as chemicals of potential concern (COPCs) [i.e., chemicals reported at concentrations that exceed human health and/or ecological risk-based screening levels (RBSLs)] in the site media. The risk assessments will be conducted in accordance with the IDEM's RISC Technical Guide (IDEM, 2001a), RCRA Corrective Action requirements identified in NSWC Crane's RCRA Part B Permit, U.S. EPA's Risk Assessment Guidance for Superfund (RAGS) (U.S. EPA, 1989), and other available risk assessment guidance. Details on conducting the human health and ecological risk assessments can be found in Sections 1.5.2 and 1.5.3. The data collection strategies, presented later, are designed to provide information to support a baseline HHRA

and a screening-level ERA (SERA), including Navy Step 3A (see Section 1.5.3). The RBSLs will be based on IDEM Default Closure Levels (DCLs) and U.S. EPA screening criteria. Details on the derivation of the RBSLs can be found in Section 1.5.1.2.

Because no data are available to establish whether contaminants are present at concentrations that exceed RBSLs, the investigations of SWMUs 8 and 15 will begin with contaminant screening against applicable screening criteria. This will be followed by further investigations if warranted. The decision statements for SWMUs 8 and 15 are as follows:

- If any contaminant concentrations in soils at a particular location exceed the applicable screening criteria, conduct further investigations in accordance with the two decision statements presented below. If no contaminants are found to exceed applicable screening criteria, take no further action.

- From ground water, 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, and surface water). If concentrations exceeding screening levels (all media) and background levels (metals) are found, proceed to risk assessments; otherwise, take no further action. There may be some circumstances under which the available data indicate that the contamination is largely but not completely bounded in all directions. In those cases the Navy may consult with IDEM to discuss the need for further delineation.

- Determine whether contamination associated with SWMUs 8 and 15 poses an unacceptable risk to human or ecological receptors through the completion of a baseline HHRA and a SERA. If human health risks are unacceptable, consider implementing a corrective measures study (CMS) to evaluate options for reducing risks to acceptable levels. If ecological risks are unacceptable, consider conducting a baseline ecological risk assessment (BERA) or a CMS to reduce risks to acceptable levels. If risks are acceptable, take no further action.

SWMUs 18, 19, and 20 and the OGTSL

Data will be collected to support the completion of U.S. EPA EI (CA725) forms at SMWUs 18, 19, and 20 and the OGTSL for worker exposure. Access to the sites is restricted such that the only current human receptors at SWMUs 18, 19, and 20 and the OGTSL would be the occupational work and/or the trespassers. The indicator forms are used to assess site conditions with respect to current (as opposed to future) human risk to determine whether, under the current industrial land use, human exposure (e.g., worker exposure) is under control. The scope of this investigation is to report only surface soil conditions

at selected locations within SWMUs 18, 19, and 20 and at the OGTSL. Consequently, no decision statements are required. The data collected will be provided to the U.S. EPA Region 5 for use in completion of Forms CA725 for each site.

No soil, surface water, ground water, or sediment sampling data has been performed at SWMUs 18, 19, and 20. One round of soil sampling has been conducted at the OGTSL. No surface water, ground water, or sediment sampling has been performed at the OGTSL

1.1.2 Project Status/Phase

SWMUs 8 and 15

For SWMU 8, effluent discharge samples from the Building 106 Pond were collected in 1972. In 1985, two soil samples were analyzed for heavy metals utilizing the Extraction Procedure (EP) toxicity test and for trichloroethylene (TCE) and oil and grease. This test and its replacement [i.e., the Toxicity Characteristic Leaching Procedure (TCLP)] are designed to determine whether contaminants can be leached from the material under investigation at concentrations that cause the material to be classified as a hazardous waste. All EP test concentrations were less than the hazardous waste classification levels. However, contamination can still be present at concentrations that present significant risk, even if the contaminants are not leachable in concentrations that result in classification of the material as hazardous. Also, the samples contained large amounts of leaves and sediment, therefore, contamination at SWMU 8 cannot be dismissed (Halliburton NUS, 1992a). No other historical soil, surface water, ground water, or sediment sampling has been performed at SWMU 8.

For SWMU 15, four soil samples were collected near the bottom of the debris area on the hill south of Building 2716 and analyzed for EP toxicity (the precursor to TCLP). These samples did not fail the EP toxicity tests. However, as noted for SWMU 8, passing of the EP Toxicity test does not provide assurance that contamination that presents a significant risk is not present. One surface water sample was collected from an unknown location at Turkey Creek.

Previous sampling for these SWMUs is inadequate to determine if contamination exists or if the contamination presents risk to human and/or ecological receptors.

At least one round of sampling is expected for the SWMUs 8 and 15 investigations, with additional sampling rounds possible to determine the extent of contamination or to better evaluate risk to human or ecological receptors. The need for additional sampling rounds at either SWMU will depend on whether

data gaps exist after any given sampling round. The strategy for all sampling rounds is similar when establishing the extent of contamination. Chemical concentrations will be compared to appropriate based target levels, RBTLs, and background (or upgradient/upstream) concentrations to identify 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. If available data are not adequate to bound contamination greater than risk-based levels and background levels, an evaluation will be conducted to determine whether additional samples must be collected to complete the risk assessment and RFI process. Appropriate risk-based concentrations and background (upstream/upgradient) concentrations are described in Sections 1.1.3, 1.5.1, 1.5.2, and 1.5.3. For surface water and sediment, establishing the nature and extent of contamination will depend on the availability of those media for sampling. This is especially true in the case of surface water, which may be ephemeral, but also for sediment, which may not be present in some portions of drainage channels.

The data analyses and approach to reconciling data with project objectives are described in Section 8.3.1 and throughout this document. Section 3.0 presents the sampling plan and analyses design and rationale for the number of soil, surface water, ground water, and sediment samples for this project.

SWMUs 18, 19, and 20 and the OGTSL

One round of soil sampling has been conducted at the OGTSL. No surface water, ground water, or sediment sampling has been performed at the OGTSL. No soil, surface water, ground water, or sediment sampling has been performed at SWMUs 18, 19, and 20. One round of surface soil sampling is expected for the OGTSL and SWMUs 18, 19, and 20 investigations.

1.1.3 QAPP Preparation Guidelines and Requirements

This QAPP has been prepared in accordance with the IDEM RISC Technical Resource Guidance Document for developing a non-default approach for RCRA corrective action cleanup. For establishing the QA/QC requirements specified in this QAPP, the Naval Facilities Engineering Service Center (NFESC) guidance document entitled Navy Installation Restoration Laboratory Quality Assurance Guide (NFESC, 1996) was followed. The NFESC guidance specifies criteria for acceptable laboratory performance and monitoring of that performance. U.S. EPA human health RBSLs and ecological data quality levels (EDQLs) as well as the IDEM RISC DCLs were considered in developing this QAPP, especially when selecting sampling and analytical methods to measure target analyte concentrations in the media of interest. The EDQLs apply to the ecological risk screening similar to DCLs for human health

risk screening. All QA/QC procedures are structured in accordance with applicable IDEM and U.S. EPA Region 5 requirements, regulations, guidance, and technical standards.

Additional guidance regarding development of this QAPP was obtained through a pre-QAPP meeting held on February 25, 2004 at NSWC Crane. Representatives from NSWC Crane, IDEM, and TtNUS participated in the pre-QAPP meeting and site tour to introduce and discuss technical issues associated with field investigation and preparation of the QAPP.

Comparability of soil inorganics data between this investigation and the Base-Wide Background Soil Investigation for NSWC Crane (TtNUS, 2001) is important to interpreting the data and making background comparisons. Therefore, soil samples will be treated in a manner similar to that in which samples were 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, 1998). This format was adopted because it has been used for other QAPPs developed for RFI investigations at NSWC Crane. An effort has been made to ensure that the flow of information from one section to another is logical, while adhering to IDEM and U.S. EPA Region 5 guidance and 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 OGTSL and the five SWMUs that are the focus of this investigation. This section contains information including site location, facility size, borders, natural and man-made features, climatology, topography, local hydrology and hydrogeology, surrounding land use, and ecological communities and habitats. Greater detail is provided for SMWUs 8 and 15 where full RFIs are to be conducted. Lesser detail is provided for SWMUs 18, 19, and 20 and the OGTSL where very limited investigations are being conducted to gather data for completion of the CA725 EI Forms.

1.2.1 Location and Description

General

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 1-2. 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.

In 1983, an initial assessment study (IAS) was conducted by the Naval Energy and Environmental Support Activity (NEESA) which identifies that Buildings 104, 105, 198, and 200 are the primary locations in SWMU 18 where activities took place (NEESA, 1983).

SWMU 8, Building 106 Pond Area

The Building 106 Pond is located in the Load and Fill Area near the western boundary of NSWC Crane, approximately midway between the northern and southern boundaries of the facility.

The SWMU is located within the Boggs and Turkey Creek 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 (Figure 1-1). Site features for the SWMU are included in Figure 1-3.

SWMU 15, Roads and Grounds Area

SWMU 15 is located west of Turkey Creek in the northern half of NSWC Crane. The SWMU approaches 300 acres (ac) in size. A parking area and a Pyrotechnics Production Area are located west of the SWMU. Site features for the SWMU are included in Figure 1-4. The eastern and southern edges of the SMWU include or are upgradient of drainage channels that flow ultimately toward the southeast. To the west and north are industrialized areas. The areas of most interest for this investigation are those where roads and grounds support activities occurred. These are primarily in the southern half of the SWMU.

SWMU 18, Load and Fill Area Buildings

Site features for SWMU 18 are included in Figure 1-5. This SWMU, which spans approximately 500 ac, is located near the western boundary, approximately midway between the northern and southern

boundaries of the facility. The SMWU is situated immediately east of a large array of explosives magazines with additional magazines slightly further away to the east and northeast. The actual area under investigation comprises select SWMU buildings and immediate surrounding areas and does not include the entire area within the SMWU boundary shown on Figure 1-5. In addition, SWMU 8 is located within this SWMU, but it is not considered to be part of SMWU 18.

Based upon the 1983 IAS, deposition patterns, and the maximum potential for worker exposure, four areas near Buildings 104, 105, 198, and 200 were selected to be the focus of this data collection effort. Sampling locations near these buildings were chosen at locations where maximum potential worker exposure is anticipated based upon information from the 1987 Preliminary Review/Visual Site Inspection Report, the 1983 IAS, a February 23, 2004 site tour by NSWC Crane and TtNUS representatives, and potential deposition patterns (A. T. Kearney, 1987, NEESA, 1983).

SWMU 19, Pyrotechnic Test Area/Annex/Rocket Range/Impact Area

SWMU 19 consists of three physically separate areas (OTA, PTA Annex, and Rocket Range) located in the south-central portion of the facility. Most of SWMU 19 is within the Boggs Creek 100-year flood plain, which flows through the SWMU.

The three areas that comprise SWMU 19 total approximately 239 ac. The OTA is approximately 166 ac; the PTA Annex is approximately 54 ac; and the Rocket Range is approximately 15 ac. Two figures (Figures 1-6 and 1-7) have been developed to illustrate the site features of this large SWMU. The OTA and PTA Annex are presented in Figure 1-6, and the Rocket Range is presented in Figure 1-7.

SWMU 20, CAAA QA/QC Test Area

SWMU 20 is located adjacent to Highway 58 near the center of NSWC Crane and is relatively small (less than 7 ac). It is located less than one-half mile east of SWMU 13 (Mine Fill B) and is situated immediately west of SWMU 25, Highway 58 Dump Site A. Site features for SWMU 20 are included in Figure 1-8. The central 2 ac of the SWMU are relatively flat, with side slopes receding toward the south, east, and north.

OGTSL, Old Gun Tub Storage Lot

The OGTSL is located southeast of Building 3032. Site features are included in Figure 1-9. This relatively level, open area is approximately 4 ac in size. It is flanked by steep slopes toward the north, east, and south.

1.2.2 Land Use Classification

There is no state or local planning within the vicinity of NSWC Crane. Because most of the region is covered by vegetation, the area is classified as rural (TtNUS, 2000b). 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 degrees Fahrenheit (°F) to an average minimum January temperature of 26°F. Precipitation is fairly evenly distributed throughout the calendar year; the maximum precipitation occurs during the spring and early summer. The average annual precipitation at the facility is 44 inches and consists 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 from the northwest during January through March (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 1-10 is a wind rose summarizing the mean wind direction and wind speed distribution for the Indianapolis International Airport over a 5-year period (1985 to 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).

SWMU 8, Building 106 Pond Area

Surface drainage enters intermittent drainageways to the east of the SWMU. The drainageways continue toward the south-southeast under Highway 45. Surface flow continues toward the south while gaining volume from other intermittent sources until entering Boggs Creek.

SWMU 15, Roads and Grounds Area

Surface drainage from SWMU 15 enters intermittent drainageways to the south and southeast of the SWMU. These intermittent drainageways converge into a single intermittent drainageway that continues to flow south-southeast under Highway 99. Surface flow continues towards the south while gaining volume from other intermittent sources until the surface flow enters Turkey Creek.

1.2.5 Geology and Stratigraphy

The unconsolidated overburden deposits at NWSC Crane generally range from 0 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 United States 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 1-11). 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 (USACEWES, 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 Pennsylvanian Raccoon Creek Group occupies the higher elevations of NSWC Crane (Figure 1-11). Less than 10 feet of soil is reported to overlie the bedrock at SWMUs 8 and 15.

SWMU 8, Building 106 Pond Area

This SWMU lies within the Wellston-Gilpin Soil Unit of NSWC Crane with minor soil types including well-drained and moderately well-drained Zanesville soils.

The area around Building 106, including the discharge area of the pond, includes Zanesville-Udorthents (ZnB) soil complex at 2 to 6 percent slopes. The ZnB complex soils are residual soils comprised of clay, silt, and silty clay that directly overlay bedrock.

The soils at SWMU 8 are shallow in nature and are at the high end of the hydraulic conductivity range for ZnB complex soils. Due to the moderately steep slopes in this area, rapid storm water runoff is expected, with a decreased potential for surface soil contamination to infiltrate into bedrock and ground water, and an increased potential for contamination of surface water and drainageways.

The bedrock at SWMU 8 is composed of sandstones, shale, and limestone of the Pennsylvanian Raccoon Group. Bedrock can be found at depths less than 5 feet bgs.

SWMU 15, Roads and Grounds Area

The soils at SWMU 15 consists of Wellston-Gilpin Complex residual soils that are steeply sloping from 12 to 30 percent. The Gilpin soils are moderately deep with bedrock commonly found at a depth of 39 inches. The Wellston surface soils are silt, clay, clayey silt, and gravelly clay with subsurface soils of sandy clay and silty sand. The Gilpin soils are gravelly clay, sandy clay, clay, and clayey silt. The surface runoff is medium for both soil types.

The bedrock beneath the SWMU is sandstone, shale, and limestone of the Pennsylvania Raccoon Group with a north-south trending lineation that terminates just north of the SWMU.

The stream that runs through the SWMU is intermittent and may intersect ground water depending upon the season.

1.2.6 Hydrology and Hydrogeology

The surface drainages at NSWC Crane have 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 eastern fork of the White River and then to the Wabash River to the southwest. Figures 1-1 and 1-12 show the basins and drainages of NSWC Crane, respectively. The four SWMUs lie within the Boggs and Turkey Creeks Drainage Basins, which discharge into the eastern fork of the White River, ultimately discharging into the Wabash River. The Boggs and Turkey Creeks drainage basins drain roughly 50 percent of NSWC 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.

Ground water exists in the Lower Pennsylvanian Mansfield Formation (Raccoon Creek Group) bedrock in the higher elevations of NSWC Crane. Ground water will most likely not be encountered in the overlying unconsolidated material at higher elevations. The bedrock shale and sandstone units can be alternating and interlayered in relatively thin beds or can be thicker where not alternating or interlayered. Coal seams may also be present in the Lower Pennsylvanian bedrock. In general, ground water will travel through the fracture and joint systems in the bedrock, especially fractures within limestone and sandstone aquifers, along with some lesser flow through the individual pore spaces of coarser materials such as sandstone. Less permeable units such as shale and siltstone can act as vertical barriers to downward migration.

Three shale formations beneath the Raccoon Creek Group are important aquitards (deterrents to vertical movement of ground water and contaminants). The Indiana Springs Shale underlies the Golconda-Haney Limestone and is 20 feet thick. 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.

SWMU 8, Building 106 Pond Area

Site-specific hydrogeologic information is unavailable for the SWMU due to the absence of boring data. However, shallow ground water flow patterns are expected to mimic topography with highest ground water elevations along ridge crests and with ground water flow toward the major stream or tributary valleys. Recharge to the shallow ground water system is expected over most of the uplands and sideslopes. Ground water is expected to move downward and then laterally and eventually discharge to surface water in the deeper stream valleys.

SWMU 15, Roads and Grounds Area

The aquifer beneath SWMU 15 is considered to be vertically isolated by interlayered shale beds that act as aquitards. Ground water recharge occurs where aquifer units outcrop. After entering an aquifer outcrop, ground water flows by gravity down the dip of the aquifer unit. Ground water flow across the SWMU is towards the southwest.

1.3 FACILITY HISTORY AND BACKGROUND

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 funds for new inland ammunition production facilities, some of which was earmarked to build a Navy ammunition depot at Burns City on the site of the White River Project. Attractive characteristics of the Burns City site were a remote location that was free of congested areas, hilly terrain ideal for magazine construction and camouflage, the proximity of Lake Greenwood, which could supply water for the facility, and the distance from the eastern seaboard, which minimized the danger of enemy attack.

In 1940, Congress authorized construction of a Naval Ammunition Depot (NAD) in southern Indiana, and in late 1941, the Burns City Ammunition Depot was commissioned. In 1943, NAD Burns City was renamed NAD Crane, and the Town of Crane was built to house the rapidly growing number of civil service employees. NAD Crane's overall mission was to load, prepare, renovate, receive, store, and issue ammunition to the fleet.

During World War II (WWII), NAD Crane's mission expanded to include pyrotechnics production, mine filling, rocket assembly, field storage, torpedo storage, and ordnance spare parts and mobile equipment

storage. After WWII, NAD Crane supplied ammunition to the fleet during the Korean and Vietnam conflicts. During the 1950s, several new departments were created, the Ammunition Loading and Production Engineering Center (ALPEC) was transferred to Crane, and the central Ammunition Supply Control Office (ASCO) was established.

In 1975, NAD Crane was renamed the Naval Surface Warfare 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 CAAA was established as a Crane tenant to accomplish this task for Naval ammunition. Other functions remain under the Navy, and the Navy retains ownership of all real estate and facilities at Crane. Responsibility for overall station safety, security, and environmental protection remains with the Commanding Officer. In 1992, based on changing missions and alignment, the facility name was changed to NSWC Crane.

Until the late 1970s and early 1980s, a variety of liquid wastes from both ordnance and non-ordnance activities were disposed on site without treatment. For example, ordnance-contaminated wastewaters were discharged into unlined ponds or into storm drains; wastewaters generated from cleaning operations were discharged into an unlined pond; oily waters, battery acids, paint thinner, acetone, boiler blowdown, and solvents were dumped behind buildings or into ravines; and waste hydraulic oil was spread on dirt roads. Since that time, wastewater treatment plants have been built, wastewater streams have been connected to the sanitary sewer, and oils and solvent have been collected, segregated, and either recycled, sold, or properly disposed.

Air pollution control devices were not installed until the late 1970s. Therefore, ventilation systems at bomb-loading facilities and the Building 146 incinerators had no scrubber systems until the 1970s. Waste management activities included the burning of solid waste and subsequent disposal of ash in unlined pits or gullies.

1.3.2 SWMU 8, Building 106 Pond Area

SWMU 8 is located north and west of Turkey Creek in the west-central half of NSWC Crane. The Building 106 Pond is located in the southeastern corner of the SWMU. The pond is an unlined surface impoundment for wastewater that was generated in Buildings 106 and 107 where casings were overhauled.

The following presents historical information regarding the SWMU operations and sampling from the 1992 Final RCRA Facility Investigation Phase I Environmental Monitoring Report by Halliburton NUS.

Building 106 used a cleaning process that consisted of a caustic wash, a degreaser, and an acid wash. Prior to the cleaning process, spent shell casings were brushed clean. Then the cleaned casings were soaked in a hot caustic bath for 10 to 30 minutes. Next the casings were degreased with TCE followed by a 3-minute hydrochloric acid (HCl) soaking, and then they were rinsed.

In 1983, Building 107 activities included refinishing of wooden and metal boxes. The box refinishing process consisted of the following four steps:

Cleaning/degreasing,
Grit blasting,
Priming and painting,
Oven drying.

Refurbished boxes were stored for reuse.

For metal boxes, the cleaning portion of the process utilized approximately 712 gallons of TCE per year. Painting was done in four paint booths equipped with water washes for particulate control. The amount of dust collected daily from the accumulator/baghouse was approximately 300 to 400 pounds. After the painting, the boxes were dried in ovens that exhausted directly out of the building.

For wooden boxes, there was an additional step, treatment with pentachlorophenol (PCP). The PCP treatment step consisted of dipping the wooden boxes in a 5-percent solution of PCP in a "dip tank" for 5 minutes followed by partial drying of the boxes in a "dip pan." The dip tank and pan were located adjacent to each other under an exhaust hood that discharged outside the building. Approximately 8,800 gallons of PCP was used annually.

Although no supporting documentation could be found, facility personnel indicated that in the mid-1970s, phosphatizing of steel was conducted in Building 106. The phosphatizing process, applying of a zinc phosphate coating to the projectiles, consisted of the following five steps for the projectiles:

Degreasing
Rinsing

Phosphatizing
Cold water rinse
Conditioning rinse

The conditioning rinse was a dilute solution of either chromic acid or chromic and phosphoric acids. There was reportedly a wastewater pretreatment system associated with the phosphatizing process. The wastewater pretreatment system provided chrome reduction, metal precipitation, phosphate removal, clarification, and sludge dewatering. The pretreatment facility consisted of two 200-gallon collection sumps, a 500-gallon chrome reduction tank, a 500-gallon neutralization tank, a 200-gallon flocculation tank, a Lamellar clarifier, a filter press for sludge dewatering, a chemical feed system, process controls, mixers, pumps, and related piping. Clarified effluent from the pretreatment plant was sent to the Base wastewater treatment plant (WWTP).

Activities at Buildings 106 and 107 included the application of coatings in two paint booths. Paint Booth Number 1 applied a zinc chromate coating containing 40 weight percent toluene. Paint Booth Number 2 applied an olive drab coating containing 22 percent naphtha. Each paint booth utilized approximately 500 gallons of coating material per year. Prior to coating, the Hawk missile containers were silica sandblasted, which produced approximately 800 to 1,000 pounds of baghouse residue per day.

During WWII, the ignition ends on smokeless powder bag charges were colored red in Building 106 using naphthalene sulfonic acid sodium salt family dyes. Based upon the 1992 Halliburton NUS report, the small usage rate of these dyes would preclude environmental impacts. Therefore, for this QAPP, naphthalene sulfonic acid sodium salts have not been included in the analyses at this SWMU.

Prior to 1972, untreated wastewater from the cleaning processes in Buildings 106 and 107 was discharged into the Building 106 Pond. Sometime after 1972, the Building 106 Pond was connected to a neutralizing system that subsequently discharged into a sanitary sewer system. Reported malfunctions of the pumping system have caused the Building 106 Pond to overflow. Additionally, it has been reported that the discharge from this pretreatment system exhibited high pH and contained explosives, heavy metals, oil, and grease. Furthermore, it was reported that oil was released into the ditch located between Buildings 106 and 107 when oily water from a compressor in Building 107 leaked and flowed through a floor drain into a clay storm drain pipe leading to the ditch.

In 1972, the Building 106 Pond effluent was analyzed. Table A-1 (Appendix A) presents the summary of effluent analytical results for the 1972 sampling performed at the Building 106 Pond. In 1985, two soil

samples were analyzed for heavy metals utilizing the EP toxicity test and for TCE and oil/grease. All concentrations were less than the hazardous waste classification levels. However, contamination can still be present in concentrations that present significant risk, even if the contaminants are not leachable in concentrations that results in concentration of the material as hazardous. Also the samples contained large amounts of leaves and sediment, therefore, contamination at SWMU 8 could not be dismissed. No other historical soil, surface water, ground water, or sediment sampling has been performed at SWMU 8. A list of potential hazardous wastes associated with the Building 106 Pond is contained in Table 1-1.

Currently, repair operations are intermittently performed in Buildings 106 and 107.

A former drum storage area was located to the south of Building 106 in an open area. Information is not available on the nature of the materials that were stored in the drums. It is believed that the drums stored contained metal and organic wastes.

1.3.3 SWMU 15, Roads and Grounds Area

SWMU 15 is located west of Turkey Creek in the northern half of NSWC Crane. A parking area and a Pyrotechnics Production Area are located west of the SWMU. An instrumentation calibration and repair building is located south of the SWMU, and inert and open storage areas are located north of the SWMU.

There was a 5,000-gallon AST along the north side of the former boiler house, Building 2801. Approximately, 10,000 gallons of waste oil were removed annually from this AST.

An asphalt batch plant with unknown operational history was removed in the early 1970s. At this asphalt batch plant, tar was heated to a liquid and stored in tanks with steam coils. The batch plant spanned two ground elevations. Liquid tar from the USTs in the upper level flowed by gravity to ASTs on the lower level. The liquid tar was then used in the asphalt batching process. Although there is no supporting documentation, other asphalt plants of this era are known to have mixed waste oils such as vehicle crankcase oils with the potential to contain metals and hydraulic oils with the potential to contain polychlorinated biphenyls (PCBs) into the liquid tar.

Discharges from the storage tanks included the boiling over of asphalt and the accidental discharges associated with transfer and storage at the liquid asphalt. Liquid tar from spills was reported to have flowed as far as the drainageway between Buildings 2693 and 2801. Liquid tar from spills was reported to have flowed as far as the drainageway between Building 2693 and 2801.

Although it is presumed that maintenance activities took place at this SWMU, a description of the maintenance was not available. However, it is known that materials and wastes handled at this SWMU included: waste oils, fuel oils, antifreeze, hydraulic oils, pesticides, herbicides, paints, lubricants, solvents, and general refuse (e.g., drums, containers, construction debris).

1.3.4 SWMU 18, Load and Fill Area Building

SWMU 18 was the site of explosives load and fill operations (i.e., press loading of projectiles) and is currently used for renovation, rework, and loading of munitions items.

Press loading of projectiles consists of mechanically consolidating increments of explosive charges (e.g., energetics) into the cavities of projectiles. During WWII, Buildings 104, 105, and 198 were utilized for explosive projectile pressing operations while major caliber projectiles were press loaded in Buildings 105 and 200. These facilities were used intermittently for explosive load and fill operations through the early 1960s and possibly as late as the early 1970s.

During WWII, explosive sifting to eliminate large particles and agglomerates was conducted at SWMU 18 where spills of Explosive D were known to have occurred. In a 1972 wastewater effluent study, heavy metal, energetics, and ammonium picrate were found in wastewater discharges associated with SWMU 18 (A.T. Kearny, 1987, NEESA, 1983).

1.3.5 SWMU 19, Pyrotechnic Test Area/Annex/Rocket Range/Impact Area

SWMU 19, which is approximately 240 acres in size, is also known as the OTA and consists of three physically separate areas where related functions are performed. Each major test area is described in the subsections below.

1.3.5.1 Ordnance Test Area

The OTA, which abuts the PTA Annex, is approximately 166 ac in size. Functional testing of flares, signals, and other marking devices has been performed at this location for about 40 years. The tested devices ranged from hand-held, marine, and aerial devices such as personnel distress signal flares, ground illumination signals, decoy flares, location marker flares, smoke pots, tear gas, riot and smoke grenades, and similar devices. The OTA comprises several different test locations, some of which are used for testing more than one type of device. See Figure 1-6 for OTA structure and testing locations. Testing is generally conducted on gravel pads without features to collect any residues (e.g., shrapnel)

resulting from testing. However, the areas are inspected after every test, and most of the visible debris is collected. In addition, herbicides were used to control vegetation in those areas, but no large-scale management of pesticides was conducted at this SWMU.

Contaminants likely to be present at the OTA are chlorates, dyes, oxidizers, fuels, inorganic salts, and other by-products of flares and smokes. In addition, jet fuel-contaminated water was discharged onto the ground after cook-off tests, and phosphorus- and cyanide-contaminated water was discharged prior to 1989. The reactivity of phosphorus has led to the elimination of phosphorus or phosphates from the testing regime for this investigation because the elemental phosphorus should rapidly convert to phosphates upon contact with air and water.

Tear gas [alpha-chloroacetophenone (CN)] was used at the Riot Grenade Test Area at SWMU 19. However, the chemical is not expected to be of concern due to its high rate of hydrolysis in water, ease of decomposition, and the low sensitivity of animals to the compound. CN has a half-life of approximately 7 minutes in water solutions with a pH of 7 at room temperature. CN can easily be inactivated by means of a water solution.

The following information concerning the OTA was obtained during a teleconference among the Navy Southern Division, NSWC Crane, and TtNUS on July 11, 2001 and from the 2001 site visit by TtNUS and others:

- With some exceptions, contamination should be greatest near the test pad centers and should rapidly decrease radially outward.

- In signal test areas, the signal flares, etc. are fired vertically upward and return very close to the test pad center. Most testing is done during daylight hours, largely because of the availability of safety equipment and personnel, but sometimes the tests are conducted "after hours."

- Many of the tests emit smoke that would follow the prevailing wind direction, which is generally out of the southwest during daylight hours.

- Some signal flares and other devices are parachute suspended. For these items, the potential for longer term emission of smoke over a large area is generally much greater than land-tested devices. Wind speed did not necessarily influence whether aerial testing would be performed; however, testing was limited when winds exceeded 15 miles per hour.

- Recovery of hard debris (e.g., lead slugs) is accomplished on a visual basis. Bullets are not collected from the bullet impact area. Only about 15 rounds are tested at the site at any one time.

- Visual observation of tested devices during and after deployment supports the estimates of contaminant distributions. For example, hand-held flares are ignited by hand and held within a few feet of the test pad centers.

- This SMWU lies in a flood plain, and distribution of contamination across the SWMU could be influenced by occasional flooding.

1.3.5.2 PTA Annex

The PTA Annex covers approximately 54 ac. Figure 1-6 shows important features of the PTA Annex. Rockeye bomblets and explosives testing conducted at the Annex started in 1972, but only explosives testing is currently being conducted. Rockeye bomblets were initially loaded with Octol [a cyclotetramethylene tetranitramine (HMX) - 2,4,6-trinitrotoluene (TNT) mixture]. The bomblets later contained Composition B [a cyclo-trimethyl-trinitramine (RDX)-TNT mixture]. The Annex also includes a control room, air launch building, two test chambers, two gun turrets, a metal platform, and a wooden wall.

Rockeye bomblets (both live and dummy loaded) were air-fired from the air launch building into penetration test blocks set up in the first gun turret. Rockeye bomblets have been removed from the Navy arsenal. The second turret is located farther west of the Annex area and was used during spin testing of Rockeye bomblets. Spin testing involves dropping a bomblet onto a steel test block placed on a steel platform at the base of the turret. A 10- to 12-foot earthen berm is located west of the Annex to help contain effects of the blasting. A 5-foot-long, 4-foot-high wall constructed of 4-inch by 4-inch wooden posts is located west of the earthen berm. A steel test platform and a 3-foot by 3-foot concrete pad are located west of the wooden wall. This equipment is used in testing plastic and sheet explosives.

Contaminants likely to be present in this area are explosive residues and their by-products. Metals from bomblet casings, test blocks, and the gun tub may also have been released at this SWMU.

1.3.5.3 Rocket Range

Figure 1-7 presents important features of the Rocket Range. The Rocket Range, approximately 19 ac in size, has been in use for about 40 years. Past operations involved the testing of ordnance and rocket motors containing dummy loads were also tested here. A dye test tank was located at the Rocket Range during the 1950s and 1960s. Present-day testing involves smoke warheads, 5-inch rockets, and ordnance testing in test chambers (former gun turrets). The pyrotechnics are either fired down range from the launch site or are tested in one of the facilities at the Rocket Range. A sand pit is located at the impact area. A wave tank is used to test marine markers and signal flares. Most contamination at the Rocket Range is expected to have been deposited surficially. However, some contamination at the impact area may have been released to the subsurface. Here, as in the OTA proper, contaminants may have been dispersed by flooding because the Rocket Range is in the Lake Gallimore flood plain.

The dummy loads of the rocket test should pose no chemical risks. The contaminants likely to be present in this area from pyrotechnics and other testing are similar to those for the OTA. In addition, an occasional munitions round was reportedly found during excavations in this area (Halliburton NUS, 1992a). Explosive ordnance cook-off tests are also reported to have occurred in two of the gun turret test chambers at the Rocket Range (Halliburton NUS, 1992a).

Contaminants likely to be present at this SWMU include explosives, semivolatile organic compounds (SVOCs), volatile organic compounds (VOCs), metals, cyanide, perchlorate, and nitrate.

1.3.6 SWMU 20, CAAA QA/QC Test Area

The QA/QC testing of explosives and pyrotechnics devices occurs in Building 2167 at SWMU 20. Lead chromate contamination from testing of MARK1-3 flares has been identified on the nearby ground surface. The potential for other explosives- and pyrotechnics-related contamination also exists.

1.4 EVALUATION OF HISTORICAL DATA AND CURRENT SITE STATUS

As discussed in Section 1.3.2, effluent sampling at the Building 106 Pond was conducted in 1972. Approximately 47 samples were taken and selectively analyzed for water quality parameters [total organic carbon (TOC), turbidity, dissolved oxygen (DO), etc.], metals, and explosives. The results of these analyzes are presented in Appendix A Table A-1. Additionally, an historical report indicates that the Building 106 Pond has overflowed into a tributary of Boggs Creek. Piping into the Building 106 Pond has been disconnected and rerouted into the facility wastewater sewer system.

One round of soil sampling consisting of 13 soil samples was collected during July 2002 at the OGTSL and analyzed for SVOCs, polychlorinated biphenyls (PCBs), and selected metals (cadmium, chromium, and lead). Sporadic detections of SVOCs at trace levels were found. No PCBs were found. Cadmium, chromium, and lead were detected. No planning document was prepared for the field effort, and the data were not validated. Because the data were not validated, it is not known whether the SVOC detections were false positives. No surface water, ground water, or sediment sampling has been performed at the OGTSL. The OGTSL is currently inactive.

Aside from the EP toxicity data described in Section 1.1.2, no historical data are available for SWMU 15. Historical analytical data for SWMUs 18, 19, and 20 are also not available. SWMUs 15, 18, 19, and 20 are active sites. SWMU 19 consists of three areas (OTA, PTA Annex, and Rocket Range). The OTA is where devices such as hand-held marine and aerial devices such as personnel distress signal flares, ground illumination signals, decoy flares, location marker flares, smoke pots, tear gas, riot and smoke grenades are tested. Explosive testing is conducted at the PTA Annex. Operational ordnance test chambers (former gun turrets) exist, and smoke warhead and 5-inch rocket testing is conducted at the Rocket Range.

1.5 INTENDED DATA USES

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

All field parameter results greater than or equal to method detection limits (MDLs) will be reported. Field parameters not detected will be reported at the MDL. MDLs for field parameters are based on method or test kit capabilities and specifications. All laboratory results greater than or equal to threshold values (TVs) will be reported. Target parameters not detected will be reported at the TV.

Laboratory TVs 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. They reflect the computed instrument detection limit (IDL) or the method detection limit adjusted to reflect what the laboratory can realistically expect to achieve on a routine basis for the environmental matrices to be analyzed. This accounts for day-to-day variations in IDLs and MDLs that the laboratory has experienced in the past, plus other factors such as the recognition that MDLs were computed from data generated in matrices other than those at SWMUs 8, 15, 18, 19, and 20 and the OGTSL.

The CFR requires the MDL to be computed as the standard deviation of replicate analyses, with results multiplied by the appropriate Student's t-value. Sample-specific laboratory TVs will be computed for each sample to account for variations in the TV caused by factors such as sample moisture content, the size of the sample aliquot used in the analysis, and dilutions. The actual TV used will be an estimate of the MDL achievable in actual sample matrices. This estimate will be based on the laboratory's computed IDLs and MDLs and the laboratory's best estimate of the effect of actual sample matrices on these computed values. This approach will frequently result in a TV that is greater than the computed IDL or MDL but less than the practical quantitation limit (PQL), but it is viewed to be a reasonable compromise between using IDLs and MDLs that are unrealistically low and PQLs that reflect the quality of the concentration estimate rather than the ability to detect the presence of an analyte in a sample.

Analytical results for analytes that are less than applicable MDLs (or TVs) 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 (or TV). Analytical results that are between the MDL (or TV) and the reporting limit (RL) will be reported with a "J" flag.

1.5.1 Project Target Parameters and Rationale for Selection

Key target parameters for SWMUs 8, 15, 18, 19, and 20 and the OGTSL for each environmental medium were selected based on historical activities, types of contaminants that may have been released as a result of the activities conducted, and available historical monitoring data. Tables 1-2 through 1-4 list the analyses and the associated rationale for each site and, as appropriate, each AOC within the site.

SWMU 8

The investigation at SWMU 8 will be conducted utilizing a phased sampling approach. The objective of the first round of sampling is to determine whether and where surface and select subsurface soil, surface water, and sediment contamination exists. If the first round of sampling does not provide sufficient contamination information, additional rounds of sampling will be conducted.

Where contamination is determined to be present in subsurface soils in concentrations that could impact ground water, monitoring wells will be installed to evaluate if contamination has migrated into the ground water. However, other than perched ground water sampling at some locations, ground water samples have not been scheduled for analyses in Round 1.

The SWMU 8 operational history is presented in Section 1.3.2. The primary contaminant release pathways and deposition mechanisms are as follows:

- Floor drainage from the Building 106 caustic washing process (including caustic wash, TCE degreaser, and hydrochloric acid rinse) flowed into the Building 106 Pond.

- Floor drainage from the Building 106 paint booths [including zinc chromate and olive drab coatings that contained methyl ethyl ketone (MEK), toluene, naphtha, and xylenes] flowed into the Building 106 Pond.

- Floor drainage from the Building 107 metal and wooden box refinishing process (including baghouse dust, PCP, selenium, TCE, zinc phosphate, chromium, phosphoric acid, and boric acid) flowed into the Building 106 Pond.

- Overflow from the metal and wooden box refinishing flocculant tank into the Building 107 floor drainage flowed into the Building 106 Pond. This overflow included aluminum in nitric acid and solutions that potentially contained lead and selenium.

- Overflow from the Building 106 Pond onto surface soil and into sediment, potentially affected underlying subsurface soil and ground water.

- Overflow of stored oil used in weapons coating at Buildings 106 or 107 flowed into the Building 106 Pond.

- Floor drainage from energetics associated with reported load and fill operations at Buildings 106 and 107 flowed into the Building 106 Pond.

- Floor drainage from oil storage overflow at Buildings 106 or 107 flowed into the Building 106 Pond.

- Spills or leaching from drums potentially containing metals, organic solvents and fuels, pesticides, herbicides, and PCBs to surface soil are suspected.

These release pathways and deposition mechanisms affect primarily surface soils. Contaminants in surface soils and pond sediment may have migrated into subsurface soils. Contaminated surface soil and contaminated pond water overflow may also have migrated into site drainage channels and ultimately

into Boggs Creek. Surface water may have been contaminated via contact with contaminated surface soils and pond water. Subsurface soils could release contaminants to ground water.

The chemicals or chemical mixtures potentially released at SMWU 8 fall primarily into three categories: caustics, organics, and metals. Caustics could be a concern because of the potential use in Building 106 caustic wash cleaning process. VOCs, SVOCs, and metals could be a concern because of potential use at Buildings 106 and 107.

Existing analytical methodologies are suitable for quantifying these chemicals in each of the environmental matrices of interest for comparison to risk-based screening criteria and for risk assessment. Refer to Table 1-2 for a summary of the SWMU 8 analytical program and rationale and to Table 1-5 for specific analytical methodologies and corresponding target analyte lists. The following analytical scheme has been selected for SWMU 8:

- Metals (surface and subsurface soils, surface water, sediments, and ground water) - Metals may have been released from the Building 106 Pond and the former drum storage area directly to surface or subsurface soils with subsequent migration to sediments, surface water, and ground water.

- SW-846 nitroaromatics/nitramines (surface and subsurface soils, surface water, sediments, and ground water) - These compounds may have been released from the Building106 Pond directly to surface or subsurface soils with subsequent migration to sediments, surface water, and ground water.

- VOCs (surface and subsurface soil) - VOCs may have been released to subsurface soils near the Building 106 Pond and at the former drum storage area.

- SVOCs (surface and subsurface soils, surface water, and sediments) - SVOCs, including polynuclear aromatic hydrocarbons (PAHs), may have been released into soils and accumulated near the Building 106 Pond and at the former drum storage area. The potential exists for migration toward downstream surface water conveyances.

- General water-quality parameters [DO, oxidation-reduction potential (ORP), pH, specific conductance, temperature, turbidity, and flow rate (surface water only)] - Information on general water-quality parameters is necessary to evaluate the overall quality of surface water in Boggs Creek tributaries and to provide information on contaminant masses (flow rate).

- TOC, cation exchange capacity (CEC), and pH - (soils and sediments) - This provides information for use in corroborating the absence or presence of contamination and potential bioavailability.

- Depositional environment and grain size (sediment, surface soil, and subsurface soil) - This provides information for potential use in the CMS and for comparison to background concentrations (for naturally occurring inorganics).

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.

Table 1-2 presents proposed sampling analyses and rationales for various areas throughout the SWMU.

Soil

Soil sampling will be conducted for surface soils at a depth ranging from 0 to 2 feet and for subsurface soil from 2 feet to the depth of the bedrock. Soil samples will be analyzed for Target Analyte List (TAL) metals plus tin, explosives, VOCs, SVOCs including PAHs, pesticides, and herbicides.

Ground Water

Ground water samples will be analyzed for TAL metals, energetics, perchlorates, VOCs, SVOCs including PAHs, and fecal coliform.

Surface Water and Sediment

Surface water and sediment samples will be analyzed for total and dissolved TAL metals, energetics, VOCs, and SVOCs including PAHs.

SWMU 15

The investigation at SWMU 15 will be conducted utilizing a phased sampling approach. The objective of the first round of sampling is to determine whether and where surface and select subsurface soil, surface water, and sediment contamination exists. If the first round of sampling does not provide sufficient contamination information, additional rounds of sampling will be conducted.

Where contamination is determined to be present in subsurface soils in concentrations that could impact ground water, monitoring wells will be installed to evaluate if contamination has migrated into the ground water.

The SWMU 15 operational history is presented in Section 1.3.3. The primary contaminant release and migration mechanisms and pathways are as follows:

- AOC A, Former Asphalt Batch Plant - spills of asphalt process materials onto surface soils from the batch plant operations are know to have occurred. This could have resulted in releases of SVOCs and VOCs to soil with subsequent migration to ground water, surface water, and sediment. Metals may have been released from the crankcase oil spills directly to surface or subsurface soils with subsequent migration to sediments, surface water, and ground water.

- AOC B, Former UST and Gasoline Pump Area - spills of leaded gasoline from the UST to subsurface soil are suspected due to a petroleum-type odor during previous excavations in this area. This could have resulted in releases of SVOCs and VOCs to soil with subsequent migration to ground water, surface water, and sediment. Metals (e.g., lead released as tetraethyl lead in gasoline) may not have migrated as readily as SVOCs and VOCs.

- AOC C, Former AST near former Building 2801 - spills to surface soil of waste oil potentially containing PCBs are suspected from the former AST. Organic solvent storage also allegedly occurred in this area. Chemicals that may have been released would be limited primarily to SVOCs, VOCs, and potentially related chemicals such as PCBs, with migration to other downgradient media. PCBs, however, are very insoluble and not likely to be dissolved in ground water.

- AOC D, Former Inert Storage (Building 2716) - pesticide and herbicide leakage to surface soil is suspected from pesticide and herbicide paper bag storage in this area.

- AOC E, Former Wash Rack(s) and Paint House (Building 2774) - spills to surface soil from the washdown of equipment which potentially contained metals, pesticides, herbicides, solvents, and PCBs as well as from the Former Asphalt Batch Plant are suspected in this area.

- AOC F, Former AST Areas (Former Buildings 2717 and 2718) - spills to surface soil from oil storage tanks are suspected.

- AOC G, Hillside Debris Area South of Former Buildings 2717 and 2718 - spills or leaching from debris potentially containing metals, organic solvents and fuels, pesticides, herbicides, and PCBs to surface soil are suspected.

- AOC H, Drainage Area Across Intermittent Stream South of AOC G - spills or leaching from debris potentially containing metals, organic solvents and fuels, pesticides, herbicides, PCBs, and cyanide to surface soil are suspected. The cyanide may have been released from plating operations upstream of the SWMU.

- AOC I, Drainage Channels Downgradient of Source Areas - spills to surface soil can migrate downgradient via sediment, surface water, and ground water, potentially containing all potential site contaminants (metals, VOCs, SVOCs, pesticides, herbicides, PCBs, and cyanide).

- AOC J, Areas Upgradient of the Sources - background samples for sediment, surface water, and ground water will be analyzed for all potential site contaminants (metals, VOCs, SVOCs, pesticides, herbicides, PCBs, and cyanide).

- AOC K, Catch Basin West of Roadway along the western side of Building 3330 - background samples for sediment and surface water will be analyzed for all potential site contaminants (metals, VOCs, SVOCs, pesticides, herbicides, PCBs, and cyanide).

- AOC L, Drainageway Southeast of Former Asphalt Batch Plant - spills of asphalt process materials onto surface soils from the batch plant operations are known to have occurred and might have migrated to the drainageway.

- AOC M, Drainageway along the Southern Area of SWMU 15 - spills from wash rack activities onto surface soil might migrate to the drainageway and may have contained metals, pesticides, herbicides, solvents, and PCBs.

- AOC N, Catch Basin South of Former Asphalt Batch Plant - spills of asphalt process materials onto surface soils from the batch plant operations are known to have occurred and might have migrated to the catch basin.

- AOC O, Former Paint Locker - spills onto surface soil from paint and resin storage areas are suspected in this area. The paint and resin may have contained metals.

- AOC P, Catch Basin West of Building 3330 - background samples for sediment and surface water will be analyzed for all potential site contaminants (metals, pesticides, herbicides, PCBs, VOCs, and cyanide).

- AOC Q, Drainageway South of Former UST and Former Gasoline Pump Area - spills of leaded gasoline from UST(s) into subsurface soil with a potential to migrate into sediment ground water and surface water are suspected due to a petroleum-type odor during previous excavations in this area.

- AOC R, Drainageway Southwest of Former Wash Rack - spills from wash rack activities onto surface soil might migrate to the drainageway. The wash waters may have contained metals, pesticides, herbicides, solvents, and PCBs.

- AOC S, Catch Basin at the Intersection of Two Storm Sewers West of the Center of Building 3330 - background samples for sediment and surface water will be analyzed for all potential site contaminants (metals, VOCs, SVOCs, pesticides, herbicides, PCBs, and cyanide).

- AOC T, Storm Water Drop Box/Junction Box Northwest of Former Wash Rack - spills from wash rack activities onto surface soil might migrate to the drainageway. The wash waters may have contained metals, pesticides, herbicides, solvents, and PCBs. This location is upgradient of other monitoring points.

- AOC U, Hillside Debris Area Northeast of SWMU 15 - spills to surface soil or leaching from debris potentially containing metals, pesticides, herbicides, PCBs, and solvents containing VOCs or SVOCs are suspected.

- AOC V, Intermittent Stream Banks South and East of SWMU 15 - spills to surface soil can flow or migrate downgradient via sediment, surface water, and ground water and may potentially contain all potential site contaminants (metals, VOCs, SVOCs, pesticides, herbicides, PCBs, and cyanide).

These deposition mechanisms would primarily have resulted in release to surface soils and catch basins. Releases from USTs would have been to subsurface soils. Contaminants in surface soils may have migrated into the subsurface. Surface water may be contaminated via contact with contaminated surface soils and sediments or via the discharge of contaminated ground water as seeps or springs. Subsurface

soils could release contaminants to ground water, and ground water could release contaminants to subsurface soils.

The chemicals or chemical mixtures potentially released at SMWU 15 generally fall into five categories: inorganics, SVOCs, VOCs, and herbicides/pesticides. Existing analytical methodologies are suitable for quantifying these chemicals in each of the environmental matrices of interest for comparison to risk-based screening criteria and for risk assessment. Refer to Table 1-3 for a summary of the SWMU 15 analytical program and rationale and to Table 1-5 for specific analytical methodologies and corresponding target analyte lists. The following analytical scheme has been selected for SWMU 15:

- Metals (surface and subsurface soils, sediments, surface water, and ground water) - Metals may have been released directly to surface or subsurface soils, depending on the location, with subsequent migration to sediments, surface water, and ground water.

- VOCs (surface and subsurface soils and ground water) - VOCs may have been released directly to surface or subsurface soils, depending on the location. In particular, large quantities of VOCs may have been released in the UST area as a result of UST or transfer line leaks.

- SVOCs (surface and subsurface soils, sediments, surface water, and ground water) - SVOCs, including PAHs, may have been released directly to surface or subsurface soils. Sediment sample results will be used to establish, at least in part, the influence of surface soil runoff because they represent the accumulation of surface water runoff from a relatively large area.

- Herbicides/Pesticides (surface and subsurface soils, sediments, surface water, and ground water) - Herbicides/pesticides may have been released directly to surface soils with subsequent migration to subsurface soils, sediments, surface water, and ground water.

- PCBs (surface and subsurface soils, sediments, surface water, and ground water) - PCBs may have been released directly to surface soils with subsequent migration to subsurface soils, sediments, surface water, and ground water. The ability to detect PCBs in ground water is expected to be limited, however, because of the low solubilities of these compounds.

- General surface water quality parameters [DO, ORP, pH, specific conductance, temperature, turbidity, and flow rate (surface water only)] - Information on general water-quality parameters is

necessary to evaluate the overall quality of surface water in Turkey Creek tributaries and to provide information on contaminant masses (flow rates).

- TOC, CEC, and pH (soils, and sediments) - This provides information for use in corroborating the absence or presence of contamination and the potential bioavailability of contamination.

- Depositional environment and grain size (surface soil, subsurface soil, and sediment) - This test will provide information for potential use in the CMS and for comparison to background concentrations (for naturally occurring inorganics).

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.

SWMU 18

Based on the 1983 Initial Assessment Study (IAS) by the Naval Energy and Environmental Support Activity (NEESA) and the 1987 Preliminary Review/Visual Site Inspection Report by A. T. Kearney, Inc., it was determined that the primary contaminant releases would be particulate in nature and the primary release pattern would have been deposition onto surface soils (NEESA, 1983, A. T. Kearney, 1987). The exposure pathway of most concern would be worker exposure to surface soils. Soil sampling will be conducted for surface soils at a depth ranging from 0 to 2 feet. The most likely locations for worker exposure at SWMU 18 are near Buildings 104, 105, 198, and 200 where releases may have occurred.

Refer to Table 1-4 for a summary of the SWMU 18 analytical program and rationale and to Table 1-5 for specific analytical methodologies and corresponding target analyte lists. Energetics and metals would have been the primary contaminants released; however, release records indicate that ammonium picrate spills have occurred at SWMU 18. The data collected will be used to assess worker exposure for completion of the EI Form CA725 by U.S. EPA Region 5. The following parameters will be evaluated:

- Metals (surface soils).
- Energetics (surface soils).
- Ammonium picrate (surface soils).

SWMU 19

The SWMU 19 OTA operational history is presented in Section 1.3.5. The primary contaminant deposition mechanism is aerial release directly to surface soils. Soil sampling will be conducted for surface soils at a depth ranging from 0 to 2 feet. The data collected will be used to assess worker exposure for completion of the EI Form CA725 by U.S. EPA Region 5. Refer to Table 1-4 for a summary of the SWMU 19 analytical program and rationale and to Table 1-5 for specific analytical methodologies and corresponding target analyte lists.

With a few exceptions, the chemicals or chemical mixtures potentially released at SMWU 19 generally fall into four categories: inorganic chemicals, SVOCs, VOCs, and energetics depending on location. The following parameters will be evaluated:

- Metals (surface soils)
- Energetics (surface soils)
- VOCs (surface soils)
- SVOCs (surface soils)
- Perchlorate (surface soils)

The data that is collected will be used for purposes of assessing worker exposure for completion of the EI Form CA725 by U.S. EPA Region 5.

SWMU 20

The primary contaminant release pattern would have been deposition onto surface soils. The exposure pathway of most concern would be worker exposure to surface soils. Soil sampling will be conducted for surface soils at a depth ranging from 0 to 2 feet. The most likely locations for worker exposure at SWMU 20 are near the areas where testing takes place and where workers set up testing. Refer to Table 1-4 for a summary of the SWMU 20 analytical program and rationale and to Table 1-5 for specific analytical methodologies and corresponding target analyte lists. Energetics and metals would have been the primary contaminants released. The data that is collected will be used for purposes of assessing worker exposure for completion of the EI Form CA725 by U.S. EPA Region 5. The following parameters will be evaluated:

- Metals (surface soils).
- Explosives (surface soils).

OGTSL

The primary contaminant release pattern would have been deposition onto surface soils. The exposure pathway of most concern would be worker exposure to surface soils. The most likely locations for worker exposure at the OGTSL were determined based upon the July 2002 site sampling locations. Refer to Table 1-4 for a summary of the OGTSL analytical program and rationale and to Table 1-5 for specific analytical methodologies and corresponding target analyte lists. PCBs, SVOCs, and metals would have been the primary contaminants released. The data collected will be used to assess worker exposure for completion of the EI Form CA725 by U.S. EPA Region 5. The following parameters will be evaluated:

- Metals (surface soils).
- SVOCs (surface soils).
- PCBs (surface soils).

1.5.1.1 Field Parameters

Several field measurements will be made for this investigation. As previously noted, Tables 1-2 through 1-4 summarize project target parameters and the associated intended data uses.

1.5.1.2 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 decision making is described in Sections 1.5.2, 1.5.3, and 1.5.4.

Part of the data use includes comparing metals concentrations in soil at the individual SMWUs to soil background concentrations. The background concentrations for soil types found at the SWMUs will be obtained from the NSWC Crane Base-Wide Background Soil Investigation (TtNUS, 2001). This report contains concentrations of naturally occurring metals in soil types found at the NSWC Crane SWMUs, including SWMUs 8, 15, 18, 19, and 20 and the OGTSL.

The data use also includes comparing the analytical data to RBTLs, which are action levels derived from human health and ecological RBSLs. The RBTL for a particular matrix is the lowest (i.e., most conservative) of human health or ecological RBSL for that matrix. The following is a list of sources for the RBSLs applicable to this project:

Ground Water and Surface Water RBSLs

- 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 EDQLs for Surface Water
- Federal Ambient Water Quality Criteria (AWQCs) for Freshwater

Soil and Sediment RBSLs

- U.S. EPA Generic Soil Screening Levels (SSLs) for 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 1-5 lists the laboratory parameters, analytical methods, laboratory TVs and RLs, and RBTLs for water (applicable to both ground water and surface water), soil, and sediment. TVs are generally less than RLs. Measurement uncertainty is so great at concentrations less than the TVs that the presence of an analyte cannot be asserted with reasonable confidence in that concentration range. Thus, results less than the TV represent analytes that are labeled as "non-detects." As concentration increases from the TV to the RL and beyond, the relative measurement uncertainty typically decreases. 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 TV 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 TVs was made to provide the greatest chance for achieving the RBTLs in Table 1-5. 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 TVs (or even RLs) that are less than or equal to the RBTLs. It is widely recognized that MDLs computed according to the industry standard (40 CFR Part 136, Appendix B) are determined in sample matrices that are relatively simple. As such, they do not

necessarily reflect what is achievable in actual environmental sample matrices. TVs in Table 1-5 reflect the computed MDL based on 40 CFR protocol tempered by the laboratory's experience with analyzing samples with more complex matrices than those used to determine the TVs. Therefore, the TVs in the tables may be greater than the computed MDLs. Analytes for which the TV is greater than the RBTL for either aqueous or solid matrices are identified in Table 1-5 by shading.

1.5.2 Human Health Risk Assessment

A baseline HHRA will be prepared to estimate risks to current or hypothetical future receptors at SWMUs 8 and 15. The detailed risk assessment methodology is presented in Appendix C. The methodology considers risk assessment protocols established by U.S. EPA Region 5 and the IDEM. The following components of a baseline risk assessment are included in Appendix C:

- Data evaluation protocol (including data usability assessment and COPC selection)
- Exposure assessment (including CSM)
- Toxicity assessment
- Risk characterization
- Uncertainty analysis

1.5.3 Ecological Risk Assessment

The SERA will consist of the first two of eight steps required in the U.S. EPA guidance (U.S. EPA, 1997 and 1998b). Step 3A of the Navy Policy for Conducting Ecological Risk Assessments is the first step of the BERA and consists of refining the list of COPCs that were retained following the SERA. Step 3A will be included as an attachment to the SERA. Steps 3B through 7 will be conducted if additional evaluations or investigations are necessary. Finally, Step 8, Risk Management, will be incorporated throughout the ERA process in cooperation with Region 5 regulators.

The first phase in the ERA process is the SERA. 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 Appendix D:

- Screening-level problem formulation
- Screening-level ecological effects evaluation

- Screening-level exposure estimate
- Screening-level risk calculation

1.5.4 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 and the risks to human health and ecological receptors.

The overall strategy for SWMUs 8 and 15 is to first screen analytical results against risk-based screening criteria to select COPCs. If COPCs are identified during screening, data assessment continues with an evaluation of the nature and extent of contamination and an evaluation of the associated human and ecological risks. Additional data collection may be necessary. However, additional sampling beyond the second round of sampling is less likely.

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 or upgradient concentrations.

Human health and ecological risks will be computed within an exposure unit (EU) boundary and compared to unacceptable risk limits to determine whether an unacceptable risk exists within the EU. For these SWMUs, the EU consists of the entire sampled area, which represents an area likely to be traversed by a human receptor. 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 chosen area. 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 surface water, the ability to collect samples will be affected by rain events. Sampling will be timed to coincide with rain events that occur during field shifts.

All of these facets of decision making are presented in detail below.

1.5.4.1 Definition

The decision rule is a statement that integrates DQO planning process outputs into a concise summary of how data will be interpreted when decisions are made 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. 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 decisions are made.

1.5.4.2 Decision Rules for Establishing Background Concentrations

COPC selection 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. For metals, the background concentrations will be represented by soil data from the NSWC Crane Basewide Background Soil Investigation (TtNUS, 2001). The background data set corresponding to soil having physical characteristics (i.e., grain size, depositional environment, and depth) that most closely represent the SWMU samples will be used. For COPC selection, organic chemicals will be assumed to have zero concentration in the natural environment.

If data from selected locations upstream or upgradient of a SWMU indicate that any of the media do not represent background concentrations, the Navy may consult with IDEM to agree on the most appropriate course of action. Specific background samples for each of the media are identified in Section 3.0.

1.5.4.3 Decision Rules for Selecting COPCs

<u>Non-Detected Chemicals</u>

As explained in Section 1.5.1.2, 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 IDL/TV in all the samples in a particular medium, and the IDL/TV exceeds the risk-based level, the chemical will be qualitatively discussed in the uncertainty analysis section. Statistical calculations described below will not be conducted if an insufficient number of background/upgradient on-site data values are obtained. In general, the following decision rules will be used for selecting COPCs:

- Organic target analytes in surface water and sediment:
  - An organic target analyte is classified as a COPC if the maximum detected target analyte concentration in any site surface water or sediment sample exceeds its RBTL.

- Inorganic target analytes in surface water and sediment:
  - An inorganic target analyte is classified as a COPC if

    1. The Wilcoxon Rank-Sum (WRS) test at a 5-percent significance level indicates that the site surface water or sediment population has a concentration exceeding the corresponding upstream surface water or sediment population concentration. The upstream data set used for these comparisons will be surface water or sediment samples collected upstream of the SWMU.

       AND

    2. The maximum detected target analyte concentration in any site surface water or sediment sample exceeds its RBTL.

- Organic target analytes in surface soil:
  - 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.

- Inorganic target analytes in surface soil:
  - An inorganic target analyte is classified as a COPC if

    1. The WRS test at a 5-percent 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 that

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.

- Organic target analytes in subsurface soil (human health risk only):
  - 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 in subsurface soil (human health risk only):
  - An inorganic target analyte is classified as a COPC if

    1. The WRS test at a 5-percent 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 that 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.

- Organic target analytes in ground water (human health risk only):
  - 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 in ground water:
  - An inorganic target analyte is classified as a COPC if

    1. The WRS test at a 5-percent 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.

Initially, the SWMU 8 and 15 investigations will be focused on surface soil sampling. In brief, the analytical results will be compared against screening criteria and, if the criteria are exceeded (i.e., COPCs are identified) and other indications exist to suggest that other media have been impacted, an evaluation of the data will be undertaken to determine whether media other than surface soils are likely to be contaminated. This evaluation will involve a consultation between the Navy and IDEM. If other media warrant sampling and analysis, additional sampling and data collection will be planned for all media of interest.

The strategy will be similar to the sequential strategy used for the other three SWMUs, as follows:

- Identification of COPCs
- Evaluation of the nature and extent of contamination
- Evaluation of human health and ecological risk

1.5.4.4 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.

Ground Water and Soil Nature and Extent of Contamination

Ground water and soil samples will be collected as detailed in Section 3.0 of this QAPP. Samples will not be collected from beyond the study area of the SWMUs without discussions between the Navy and IDEM.

Surface Water and Sediment Nature and Extent of Contamination

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.

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

If the COPC extent boundary is not identified relative to RBTLs within two rounds of sampling at SWMUs 8 and 15, the Navy will seek consultation with IDEM to discuss the need for additional sampling. The following will be considered:

- The expected contribution to risk estimates of the 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

1.5.4.5 Decision Rules for Evaluations of Risk

The human health and ecological risk assessment methodologies are summarized in Sections 1.5.2 and 1.5.3, respectively, and the related appendices. EPCs in the figures refer to those established in Section 1.5.4.

1.6 STATISTICAL METHODOLOGY

The analysis of variance (or the ANOVA technique) is the basic approach used to compare one data set to another. For soils, this involves a comparison of background soil data to site soil data; for aqueous samples, it involves a comparison of upgradient (or cross-gradient) sample results with downgradient sample results. The ANOVA technique is used to test whether there is statistically significant evidence of contamination. There are two types of ANOVA: parametric and non-parametric. The parametric ANOVA method makes two important assumptions: the data are normally distributed and whether or not the group variances are homogeneous.

- When either of these crucial assumptions to the parametric ANOVA is violated, a more appropriate test will be conducted. Normal data distribution is checked using the Shapiro-Wilk Test of Normality; Group variance homogeneity is checked using the Levene's test of Homogeneity of Variance.

- When the analysis demonstrates that the Shapiro-Wilk Test of Normality passes but the Levene's Test of Homogeneity of Variance does not, then the Satterthwaite t-Test will be utilized to conduct the comparison on the individual observations.

- When the data analysis demonstrates that the Shapiro-Wilk Test of Normality, critical to the parametric ANOVA, is violated, a non-parametric test will be conducted using the ranks of the observations rather than the original observations themselves. Additionally, the Wilcoxon Rank-Sum test (also known as the Mann-Whitney U test) in conjunction with the Quantile Test can be employed as the non-parametric ANOVA for comparing the site results to the background results.

1.6.1 Limit of Detection / Field Duplicates

In the chemical analysis of environmental samples, some analytes may be present at concentrations that are less than the lowest detectable concentration for the analytical procedure. The results are generally reported as not detected (rather than zero), and the appropriate limit of detection is given. This is interpreted to mean that the actual concentration lies between zero and the reported detection limit. The

amount of data that are less than the detection limit plays an important role in selecting the method of addressing the limit of detection problem. The nondetects found at this Crane site will be replaced with the TV divided by two prior to statistical analysis. This substitution is a compromise that allows the insertion of a single numerical value in place of a range of values between zero and the TV so that the data can be used in statistical calculations. If all site observations are nondetect results, no statistical analysis is warranted because the data simply reflect the achievable detection limits divided by two. Another practice that has been adopted is to use only the original sample of field duplicate results in the statistical analysis. This maintains the integrity of the data set by always using the field samples to represent the site analyte concentrations and the QC samples to evaluate reproducibility of the data.

1.6.2 Non-Parametric ANOVA: The WRS Test

The following equations present a step-by-step procedure for conducting the WRS test (also known as the Mann-Whitney U Test).

The null hypothesis (H_0) that is tested is

H_O *The site concentration IS NOT greater than the background (upgradient) concentration.*

The alternate hypothesis (H_A) is

H_A *The site concentration IS greater than the background (upgradient) concentration.*

If H_O is rejected, then H_A is accepted. If H_0 is not rejected, the data set is consistent with the H_0 distribution.

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

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

where E_i are the ranks of the site samples (Large values of the statistic *W* give evidence of contamination in site soils).

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

- 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 WRS 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 because the discrete distribution of the statistic *W* is being approximated by the continuous normal distribution. If *n and m* are greater than 10 and ties 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: *S'D* $\quad (W) = \left(\frac{mn}{12} \left[N + 1 - \frac{\sum_{j=1}^{g} t_j (t_j^2 - 1)}{N(N-1)} \right] \right)^{\frac{1}{2}}$

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 95 percent confidence level test for H_0 versus the, reject H_0 and accept H_A if $Z_{ADJUSTED} > Z_{0.95} = +1.645$.

TABLE 1-1

POTENTIAL HAZARDOUS WASTE
BUILDING 106 POND
NSWC CRANE, CRANE, INDIANA

Waste/Activity	Hazardous Constituent	Comments
Caustic Cleaning	sodium hydroxide chromium lead	
Degreasing	trichloroethane (TCE)	Spent halogented solvents
Paint/Coating	chromium lead dichloromethane acetone ethanol isopropanol methanol methyl ethyl ketone (MEK) naphtha toluene xylene	
Wooden box treatment	pentachlorophenol (PCP)	
waste oils	barium chromium	
Plating/Coating	boric acid cadmium chromic acid chromium hydrofluoric acid	Including coating wastes and sludges as well as caustic cleaning
Solutions	lead nitric acid selenium sodium hydroxide	
Grit Blasting	cadmium chromium lead barium	
Load and Fill Operations	HMX RDX TNT	Explosives

HMX — octahydro 1,3,5,7 tetranitro 1,2,5,7-tetrazocine (which is cyclotetramethylene tetranitramine).
RDX — hexahydro 1,3,5 trinitro 1,3,5 triazine (which is cyclo-trimethyl-trinitramine or "cyclonite").
TNT — 2,4,6-trinitrotoluene.

TABLE 1-2

PROJECT TARGET PARAMETERS AND RATIONALES
SWMU 8
NSWC CRANE, CRANE, INDIANA

Description	Analyses	SS	SB	SD	SW	GW	Rationale
Areas around the floor drain piping from Building 106 to the Building 106 Pond	Energetics TAL metals App IX VOCs App IX SVOCs Fecal coliform	x x x x	x x x x			x x x x x	Building operations included caustic washing, degreasing with TCE, acid wash with HCl, sand blasting, oil storage and the potential of oil-coated weapons storage, a paint shop that utilized paint thinners, toluene, naphtha, metals; xylenes, MEK, and a flocculant tank that could have contained Al, solutions of Pb, HNO_3, and Se. Explosives load and fill operations also reportedly have taken place. Additionally, waste oil with the potential of containing Ba, Cr, and other metals might have been present, and raw sewage may have been released. Building 106 operations included reconditioning and testing of various types of cartridge cases as well as the repair to all types of ammunition containers. Contaminant release mechanism would be leaks from drain lines to soil (primarily subusurface). Contaminant migration would be to deeper subsurface soils and possibly ground water. Ground water could have migrated to surface drainage channels to contaminate surface water and sediment.
Area between Buildings 106 and 107	Energetics TAL metals App IX VOCs App IX SVOCs Fecal coliform PCBs	x x x x x	x x x x x	x x x x x	x x x x	x x x x x	At least one spill to surface soil (unknown volume and composition) from Building 107 is known to have occurred in this area. Other spills to surface soil from either building may also have occurred in this area. Any of the chemicals associated with Building 106 or 107 operations could be a contaminant. A small drainage channel used to exist between these buildings. Any contaminants would be expected to migrate to deeper soils (and possibly ground water), and to downgradient areas via overland runoff (and possibly ground water).
Areas around the floor drain piping from Buildings 107 to the Building 106 Pond	Energetics TAL metals App IX VOCs App IX SVOCs Fecal coliform PCBs	x x x x x	x x x x x	 x		x x x x x	Building operations included sand blasting, possible oil storage for oil-coated weapons, metal and wooden box processing including cleaning and painting of the boxes, and a flocculant tank that could have contained Al, solutions of Pb, HNO_3, and Se. Explosives load and fill operations also reportedly have taken place. Chemicals used in the box processing included PCP, TCE, $Zn_3(PO_4)_2$, Cr, H_3PO_4, and H_3BO_3. Additionally, waste oil with the potential of containing Ba and Cr might have been present, and raw sewage may have been released. Building 107 operations included reconditioning and testing of various types of cartridge cases as well as the repair to all types of ammunition containers. Contaminant release mechanism would be leaks from drain lines to subsurface soil. Contaminant migration would be to deeper subsurface soils and possibly ground water. Contaminants in ground water could migrate toward downgradient drainage channels.

TABLE 1-2

PROJECT TARGET PARAMETERS AND RATIONALES
SWMU 8
NSWC CRANE, CRANE, INDIANA

Description	Analyses	SS	SB	SD	SW	GW	Rationale
Building 107 Compressor Room Outfall	Energetics	x	x	x	x	x	The outfall from the cooling water associated with compressor operations in Building 107 discharged to a catch basin located north of Building 106. Visual soil staining existed around this catch basin during a 2004 site visit. This staining is suspected to be oil leakage from the compressor. Any contaminants would be expected to migrate from surface soil and subsurface soil to deeper soils (and possibly ground water), and and from surface soil to downgradient areas via overland runoff. Overland flows and ground water may have transported contaminants to the downgradient stream channel.
	TAL metals	x	x	x	x	x	
	App IX VOCs	x	x	x	x	x	
	App IX SVOCs	x	x	x	x	x	
	PCBs	x	x	x			
Building 106 Pond and Pond Area (The pond is unlined)	Energetics	x	x	x	x	x	The pond received discharges from operations in Buildings 106 and 107 and surface runoff from the surrounding area. Any of the chemicals associated with Bldg 106 or 107 operations could be a contaminant. A septic odor was noticed at the former water treatment pump station for the pond during a 2004 site visit. The source of the odor is unknown. During a 1987 site visit, an oily sheen was observed on the pond surface. Contaminant release would be from the unlined pond to subsurface soils (and possibly ground water) and from pond overflow to surrounding surface soils, subsurface soils, and downgradient surface water and sediment. Surface overflows have spilled down the embankment to the northeast into the ravine below. A corrugated metal pipe also directs pond overflow toward the east into the ravine. Ground water may receive contamination from the contaminated drainage channels. The unlined pond has a buildup of leaves and other organic debris on the bottom of the pond, Sediment sampling of the pond will be to a depth of 18 inches to ensure that the pond sediment is being sampled.
	TAL metals	x	x	x	x	x	
	App IX VOCs	x	x	x	x	x	
	App IX SVOCs	x	x	x	x	x	
	PCBs	x	x	x			
	Fecal coliform				x	x	
Former Drum Storage Area	TAL metals	x	x			x	Miscellaneous steel drums were stored in the open at this area. Contents of these drums are unknown. However, energetics (including perchlorate) are not suspected to be stored in this area. Contaminant release would be to surface soils. Migration would be to deeper soils and to downgradient areas via overland runoff, eventually into the surface water and sediment of the nearby stream. Contaminant migration of metals, VOCs, and SVOCs into ground water could occur. Pesticides and herbicides do not move readily to ground water from soil or sediment.
	App IX VOCs	x	x			x	
	App IX SVOCs	x	x			x	
	Pesticides	x	x			x	
	Herbicides	x	x			x	
	PCBs	x	x				

TABLE 1-2

PROJECT TARGET PARAMETERS AND RATIONALES
SWMU 8
NSWC CRANE, CRANE, INDIANA

Description	Analyses	SS	SB	SD	SW	GW	Rationale
Building 2722 Storm Sewer Junction Box Area	Energetics TAL metals App IX VOCs App IX SVOCs Fecal coliform		x x x x			x x x x x	Releases associated with Buildings 106 and 107 operations could potentially migrate to the Building 2722 storm sewer. This included caustic washing, degreasing with TCE, acid wash with HCl, sand blasting, oil storage and the potential of oil-coated weapons storage, a paint shop which utilized paint thinners, toluene, naphtha, metals, xylenes, MEK, and a flocculant tank that could have contained Al, solutions of Pb, HNO3, and Se. Explosives load and fill operations also reportedly have taken place. Additionally, waste oil with the potential of containing Ba, Cr, and other metals might have been present, and raw sewage may have been released. Building 106 operations included reconditioning and testing of various types of cartridge cases as well as the repair to all types of ammunition containers. Contaminant release mechanism would be leaks from drain lines to soil (primarily subsurface). Contaminant migration would be to deeper subsurface soils and possibly ground water. Ground water could have migrated to surface drainage channels to contaminate surface water and sediment.
Surface water and sediment downgradient of source areas	Energetics TAL metals App IX VOCs App IX SVOCs PCBs Fecal coliform			x x x x x x	x x x x x x		Chemicals may have migrated to or may have been dischared into surface water and sediment at source areas and downgradient of the SWMU.
Surface water and sediment upgradient of source areas	Energetics TAL metals App IX VOCs App IX SVOCs Fecal coliform			x x x x x	x x x x x		The surface water upgradient of the source areas provides a point of reference when interpreting site data. It reflects surface water that has not been affected by site operations. Contaminants analyzed in the SWMU must be analyzed in these upgradient samples to enable comprisons of the two sampled populations.

TABLE 1-2

PROJECT TARGET PARAMETERS AND RATIONALES
SWMU 8
NSWC CRANE, CRANE, INDIANA

Description	Analyses	SS	SB	SD	SW	GW	Rationale
Upgradient sediment and surface and subsurface soils areas (uncontaminated areas)	CEC pH TOC	x x x	x x x	x x x			Information from samples collected in these areas will be useful for evaluating contaminant migration potential.

Al - Aluminum.
App IX - Appendix IX of 40 Code of Federal Regulations 264.
Ba - Barium.
CEC - Cation exchange capacity.
CFR - Code of Federal Regulations.
Cr - Chromium.
GW - Ground water.
H_3BO_3 - Boric acid.
H_3PO_4 - Phosphoric acid.
HCl - Hydrochloric acid
HNO3 - Nitric acid.
MEK - Methyl ethyl ketone
Pb - Lead
PCBs - Polychlorinated biphenyls.
PCP - Pentachlorophenol.
SB - Subsurface soil.
SD - Sediment.
Se - Selenium
Sn - Tin.
SS - Surface soil.
SVOCs - Semivolatile organic compounds.
SW - Surface water.
TAL - Target analyte list.
TCE - Trichloroethylene.
TOC - Total organic carbon.
VOCs - Volatile organic compounds.
$Zn(PO_4)$ - Zinc phosphate.

TABLE 1-3

PROJECT TARGET PARAMETERS AND RATIONALES
SWMU 15
NSWC CRANE, CRANE, INDIANA

AOC	Description	Analyses	SS	SB	SD	SW	GW[1]	Rationale
A	Former Asphalt Batch Plant	App IX VOCs App IX SVOCs TAL Metals plus Sn PCBs	x x x x	x x x x			x x x x	The selected chemicals are associated with asphalt manufacturing. Asphalt spills are known to have occurred, and related chemical releases to surface soils may have occurred. Contaminant migration would be to deeper soils and possibly ground water (minimal ground water impact is expected), and also via overland asphalt flow and precipitation runoff.
B	Former UST and Gasoline Pump Area	TAL Metals plus Sn Dissolved TAL Metals plus Sn App IX VOCs App IX SVOCs Water quality parameters	x x x	x x x			x x x x x	Previous excavation at UST west of Building 2801 indicated the presence of "heavy petroleum-type" material (e.g., SVOCs or VOCs). Additionally, the USTs had the potential to have contained leaded gasoline. Contaminant release would have been to subsurface soils from leaking tanks and transfer lines, and possilby some spillage onto surface soils, with potential migration to deeper soils and ground water. Ground water may have migrated to surface drainage channels.
C	Former AST near Former Building 2801	App IX VOCs App IX SVOCs PCBs	x x x	x x x				The AST is known to have stored waste oils and may have also stored organic solvents. Contaminant release would have been to surface soils with potential migration to deeper soil, to other areas via overland runoff, and possibly to ground water. It will be necessary to analyze ground water for PCBs because PCB solubility, which is normally very low in water, can be increased in the presence of organic solvents.
D	Former Inert Storage (Building 2716)	TAL Metals plus Sn Dissolved TAL Metals plus Sn Pesticides Herbicides	x x x	x x x				Granular herbicide ureabor (approximately 800 lb) was once stored here in paper bags. Ureabor contains about 67% sodium metaborate, 30% sodium chlorate, 1.5% bromacil (5-bromo-3-sec-butyl-6-methyluracil), and 1 to 2% inert ingredients. Contaminant release mechanism would be spillage to surface soil. Migration would be to deeper soil and possibly ground water and to downgradient areas via overland runoff. Because some older pesticides contained arsenic, metals analyses will also be conducted. Impact to ground water can be measured by collecting ground water samples.

TABLE 1-3

PROJECT TARGET PARAMETERS AND RATIONALES
SWMU 15
NSWC CRANE, CRANE, INDIANA

AOC	Description	Analyses	SS	SB	SD	SW	GW[1]	Rationale
E[2]	Former Wash Rack(s) and Paint House (Building 2774)	TAL Metals plus Sn	x	x				Wash Racks: Equipment with the potential to have contained pesticides may have been washed out at this rack. Additionally, the pipe bottoms entering and exiting the rack area are coated with asphalt-like material. Trucks from all over Crane were washed at this location resulting in a potential for a wide variety of contamination from many sources. However, VOC analysis has been excluded because VOCs would have volatilized. Contaminant release would have been to drainage channels (potential surface water and sediment contamination). Contaminant migration would be to downgradient areas via channel flow, possibly to subsurface soils in the vicinity of the drainage channels, and possibly to ground water. Additionally, there is a potential for degreaser which contained chlorinated solvents to have been used in equipment washing at the wash racks. Paint House: Paints containing metals (i.e., Pb, Cr, Ti) and resins were stored in Building 2774. Volatile solvents were used as paint thinners and for paint removal. Additionally, oils may have been stored in this location. Pesticides and herbicides are scheduled for analysis at both the wash rack(s) and the Paint House because these areas were close to each other. Contaminant release would be to surface soil from spillage. Contaminnant migration would be to deeper soil and possibly ground water, and to downgradient areas via overland runoff. Pesticides, herbicides, and PCBs will be analyzed in ground water because cosolvency with organic solvents can increase the normally very low solubilities of these chemicals.
		Dissolved TAL Metals plus Sn						
		App IX VOCs	x	x				
		App IX SVOCs	x	x				
		Pesticides	x	x				
		Herbicides	x	x				
		PCBs	x	x				
F	Former AST Areas (Former Buildings 2717 and 2718)	App IX VOCs	x	x				Oil-burning space heaters were used in Buildings 2717 and 2718. ASTs for the fuel oil were located at the northeastern corner of each building. The contamiant release mechanism would have been spillage to surface soil. Contaminant migration would be to deeper soil and possibly ground water, and to downgradient areas via overland runoff. Impact to ground water can be measured by collecting ground water samples.
		App IX SVOCs	x	x				
G	Hillside Debris Area South of Former Buildings 2717 and 2718 (extending to stream bed)	TAL Metals plus Sn	x	x			x	Unknown types of debris from SWMU 15 or elsewhere from the Base may have been dumped in this area. Therefore, a wide array of chemical analyses is required to address the potential contamination. The contamination is expected to be shallow because the contaminant release mechanism is spillage and other releases to surface soils. Contaminnat migration would be to deeper soil and possibly ground water, and to downgradient areas via overland flow.
		Dissolved TAL Metals plus Sn					x	
		App IX VOCs	x	x			x	
		App IX SVOCs	x	x			x	
		Pesticides	x	x			x	
		Herbicides	x	x			x	
		PCBs	x	x			x	
		Water quality parameters					x	

TABLE 1-3

PROJECT TARGET PARAMETERS AND RATIONALES
SWMU 15
NSWC CRANE, CRANE, INDIANA

AOC	Description	Analyses	SS	SB	SD	SW	GW(1)	Rationale
H	Drainage Area Across Intermittent Stream South of Hillside Debris Area	TAL Metals plus Sn	x	x			x	Unknown types of debris from SWMU 15 or elsewhere from the Base have been dumped here. Therefore, a wide array of analyses will be considered for all media. Contamiant release mechansim would have been spillage to surface soil. Contaminant migration would be to deeper soil and possibly ground water, and to downgradient areas via overland runoff.
		Dissolved TAL Metals plus Sn					x	
		App IX VOCs	x	x			x	
		App IX SVOCs	x	x			x	
		Pesticides	x	x			x	
		Herbicides	x	x			x	
		PCBs	x	x			x	
		Water quality parameters					x	
I	Drainage Channels Downgradient of Source Areas (Downgradient of SWMU 15)	TAL Metals plus Sn			x	x		The same analyses as conducted on the SWMU and upgradient areas will be conducted on these samples from the drainage channels because contaminants may have migrated in a downgradient direction. These drainage channels are conduits for potential contaminant transport and are potential contamination accumulators. One sample will be collected for each channel drainageway of the SWMU. Potentially contaminated media would be surface water and sediment with a potential for migration of contaminants into ground water and soils under and near to the drainage channels. Impact to ground water can be measured by collecting ground water samples.
		Dissolved TAL Metals plus Sn				x		
		App IX VOCs			x	x		
		App IX SVOCs			x	x		
		Pesticides			x	x		
		Herbicides			x	x		
		PCBs			x	x		
		Water quality parameters				x		
J	Areas Upgradient of Source Areas. (Upgradient of SWMU 15)	TAL Metals plus Sn			x	x		To provide a reference for determining whether operationally related contamination has been released at the site or contaminants have been transported onto the site from upgradient sources. Impact to ground water can be measured by collecting ground water samples.
		Dissolved TAL Metals plus Sn				x		
		App IX VOCs			x	x		
		App IX SVOCs			x	x		
		Pesticides			x	x		
		Herbicides			x	x		One upgradiant sediment sample from this AOC should be analyzed for cyanide to determine if the cyanide is being carried onto the SWMU from upgradient plating activities.
		PCBs			x	x		
		Water quality parameters				x		

TABLE 1-3

PROJECT TARGET PARAMETERS AND RATIONALES
SWMU 15
NSWC CRANE, CRANE, INDIANA

AOC	Description	Analyses	SS	SB	SD	SW	GW[1]	Rationale
K	Catch Basin West of Roadway Along West Side of Building 3330 (Upgradient of SWMU 15)	TAL Metals plus Sn TAL Metals plus Sn App IX VOCs App IX SVOCs Pesticides Herbicides PCBs Cn Water quality parameters			x x x x x x x	x x x x x x x x		To provide a reference for determining whether operationally related contamination has been released at the SWMU or whether contaminants have been transported onto the SWMU from upgradient sources. Impact to ground water can be measured by collecting ground water samples. One upgradiant sediment sample from this AOC should be analyzed for cyanide to determine if the cyanide is being carried onto the SWMU from upgradient plating activities.
L	Drainageway Southeast of Former Asphalt Batch Plant	TAL Metals plus Sn Dissolved TAL Metals plus Sn App IX VOCs App IX SVOCs PCBs Water quality parameters			x x x x x	x x x x x x		The selected chemicals are associated with asphalt manufacturing and other chemicals that may have migrated to this area from other sources. Releases of asphalt to surface soils may have occurred at and downgradient of the asphalt batch plant. Contaminant migration would be to deeper soils and possibly ground water, and also to surface water and sediment via overland asphalt flow and precipitation runoff. Impact to ground water can be measured by collecting ground
M	Drainageways Along the Southern Area of SWMU 15	TAL Metals plus Sn Dissolved TAL Metals plus Sn App IX VOCs App IX SVOCs Pesticides Herbicides PCBs Water quality parameters			x x x x x x	x x x x x x x x		Equipment with the potential to have contained pesticides may have been washed at this rack. Additionally, the pipe bottoms entering and exiting the rack area are coated with asphalt-like material. Trucks from all over Crane were washed at this location resulting in a potential for a wide variety of contamination from many sources. However, VOC analysis has been excluded because VOCs would have volatilized. Contaminant release would have been to drainage channels (potential surface water and sediment contamination). Contaminant migration would be to downgradient areas via channel flow, and possibly to subsurface soils and ground water in the vicinity of the drainage channels. Impact to ground water can be measured by collecting ground water samples.
N	Catch Basin South of Former Asphalt Batch Plant	App IX VOCs App IX SVOCs TAL Metals plus Sn PCBs Water quality parameters			x x x x	x x x x x		The selected chemicals are associated with asphalt manufacturing. Releases of ashpalt to surface soils may have occurred at and downgradient of the asphalt batch plant. Contaminant migration would be to deeper soils and possibly ground water, and also to surface water and sediment via overland asphalt flow through the drainage ways. Impact to ground water can be measured by collecting ground water samples.

TABLE 1-3

PROJECT TARGET PARAMETERS AND RATIONALES
SWMU 15
NSWC CRANE, CRANE, INDIANA

AOC	Description	Analyses	SS	SB	SD	SW	GW[1]	Rationale
O	Former Paint Locker	TAL Metals plus Sn	x	x				Paints containing metals (e.g., Pb, Cr, Ti) and resins may have been stored in the paint locker. Volatile solvents were used as paint thinners and for paint removal. Additionally, oils may have been stored in this location. Contaminant release mechansim would be spillage to surface soils. Migration would be to deeper soils and possibly ground water, and to downgradient areas via overland flow. Impact to ground water can be measured by collecting ground water samples.
		Dissolved TAL Metals plus Sn						
		App IX VOCs	x	x				
		App IX SVOCs	x	x				
P	Catch Basin West of Building 3330 (Upgradient of SWMU 15)	TAL Metals plus Sn			x	x		To provide a reference for determining whether operationally related contamination has been released at the site or contaminants have been transported onto the site from upgradient sources. This catch basin is not necessarily expected to be contaminated. Because this is a reference point, samples collected from this location will receive all analyses conducted on other SWMU 15 samples. Impact to ground water can be measured by collecting ground water samples.
		Dissolved TAL Metals plus Sn				x		
		App IX VOCs			x	x		
		App IX SVOCs			x	x		
		Pesticides			x	x		
		Herbicides			x	x		
		PCBs			x	x		
		Cn			x	x		
		Water quality parameters				x		
Q	Drainageway South of Former UST and Former Gasoline Pump Area	TAL Metals plus Sn			x	x		Previous excavation at UST west of Building 2801 indicated the presence of "heavy petroleum-type" material that could include SVOCs and VOCs. Additionally, the USTs had the potential to contain leaded gasoline. Contaminant release would have been to subsurface soils with potential migration to deeper soils and ground water. Ground water may have migrated to surface drainage channels. Impact to ground water can be measured by collecting ground water samples.
		Dissolved TAL Metals plus Sn				x		
		App IX VOCs			x	x		
		App IX SVOCs			x	x		
		PCBs			x	x		
		Water quality parameters				x		
R	Drainageway Southwest of Former Wash Rack	TAL Metals plus Sn			x	x		Equipment with the potential to have contained pesticides may have been washed at this rack. Additionally, the pipe bottoms entering and exiting the rack area are coated with asphalt-like material. Trucks from all over Crane were washed at this location resulting in a potential for a wide variety of contamination from many sources. However, VOC analysis has been excluded because VOCs would have volatilized. Contaminant release would have been to drainage channels (potential surface water and sediment contamination). Contaminant migration would be to downgradient areas via channel flow, and possibly to subsurface soils and ground water in the vicinity of the drainage channels. Impact to ground water can be measured by collecting ground water samples. Additionally, there is the potential for degreasers which contained chlorinated solvents to have been used during equipment washing at the wash rack.
		Dissolved TAL Metals plus Sn				x		
		App IX VOCs			x	x		
		App IX SVOCs			x	x		
		Pesticides			x	x		
		Herbicides			x	x		
		PCBs			x	x		
		Cn			x			
		Water quality parameters			x	x		

TABLE 1-3

PROJECT TARGET PARAMETERS AND RATIONALES
SWMU 15
NSWC CRANE, CRANE, INDIANA

AOC	Description	Analyses	SS	SB	SD	SW	GW(1)	Rationale
S	Catch Basin at Intersection of Two Storm Sewers West of center of Building 3330 (Upgradient Catchbasin)	TAL Metals plus Sn			x	x		Data from this area will provide a reference for determining whether operationally related contamination has been released at the site or contamination have been transported onto the site from upgradient sources via the drainage channels. This catch basin is not necessarily expected to be contaminated, but samples collected here will received all analyses scheduled for SWMU 15 samples. Impact to ground water can be measured by collecting ground water samples.
		Dissolved TAL metals plus Sn				x		
		App IX VOCs			x	x		
		App IX SVOCs			x	x		
		Pesticides			x	x		
		Herbicides			x	x		
		PCBs			x	x		
		Cn			x			
		Water quality parameters				x		
T	Storm Water Drop Box/Junction Box northwest of Former Wash Rack	TAL Metals plus Sn			x	x		Equipment with the potential to have contained pesticides may have been washed at this rack. Additionally, the pipe bottoms entering and exiting the rack area are coated with asphalt-like material. Trucks from all over Crane were washed at this location resulting in a potential for a wide variety of contamination from many sources. However, VOC analysis has been excluded because they large quantities of VOCs would have volatilized. Contaminant release would have been to drainage channels (potential surface water and sediment contamination). Contaminant migration would be to downgradient areas via channel flow, and possibly to subsurface soils and ground water in the vicinity of the drainage channels. Impact to ground water can be measured by collecting ground water samples.
		Dissolved TAL metals plus Sn						
		App IX VOCs			x	x		
		App IX SVOCs			x	x		
		Pesticides			x	x		
		Herbicides			x	x		
		PCBs			x	x		
		Water quality parameters				x		
U	Hillside Debris Area Northeast of SWMU 15	TAL Metals plus Sn	x	x			x	Unknown types of debris from SWMU 15 or elsewhere from the base may have been dumped in this area. Therefore, a wide array of chemical analyses is required to address the potential contamination. The contamination is expected to be shallow because the contaminant release mechanism is spillage and other releases to surface soils. Contaminant migration would be to deeper soil and possibly ground water, and to downgradient areas via overland flow.
		Dissolved TAL metals plus Sn					x	
		App IX VOCs	x	x			x	
		App IX SVOCs	x	x			x	
		Pesticides	x	x			x	
		Herbicides	x	x			x	
		PCBs	x	x			x	
		Water quality parameters					x	
V	Intermittent Stream Banks South and East of SWMU 15 (Downgradient)	TAL Metals plus Sn			x	x		The streams would be major surface conduits for transporting contaminants from the SWMU to downgradient areas. Therefore, the same analyses will be conducted on samples collected from this area as are conducted on samples collected from within the SWMU and the upgradient areas. The data will be used to determine whether contaminants have migrated in the downgradient direction through these channels. Impact to ground water can be measured by collecting ground water samples in other (downgradient) areas.
		Dissolved TAL Metals plus Sn				x		
		App IX VOCs			x	x		
		App IX SVOCs			x	x		
		Pesticides			x	x		
		Herbicides			x	x		
		PCBs			x	x		
		Cn			x			
		Water quality parameters				x		

TABLE 1-3

PROJECT TARGET PARAMETERS AND RATIONALES
SWMU 15
NSWC CRANE, CRANE, INDIANA

AOC	Description	Analyses	SS	SB	SD	SW	GW(1)	Rationale
W	Sanitary Landfill South of the Salt Dome	TAL Metals plus Sn	x	x	x	x	x	In the 1960s a construction and demolition wastes were land filled in an area south of the present day salt dome which is located south of Highway 99. The debris in this landfill area is believed to have consisted of building material waste, concrete, glass, rock, demolished pavement, trees, and tree limbs as well as disposal of dead deer. Other wastes may also have been disposed of in the landfill: The waste was hauled to the landfill area by trucks and then a bulldozer was used to level the waste and cover it with native soil. Because the nature of the materials placed in the landfill is not known, the landfill area will be analzyed for a wide variety of constituents.
		Dissolved TAL Metals plus Sn				x	x	
		App IX VOCs	x	x	x	x	x	
		App IX SVOCs	x	x	x	x	x	
		Pesticides	x	x	x	x	x	
		Herbicides	x	x	x	x	x	
		PCBs	x	x	x	x	x	
		Water quality parameters				x	x	
N/A	Background Soil	Metals data from basewide BG study will be used.	x	x				These data will provide a point of reference for determining whether operationally related soil contamination has been released at the site. It is not necessary to collect samples to obtain these data because the necessary data are availble as a result of the basewide background soil investigation. Data comprise TAL metals, lithium, strontium, and tin.
NA	Background Soil and Upgradient Sediment	CEC	x	x	x			To provide points of reference for interpretation of migration potential of contaminants. It is necessary to collect background soil samples for these parameters because they were not determined during the basewide background study.
		pH	x	x	x			
		TOC	x	x	x			

% - Percent.
AOC - Area of concern.
App — Appendix.
AST - Aboveground storage tank.
BG - Background.
BTEX - Benzene, toluene, ethyl benzene and xylene.
Ca - Calcium.
Cl - Chloride.
Cn - Cyanide.
Cr - Chromium.
GW - Ground water.
Herb. - Herbicides.
lb - Pounds.
Mg - Magnesium.
MTBE - Methyl tertiary butyl ether.
N/A - Not applicable.
Na - Sodium.
NTU - Nephelometric Turbidity Unit
Pb - Lead.
PCBs - Polychlorinated biphenyls.
Pest. - Pesticides.
SB - Subsurface soil.
SD - Sediment.
Sn - Tin.
SS - Surface soil.
SVOCs - Semivolatile organic compounds.
SW - Surface water.
SWMU - Solid Waste Management Unit.
TAL - Target analyte list.
Ti - Titanium .
UST - Underground storage tank.
VOCs - Volatile organic compounds.

1 — During the Round 1 sampling event, ground water samples will be collected at the bedrock-overburden interface (perched samples) to determine if contamination has migrated through the soils and potentially along the bedrock surface. Dissolved TAL metal samples will only be collected if turbidity of ground water in the well exceeds 10 NTU.

2 — Due to the proximity of the Former Wash Rack(s) to the Paint House, both areas will be tested for the same parameters.

TABLE 1-4

PROJECT TARGET PARAMETERS AND RATIONALES
SWMUs 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

SWMU	Description	Analyses	SS	SB	SD	SW	GW	Rationale[1]
18	Load and Fill Area Buildings	Energetics (except perchlorate) TAL metals plus Sn Ammonium pricrate	x x x					SWMU 18 consists of various buildings that were used in munitions load and fill operations. Four of the buildings (104, 105, 198, and 200) have been targeted for U.S. EPA Form CA725 human health assessment. Contaminant release would have been energetics. Contaminant release mechanism would be leaks from spills to surface soil. Worker exposure is the primary receptor pathway of concern. Spills of ammonium picrate are known to have occurred at this SWMU.
19	PTA • OTA • PTA Annex • RR	Energetics VOCs[2] SVOCs[2] TAL metals plus Li and Sr Perchlorate	x x x x x					SWMU 19 consists of a large, open field with concrete buildings that are used for QA/QC test burning of pyrotechnic devices as well as submarine batteries and rocket motors. Contamination from testing activities may include perchlorate and chlorates, oxidizers, explosives, propellants, and fuels. The primary contaminant deposition mechanism is aerial release directly to surface soils. Worker exposure is the primary receptor pathway of concern. Fuels and organic solvents were used in the pyrotechnic testing in the Fast Cook-Off Area.
20	CAAA QA/QC Test Area	Energetics TAL metals plus Sn Perchlorate	x x x					SWMU 20 consists of ordnance and pyrotechnic test areas. The primary contaminant deposition mechanism would be released directly to surface soils. Worker exposure is the primary receptor pathway of concern.
OGTSL	OGTSL	TAL metals plus Sn PCBs SVOCs (including PAHs)	x x x					The OGTSL consists of a relatively flat area covered by gravel where gun tubs from ships were stored in the open. The information collected in this effort will focus on determining whether releases may have occurred to surface soil.

AST — Aboveground storage tank.
CAAA — Crane Army Ammunition Activity
OGTSL — Old Gun Tub Storage Lot.
OTA — Ordnance Test Area.
PAHs — Polynuclear aromatic hydrocarbons
PCBs — Polychlorinated biphenyls.
PTA — Pyrotechnic Test Area.
QA/QC — Quality Assurance/Quality Control.
RR — Rocket Range.
Sn — Tin.
SVOCs — Semivolatile organic compounds.
SWMU — Solid Waste Management Unit.
TAL — Target analyte list.
UST — Underground storage tank.
VOCs — Volatile organic compounds.

1 — The information collected in this effort will focus on determining whether releases may have occurred to surface soil which pose a risk to human receptors utilizing the C725 Environmental Indicator form.
2 — VOCs and SVOC will be sampled for at the 19SB007, the Fast Cook-Off Area.

TABLE 1-5

DETECTION LIMITS AND RISK CRITERIA
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETER	CAS NUMBER	Aqueous Matrix			Solid Matrix			
		Laboratory		Risk-Based Target Level [2] (µg/L)	Laboratory		Risk-Based Soil Target Level [2] (mg/kg)	Risk-Based Sediment Target Level [2] (mg/kg)
		TV [1] (µg/L)	RL [1] (µg/L)		TV [1] (mg/kg)	RL [1] (mg/kg)		
EXPLOSIVES (NITROAROMATICS AND NITRAMINES) SW-846 METHOD 8330								
1,3,5-Trinitrobenzene	99-35-4	0.25	0.5	1100	0.25	0.5	0.376	1800
1,3-Dinitrobenzene	99-65-0	0.25	0.5	3.6	0.25	0.5	0.655	0.00861
2,4,6-Trinitrotoluene (TNT)	118-96-7	0.25	0.5	2.2	0.25	0.5	16	16
2,4-Dinitrotoluene	121-14-2	0.25	0.5	44	0.25	0.5	1.28	0.0144
2,6-Dinitrotoluene	606-20-2	0.25	0.5	36	0.25	0.5	0.0328	0.0398
2-Amino-4,6-dinitrotoluene	35572-78-2	0.25	0.5	7.3	0.25	0.5	16	16
2-Nitrotoluene	88-72-2	0.25	0.5	61	0.25	0.5	370	370
3-Nitrotoluene	99-08-1	0.25	0.5	61	0.25	0.5	370	370
4-Amino-2,6-dinitrotoluene	1946-51-0	0.25	0.5	7.3	0.25	0.5	16	16
4-Nitrotoluene	99-99-0	0.25	0.5	61	0.25	0.5	370	370
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4	0.25	0.5	0.61	0.25	0.5	4.4	4.4
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	479-45-8	0.25	0.5	360	0.25	0.5	610	610
Nitrobenzene	98-95-3	0.25	0.5	3.4	0.25	0.5	1.31	0.145
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0	0.25	0.5	1800	0.25	0.5	3100	3100
APPENDIX IX HERBICIDES (SW-846 METHOD 8151A)								
2,4-D	94-75-7	0.04	0.08	220	0.00134	0.00267	0.0272	1.273
2,4,5-T	93-76-5	0.04	0.08	360	0.00134	0.00267	0.596	58.7
2,4,5-TP (Silvex)	93-72-1	0.04	0.08	30	0.00134	0.00267	0.109	0.675
Dinoseb	88-85-7	0.04	0.08	0.48	0.00134	0.00267	0.0218	0.0145
Pentachlorophenol	87-86-5	0.25	0.5	0.56	0.00085	0.0017	0.119	3
Hexachlorophene	70-30-4	0.013	0.027	0.228	0.00045	0.0009	0.199	18

TABLE 1-5

DETECTION LIMITS AND RISK CRITERIA
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETER	CAS NUMBER	Aqueous Matrix			Solid Matrix			
		Laboratory		Risk-Based Target Level [2] (µg/L)	Laboratory		Risk-Based Soil Target Level [2] (mg/kg)	Risk-Based Sediment Target Level [2] (mg/kg)
		TV [1] (µg/L)	RL [1] (µg/L)		TV [1] (mg/kg)	RL [1] (mg/kg)		
ORGANOCHLORINE PESTICIDES (SW-846 METHOD 8081A)								
Aldrin	309-00-2	0.025	0.05	0.004	0.00085	0.0017	0.00332	0.002
alpha-BHC	319-84-6	0.025	0.05	0.011	0.00085	0.0017	0.0072	0.006
alpha-chlordane	5103-71-9	0.025	0.05	0.0043	0.00085	0.0017	0.224	0.00324
beta-BHC	319-85-7	0.025	0.05	0.037	0.00085	0.0017	0.00398	0.005
4,4'-DDD	72-54-8	0.05	0.1	0.28	0.00165	0.0033	0.758	0.00488
4,4'-DDE	72-55-9	0.05	0.1	4.51E-09	0.00165	0.0033	0.596	0.00316
4,4'-DDT	50-29-3	0.05	0.1	0.000011	0.00165	0.0033	0.0035	0.00416
delta-BHC	319-86-8	0.025	0.05	0.011	0.00085	0.0017	0.09	0.09
Dieldrin	60-57-1	0.05	0.1	0.000071	0.00165	0.0033	0.00238	0.0019
Endosulfan I	959-98-8	0.025	0.05	0.056	0.00085	0.0017	0.119	0.00326
Endosulfan II	33213-65-9	0.05	0.1	0.056	0.00165	0.0033	0.119	0.00194
Endosulfan sulfate	1031-07-8	0.05	0.1	0.056	0.0017	0.0033	0.119	0.00326
Endrin	72-20-8	0.05	0.1	0.036	0.0017	0.0033	0.0101	0.00222
Endrin aldehyde	7421-93-4	0.05	0.1	0.15	0.00165	0.0033	0.0105	0.48
Endrin Ketone	53494-70-5	0.05	0.1	0.036	0.0017	0.0033	0.0101	0.00222
gamma-BHC (Lindane)	58-89-9	0.025	0.05	0.026	0.00085	0.0017	0.005	0.00237
gamma-chlordane	12789-03-6	0.025	0.05	0.0043	0.00085	0.0017	0.224	0.00324
Heptachlor	76-44-8	0.025	0.05	0.0038	0.00085	0.0017	0.00598	0.0006
Heptachlor epoxide	1024-57-3	0.025	0.05	0.0038	0.00085	0.0017	0.053	0.00247
Methoxychlor	72-43-5	0.25	0.5	0.019	0.0085	0.017	0.0199	0.0136
Toxaphene	8001-35-2	2.5	5	0.00014	0.085	0.17	0.119	0.000077
POLYCHLORINATED BIPHENYLS (SW-846 METHOD 8082)								
Aroclor-1016	12674-11-2	0.25	0.5	0.00012	0.25	0.0166	0.000332	0.0598
Aroclor-1221	11104-28-2	0.25	0.5	0.00012	0.25	0.0166	0.000332	0.0598
Aroclor-1232	11141-16-5	0.25	0.5	0.00012	0.25	0.0166	0.000332	0.0598
Aroclor-1242	53469-21-9	0.25	0.5	0.00012	0.25	0.0166	0.000332	0.0598
Aroclor-1248	12672-29-6	0.25	0.5	0.00012	0.25	0.0166	0.000332	0.0598
Aroclor-1254	11097-69-1	0.25	0.5	0.00012	0.25	0.0166	0.000332	0.0598
Aroclor-1260	11096-82-5	0.25	0.5	0.00012	0.25	0.0166	0.000332	0.0598

TABLE 1-5

DETECTION LIMITS AND RISK CRITERIA
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETER	CAS NUMBER	Aqueous Matrix			Solid Matrix			
		Laboratory		Risk-Based Target Level [2] (µg/L)	Laboratory		Risk-Based Soil Target Level [2] (mg/kg)	Risk-Based Sediment Target Level [2] (mg/kg)
		TV [1] (µg/L)	RL [1] (µg/L)		TV [1] (mg/kg)	RL [1] (mg/kg)		
POLYNUCLEAR AROMATIC HYDROCARBONS SW-846 METHOD 8270C WITH SELECTIVE ION MONITORING								
2-Methylnaphthalene	91-57-6	0.05	0.1	5	0.00025	0.0067	3.24	0.0202
Acenaphthene	83-32-9	0.05	0.1	38	0.00025	0.0067	130	0.00671
Acenaphthylene	208-96-8	0.05	0.1	370	0.00025	0.0067	130	0.00587
Anthracene	120-12-7	0.05	0.1	0.035	0.00025	0.0067	51	0.0572
Benzo(a)anthracene	56-55-3	0.05	0.1	0.025	0.00025	0.0067	0.62	0.108
Benzo(a)pyrene	50-32-8	0.05	0.1	0.0092	0.00025	0.0067	0.062	0.062
Benzo(b)fluoranthene	205-99-2	0.05	0.1	0.092	0.00025	0.0067	0.62	0.62
Benzo(g,h,i)perylene	191-24-2	0.05	0.1	0.26	0.00025	0.0067	119	0.17
Benzo(k)fluoranthene	207-08-9	0.05	0.1	0.8	0.00025	0.0067	0.38	0.24
Carbazole	86-74-8	1	5	3.4	0.067	0.33	5.9	24
Chrysene	218-01-9	0.05	0.1	1.6	0.00025	0.0067	4.73	0.166
Dibenzo(a,h)anthracene	53-70-3	0.05	0.1	0.0092	0.00025	0.0067	0.062	0.033
Fluoranthene	206-44-0	0.05	0.1	1.9	0.00025	0.0067	122	0.423
Fluorene	86-73-7	0.05	0.1	19	0.00025	0.0067	122	0.0774
Indeno(1,2,3-cd)pyrene	193-39-5	0.05	0.1	0.022	0.00025	0.0067	0.62	0.2
Naphthalene	91-20-3	0.05	0.1	6.2	0.00025	0.0067	0.0994	0.176
Phenanthrene	85-01-8	0.05	0.1	3.6	0.00025	0.0067	13	0.204
Pyrene	129-00-0	0.05	0.1	0.3	0.00025	0.0067	78.5	0.195

TABLE 1-5

DETECTION LIMITS AND RISK CRITERIA
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETER	CAS NUMBER	Aqueous Matrix			Solid Matrix			
		Laboratory		Risk-Based Target Level [2] (µg/L)	Laboratory		Risk-Based Soil Target Level [2] (mg/kg)	Risk-Based Sediment Target Level [2] (mg/kg)
		TV [1] (µg/L)	RL [1] (µg/L)		TV [1] (mg/kg)	RL [1] (mg/kg)		
SEMIVOLATILE ORGANIC COMPOUNDS (EXCEPT PAHs) SW-846 METHOD 8270C								
1,2,4,5-Tetrachlorobenzene	95-94-3	1	5	3	0.067	0.33	2.02	1.252
1,2,4-Trichlorobenzene	120-82-1	1	5	30	0.067	0.33	11.1	5.062
1,2-Dichlorobenzene	95-50-1	1	5	14	0.067	0.33	2.96	0.294
1,3-Dichlorobenzene	541-73-1	1	5	5.5	0.067	0.33	0.2	1.315
1,4-Dichlorobenzene	106-46-7	1	5	0.5	0.067	0.33	0.546	0.318
1,4-Naphthoquinone	130-15-4	1	5	--[4]	0.067	0.33	1.67	--[4]
1,4-Phenylenediamine	106-50-3	1	10	6900	0.067	0.67	6.16	12000
1-Naphthylamine	134-32-7	1	5	--[4]	0.067	0.33	9.34	--[4]
2,3,4,6-Tetrachlorophenol	58-90-2	1	5	1.2	0.067	0.33	0.199	0.129
2,4,5-Trichlorophenol	95-95-4	1	5	3600	0.067	0.33	14.1	6100
2,4,6-Trichlorophenol	88-06-2	1	5	0.96	0.067	0.33	0.07	0.208
2,4-Dichlorophenol	120-83-2	1	5	11	0.067	0.33	111	0.0817
2,4-Dimethylphenol	105-67-9	1	5	100	0.067	0.33	0.01	0.304
2,4-Dinitrophenol	51-28-5	1	10	19	0.067	0.67	0.0609	0.00621
2,6-Dichlorophenol	87-65-0	1	5	--[4]	0.067	0.33	1.17	--[4]
2-Acetylaminofluorene	53-96-3	1	5	535	0.067	0.33	0.596	0.0153
2-Chloronaphthalene	91-58-7	1	5	0.396	0.067	0.33	0.0122	0.417
2-Chlorophenol	95-57-8	1	5	24	0.067	0.33	0.243	0.0319
2-Methylphenol	95-48-7	1	5	67	0.067	0.33	40.4	0.0554
2-Naphthylamine	91-59-8	1	5	--[4]	0.067	0.33	3.03	--[4]
2-Nitroaniline	88-74-4	1	5	1	0.067	0.33	1.7	1.7
2-Nitrophenol	88-75-5	1	5	--[4]	0.067	0.33	1.6	--[4]
2-Picoline	109-06-8	1	5	--[4]	0.067	0.33	--[4]	--[4]
3,3'-Dichlorobenzidine	91-94-1	1	5	0.15	0.067	0.33	0.646	0.127
3,3'-Dimethylbenzidine	119-93-7	1	5	0.0073	0.067	0.33	0.053	0.053
3-Methylcholanthrene	56-49-5	1	5	0.0891	0.067	0.33	0.0779	8190
3&4-Methylphenol [5]	1319-77-3	2.5	5	25	0.067	0.33	3.49	0.0524

TABLE 1-5

DETECTION LIMITS AND RISK CRITERIA
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETER	CAS NUMBER	Aqueous Matrix			Solid Matrix			
		Laboratory		Risk-Based Target Level [2] (µg/L)	Laboratory		Risk-Based Soil Target Level [2] (mg/kg)	Risk-Based Sediment Target Level [2] (mg/kg)
		TV [1] (µg/L)	RL [1] (µg/L)		TV [1] (mg/kg)	RL [1] (mg/kg)		
SEMIVOLATILE ORGANIC COMPOUNDS (EXCEPT PAHs) SW-846 METHOD 8270C (Continued)								
3-Nitroaniline	99-09-2	1	5	--[4]	0.067	0.33	--[4]	--[4]
4,6-Dinitro-2-methylphenol	534-52-1	1	5	23	0.067	0.33	0.144	0.104
4-Aminobiphenyl	92-67-1	1	5	--[4]	0.067	0.33	0.00305	--[4]
4-Bromophenyl phenyl ether	101-55-3	1	5	1.5	0.067	0.33	--[4]	1.55
4-Chloro-3-methylphenol	59-50-7	1	5	34.8	0.067	0.33	7.95	0.388
4-Chloroaniline	106-47-8	1	5	150	0.067	0.33	1.1	0.146
4-Chlorophenyl phenyl ether	7005-72-3	1	5	--[4]	0.067	0.33	--[4]	--[4]
4-Nitroaniline	100-01-6	1	5	--[4]	0.067	0.33	--[4]	--[4]
4-Nitrophenol	100-02-7	1	5	--[4]	0.067	0.33	--[4]	--[4]
4-Nitroquinoline-1-oxide	56-57-5	1	5	--[4]	0.067	0.33	0.122	--[4]
5-Nitro-o-toluidine	99-55-8	1	5	2	0.067	0.33	8.73	15
7,12-Dimethylbenz(a)anthracene	57-97-6	1	5	0.548	0.067	0.33	16.3	66.4
Acetophenone	98-86-2	1	5	--[4]	0.067	0.33	300	--[4]
Aniline	62-53-3	1	5	4.1	0.067	0.33	0.0568	0.00031
Aramite	140-57-8	1	10	2.7	0.067	0.33	19	19
Benzyl alcohol	100-51-6	1	5	8.6	0.067	0.33	48	0.00104
bis(2-Chloroethoxy)methane	111-91-1	1	5	--[4]	0.067	0.33	0.302	--[4]
bis(2-Chloroethyl)ether	111-44-4	0.9	5	0.0098	0.067	0.67	0.0007	0.21
bis(2-Chloroisopropyl)ether	108-60-1	1	5	0.27	0.067	0.33	0.027	2.9
bis(2-Ethylhexyl) phthalate	117-81-7	1	5	0.3	0.067	0.33	0.925	0.182
Butyl benzyl phthalate	85-68-7	1	5	23	0.067	0.33	0.239	1.97
Chlorobenzilate	510-15-6	1	5	0.25	0.067	0.33	1.8	0.86
Diallate	2303-16-4	1	5	1.1	0.067	0.33	0.452	8
Di-n-butyl phthalate	84-74-2	1	5	9.7	0.067	0.33	0.15	1.114
Di-n-octyl phthalate	117-84-0	1	5	20	0.067	0.33	709	40.6
Dibenzofuran	132-64-9	1	5	4	0.067	0.33	4.9	0.449
Diethyl phthalate	84-66-2	1	5	110	0.067	0.33	24.8	0.295

TABLE 1-5

DETECTION LIMITS AND RISK CRITERIA
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETER	CAS NUMBER	Aqueous Matrix			Solid Matrix			
		Laboratory		Risk-Based Target Level [2] (µg/L)	Laboratory		Risk-Based Soil Target Level [2] (mg/kg)	Risk-Based Sediment Target Level [2] (mg/kg)
		TV [1] (µg/L)	RL [1] (µg/L)		TV [1] (mg/kg)	RL [1] (mg/kg)		
SEMIVOLATILE ORGANIC COMPOUNDS (EXCEPT PAHs) SW-846 METHOD 8270C (Continued)								
p-(Dimethylamino)azobenzene	60-11-7	1	5	1.65	0.067	0.33	0.04	0.318
a,a-Dimethylphenethylamine	122-09-8	1	5	36	0.067	0.33	61	61
Dimethyl phthalate	131-11-3	1	5	360000	0.067	0.33	734	100000
Diphenylamine [6]	122-39-4	1	5	412	0.067	0.33	1.01	0.0346
Ethyl methane sulfonate	62-50-0	1	5	--[4]	0.067	0.33	--[4]	--[4]
Hexachlorobenzene	118-74-1	1	5	0.0003	0.067	0.33	0.199	0.02
Hexachlorobutadiene	87-68-3	1	5	0.053	0.067	0.33	0.0398	0.0265
Hexachlorocyclopentadiene	77-47-4	1	5	50	0.067	0.33	0.755	0.901
Hexachloroethane	67-72-1	1	5	4.8	0.067	0.33	0.596	0.584
Hexachloropropene	1888-71-7	1	5	--[4]	0.067	0.33	--[4]	--[4]
Isodrin	465-73-6	1	5	0.0309	0.067	0.33	0.00332	0.0552
Isophorone	78-59-1	1	5	71	0.067	0.33	5.3	0.432
Isosafrole	120-58-1	1	5	--[4]	0.067	0.33	9.94	--[4]
Kepone	143-50-0	1	5	0.0084	0.067	0.33	0.0327	0.00331
Methapyrilene	91-80-5	1	5	--[4]	0.067	0.33	2.78	--[4]
Methyl methane sulfonate	66-27-3	1	5	--[4]	0.067	0.33	0.315	--[4]
n-Nitrosodi-n-butylamine	924-16-3	1	5	0.002	0.067	0.33	0.024	0.024
n-Nitrosodiethylamine	55-18-5	1	5	0.00045	0.067	0.33	0.0032	0.0032
n-Nitrosodimethylamine	62-75-9	1	5	0.0013	0.067	0.33	0.0000321	0.0095
n-Nitrosodi-n-propylamine	621-64-7	1	5	0.0096	0.067	0.33	0.069	0.069
n-Nitrosomethylethylamine	62-75-9	1	5	0.0013	0.067	0.33	0.0000321	0.0095
n-Nitrosomorpholine	59-89-2	1	5	--[4]	0.067	0.33	--[4]	--[4]
n-Nitrosopiperidine	100-75-4	1	5	--[4]	0.067	0.33	0.00665	--[4]
n-Nitrosopyrrolidine	930-55-2	1	5	0.032	0.067	0.33	0.0126	0.23
Pentachlorobenzene	608-93-5	1	5	0.019	0.067	0.33	0.497	0.024
Pentachloroethane	76-01-7	1	5	--[4]	0.067	0.33	--[4]	--[4]
Pentachloronitrobenzene	82-68-8	1	5	0.26	0.067	0.33	1.9	1.9

TABLE 1-5

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PARAMETER	CAS NUMBER	Aqueous Matrix			Solid Matrix			
		Laboratory		Risk-Based Target Level [2] (µg/L)	Laboratory		Risk-Based Soil Target Level [2] (mg/kg)	Risk-Based Sediment Target Level [2] (mg/kg)
		TV [1] (µg/L)	RL [1] (µg/L)		TV [1] (mg/kg)	RL [1] (mg/kg)		
SEMIVOLATILE ORGANIC COMPOUNDS (EXCEPT PAHs)								
SW-846 METHOD 8270C (Continued)								
Phenacetin	62-44-2	1	5	--[4]	0.067	0.33	11.7	--[4]
Phenol	108-95-2	1	5	180	0.067	0.33	56	0.0491
Pronamide	23950-58-5	1	5	2700	0.067	0.33	0.0136	4600
Pyridine	110-86-1	1	5	36	0.067	0.33	1.03	0.106
Safrole	94-59-7	1	5	--[4]	0.067	0.33	0.404	--[4]
o-Toluidine	95-53-4	1	5	0.28	0.067	0.33	2	2
O,O,O-Triethyl phosphorothioate	126-68-1	2.5	5	0.0038	0.067	0.33	0.152	0.00247
TAL METALS PLUS TIN								
SW-846 Method 6020								
Aluminum	7429-90-5	2.6	50	36000	1.3	25	76000	76000
Antimony	7440-36-0	0.1	1	6	0.05	0.5	0.142	31
Arsenic	7440-38-2	0.2	1	0.045	0.1	0.5	0.39	0.39
Barium	7440-39-3	0.1	1	220	0.05	0.5	1.04	5400
Beryllium	7440-41-7	0.1	1	3.6	0.05	0.5	1.06	150
Cadmium	7440-43-9	0.7	1	0.15	0.35	0.5	0.00222	0.99
Calcium	7440-70-2	2.7	100	--[4]	1.35	50	--[4]	--[4]
Chromium (total)	7440-47-3	0.1	1	42	0.05	0.5	0.4	43.4
Cobalt	7440-48-4	0.1	1	24	0.05	0.5	0.14	50
Copper	7440-50-8	0.1	2	1.58	0.05	1	5.4	31.6
Iron	7439-89-6	3.9	50	11000	1.95	25	23000	23000
Lead	7439-92-1	0.1	1	1.17	0.05	0.5	0.0537	35.8
Magnesium	7439-95-4	3.7	100	--[4]	1.85	50	--[4]	--[4]
Manganese	7439-96-5	0.1	5	880	0.05	2.5	1800	1800
Nickel	7440-02-0	0.1	1	730	0.05	0.5	1600	1600
Potassium	7440-09-7	50	100	--[4]	25	50	--[4]	--[4]
Selenium	7782-49-2	0.4	1	5	0.2	0.5	0.0276	390
Silver	7440-22-4	0.1	1	0.12	0.05	0.5	4.04	0.5

TABLE 1-5

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PARAMETER	CAS NUMBER	Aqueous Matrix			Solid Matrix			
		Laboratory		Risk-Based Target Level [2] (µg/L)	Laboratory		Risk-Based Soil Target Level [2] (mg/kg)	Risk-Based Sediment Target Level [2] (mg/kg)
		TV [1] (µg/L)	RL [1] (µg/L)		TV [1] (mg/kg)	RL [1] (mg/kg)		
TAL METALS PLUS TIN SW-846 Method 6020 (Continued)								
Sodium	7440-23-5	1.6	500	--[4]	0.8	50	--[4]	--[4]
Thallium	7440-28-0	0.1	1	2	0.05	0.5	0.0569	5.2
Tin	7440-31-5	0.1	10	180	0.05	5	7.62	--
Vanadium	7440-62-2	0.1	2	12	0.05	1	1.59	550
Zinc	7440-66-6	0.5	10	65.7	0.25	5	6.62	121
SW-846 7470A (WATER)/7471A (SOLID)								
Mercury	7439-97-6	0.1	0.2	0.0013	0.02	0.1	0.1	0.174
VOLATILE ORGANIC COMPOUNDS SW-846 METHOD 5035B/8260B								
1,1,1-Trichloroethane	71-55-6	0.3	1	76	0.001	0.003	1.9	0.213
1,1,1,2-Tetrachloroethane	630-20-6	0.3	1	0.43	0.001	0.003	0.053	3.2
1,1,2,2-Tetrachloroethane	79-34-5	0.3	1	0.055	0.001	0.003	0.007	0.41
1,1,2-Trichloroethane	79-00-5	0.3	1	0.2	0.001	0.003	0.03	0.73
1,2,3-Trichloropropane	96-18-4	0.3	1	0.0056	0.001	0.003	0.005	0.005
1,1-Dichloroethane	75-34-3	0.3	1	47	0.001	0.003	5.6	0.000575
1,1-Dichloroethene	75-35-4	0.3	1	7	0.001	0.003	0.058	0.0194
1,2-Dibromo-3-chloropropane	96-12-8	0.3	1	0.0016	0.001	0.003	0.019	0.019
1,2-Dibromoethane	106-93-4	0.3	1	0.00076	0.001	0.003	0.0069	0.0069
1,2-Dichloroethane	107-06-2	0.3	1	0.12	0.001	0.003	0.024	0.28
1,2-Dichloropropane	78-87-5	0.3	1	0.16	0.001	0.003	0.03	0.333
2-Butanone	78-93-3	0.5	5	1900	0.001	0.01	35	0.0424
2-Chloro-1,3-butadiene (chloroprene)	126-99-8	0.5	5	14	0.001	0.01	0.0029	3.6
2-Hexanone	591-78-6	0.5	5	99	0.001	0.01	12.6	0.0582
4-Methyl-2-pentanone	108-10-1	0.5	5	160	0.001	0.01	20	0.0251
Acetone	67-64-1	0.5	5	610	0.001	0.01	2.5	0.0099
Acrolein	107-02-8	0.5	5	0.042	0.001	0.01	0.00027	0.00000152
Acrylonitrile	107-13-1	0.5	5	0.039	0.001	0.01	0.0239	0.0012

TABLE 1-5

DETECTION LIMITS AND RISK CRITERIA
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETER	CAS NUMBER	Aqueous Matrix			Solid Matrix			
		Laboratory		Risk-Based Target Level [2] (µg/L)	Laboratory		Risk-Based Soil Target Level [2] (mg/kg)	Risk-Based Sediment Target Level [2] (mg/kg)
		TV [1] (µg/L)	RL [1] (µg/L)		TV [1] (mg/kg)	RL [1] (mg/kg)		
VOLATILE ORGANIC COMPOUNDS SW-846 METHOD 5035B/8260B (Continued)								
Allyl chloride (3-chloro-1-propene)	107-05-1	0.5	5	1800	0.001	0.01	0.0134	3000
Benzene	71-43-2	0.3	1	0.34	0.001	0.003	0.034	0.142
Bromodichloromethane	75-27-4	0.3	1	0.18	0.001	0.003	0.51	0.82
Bromoform	75-25-2	0.3	1	8.5	0.001	0.003	15.9	0.492
Bromomethane	74-83-9	0.3	1	8.7	0.001	0.003	0.235	0.00137
Carbon disulfide	75-15-0	0.3	1	15	0.001	0.003	0.0941	0.0239
Carbon tetrachloride	56-23-5	0.3	1	0.17	0.001	0.003	0.066	0.25
Chlorobenzene	108-90-7	0.3	1	47	0.001	0.003	1.3	0.291
Chloroethane	75-00-3	0.3	1	4.6	0.001	0.003	0.65	3
Chloroform	67-66-3	0.3	1	6.2	0.001	0.003	0.47	0.121
Chloromethane	74-87-3	0.3	1	1.5	0.001	0.003	1.2	1.2
cis-1,2-Dichloroethene	156-59-2	0.3	1	61	0.001	0.003	0.4	43
cis-1,3-Dichloropropene	10061-01-5	0.3	1	0.4	0.001	0.003	0.78	0.78
Dibromochloromethane	124-48-1	0.3	1	0.13	0.001	0.003	1.1	1.1
Dibromomethane	74-95-3	0.3	1	61	0.001	0.003	65	67
Dichlorodifluoromethane	75-71-8	0.3	1	390	0.001	0.003	39.5	94
Ethylbenzene	100-41-4	0.3	1	2.9	0.001	0.003	5.16	0.175
Ethyl methacrylate	97-63-2	0.5	5	550	0.001	0.01	30	140
Methacrylonitrile	126-98-7	0.5	5	1	0.001	0.01	0.057	2.1
Methylene chloride	75-09-2	0.3	1	4.3	0.001	0.003	0.023	9.1
Methyl iodide	74-88-4	0.5	5	--[4]	0.001	0.01	1.23	--[4]
Methyl methacrylate	80-62-6	0.5	5	1400	0.001	0.01	984	0.168
Methyl tert-Butyl Ether	1634-04-4	0.5	1	13	0.001	0.003	0.18	62
Styrene	100-42-5	0.3	1	32	0.001	0.003	3.5	0.254
Tetrachloroethene	127-18-4	0.3	1	0.66	0.001	0.003	0.058	0.99
Toluene	108-88-3	0.3	1	253	0.001	0.003	5.45	1.22
trans-1,2-Dichloroethene	156-60-5	0.3	1	100	0.001	0.003	0.68	0.654
trans-1,3-Dichloropropene	10061-02-6	0.3	1	0.4	0.001	0.003	0.78	0.78

TABLE 1-5

DETECTION LIMITS AND RISK CRITERIA
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETER	CAS NUMBER	Aqueous Matrix			Solid Matrix			
		Laboratory		Risk-Based Target Level [2] (µg/L)	Laboratory		Risk-Based Soil Target Level [2] (mg/kg)	Risk-Based Sediment Target Level [2] (mg/kg)
		TV [1] (µg/L)	RL [1] (µg/L)		TV [1] (mg/kg)	RL [1] (mg/kg)		
VOLATILE ORGANIC COMPOUNDS SW-846 METHOD 5035B/8260B (Continued)								
Trichlorofluoromethane	75-69-4	0.3	1	1300	0.001	0.003	16.4	390
Vinyl acetate	108-05-4	0.5	5	410	0.001	0.01	2.3	430
Vinyl chloride	75-01-4	0.3	1	2	0.001	0.003	0.013	0.202
Total Xylenes	1330-20-7	0.3	1	27	0.001	0.003	10	0.433
1,4-Dioxane	123-91-1	50	100	6.1	0.1	0.2	2.05	0.119
Acetonitrile	75-05-8	20	40	100	0.04	0.08	1.37	0.056
Ethylene Glycol	107-21-1	2500	5000	73000	TBD	TBD	100000	100000
Isobutanol	78-83-1	20	40	1800	0.04	0.08	20.8	13000
Propionitrile	107-12-0	20	40	--[4]	0.04	0.08	0.0498	--[4]

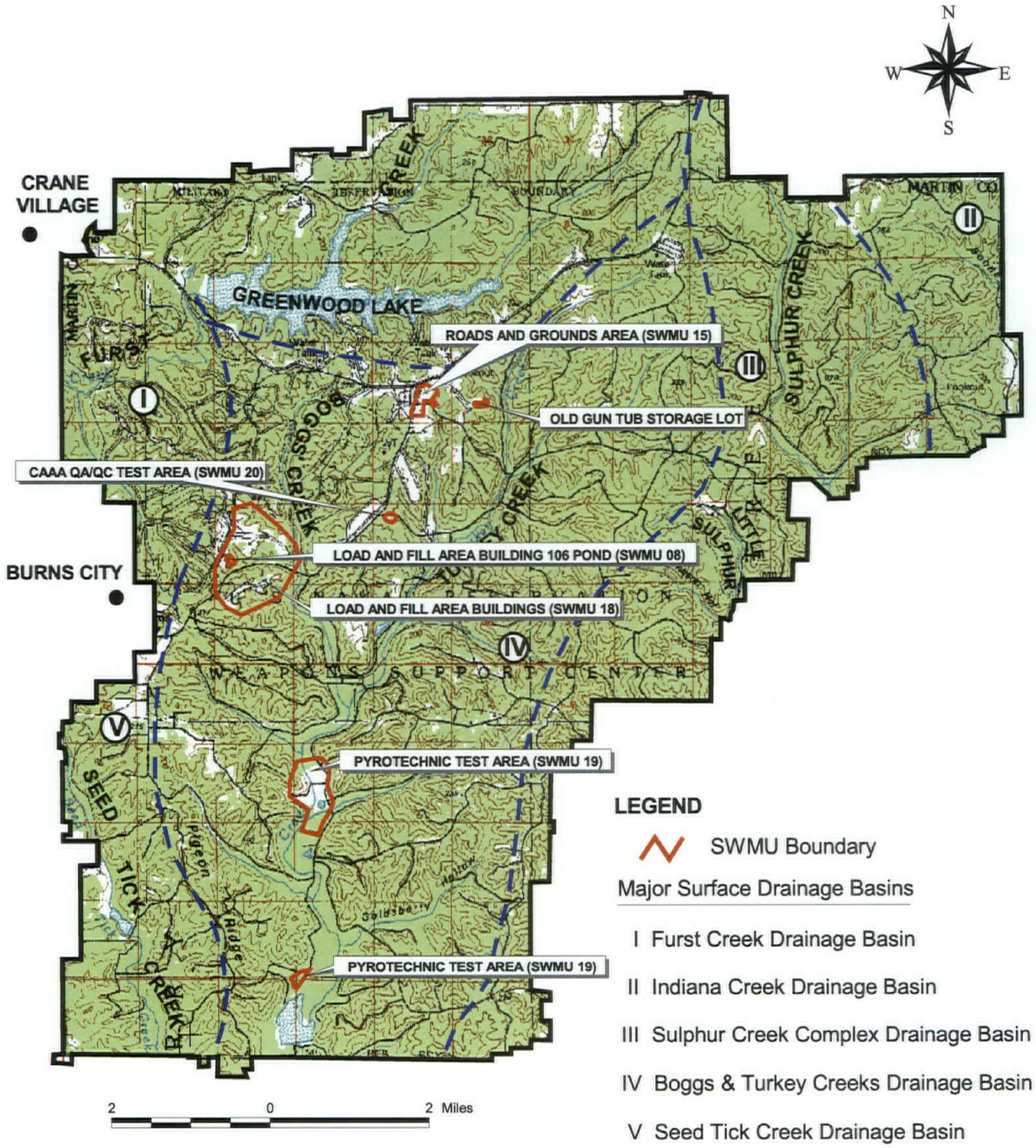
TABLE 1-5

DETECTION LIMITS AND RISK CRITERIA
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETER	CAS NUMBER	Aqueous Matrix			Solid Matrix			
		Laboratory		Risk-Based Target Level [2] (µg/L)	Laboratory		Risk-Based Soil Target Level [2] (mg/kg)	Risk-Based Sediment Target Level [2] (mg/kg)
		TV [1] (µg/L)	RL [1] (µg/L)		TV [1] (mg/kg)	RL [1] (mg/kg)		
MISCELLANEOUS PARAMETERS								
CEC SW-846 Method 9081	---	NA	NA	--[4]	0	1	--[4]	--[4]
Perchlorate EPA Method 314.0	14797-73-0	2	4	3.6	0.04	0.08	7.8	7.8
pH SW-846 Method 9045C	---	0	0	--[4]	0.1	0.1	--[4]	--[4]
TOC SW-846 Method 9060/Lloyd Khan	---	0.5	1	--[4]	0.05	0.1	--[4]	--[4]
Total Petroleum Hydrocarbons (TPH) SW-846 Method 9070/9071B	---	2500	5000	--[4]	200	400	--[4]	--[4]

µg/L = Micrograms per liter.
CEC = Cation exchange capacity.
mg/kg = Milligrams per kilogram.
NA = Not Applicable.
RL = Reporting Limit.
TBD = To be determined.
TV = Threshold value (best estimate of realistic MDL basd on statsitical calculations and laboratory experience).

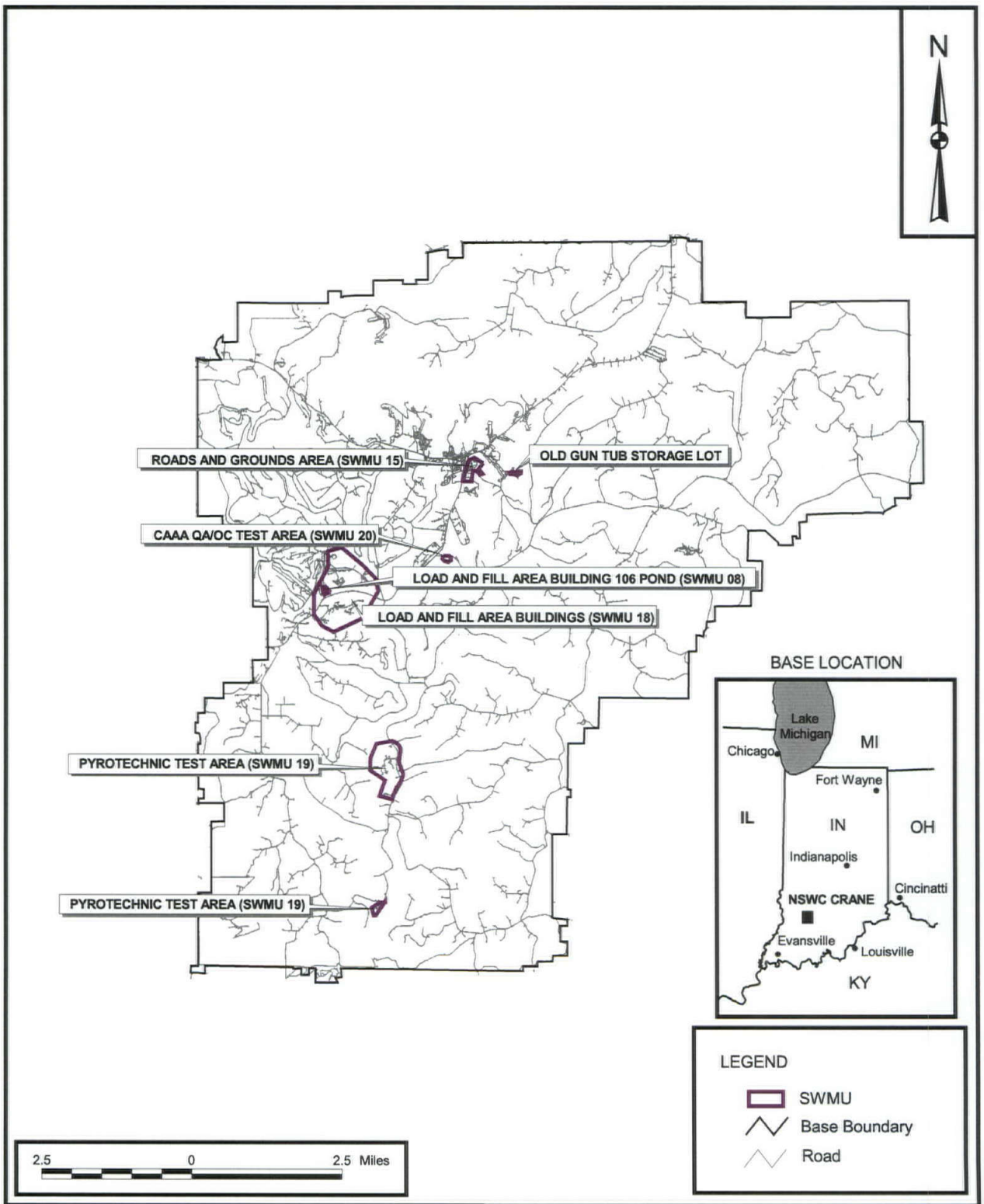
1 Threshold values and reporting limits may change prior to commencement of sampling activities.
2 Value is based on the lowest human health or ecological risk-based criterion as presented in Appendix B, Table B-1 (aqueous) and B-2 (solids).
3 Shading indicates those chemicals for which the threshold value and/or reporting limit exceeds the risk-based target level for the project.
4 Risk-based target level is not provided because human health or ecological risk-based criteria are not available for this compound.
5 3-Methylphenol and 4-methylphenol co-elute; therefore, one analytical result for 3- and 4-methylphenol will be reported.
6 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 included as n-nitrosodiphenylamine during risk assessment.



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 8/27/01	Tetra Tech NUS, Inc.	CONTRACT NUMBER N1245	OWNER NO. CTO 0331
CHECKED BY V. PLACHY — DATE 8/04/04	OLD GUN TUB STORAGE LOT (OGSTL) AND SWMUS 8, 15, 18, 19, AND 20 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 - 1	REV 0

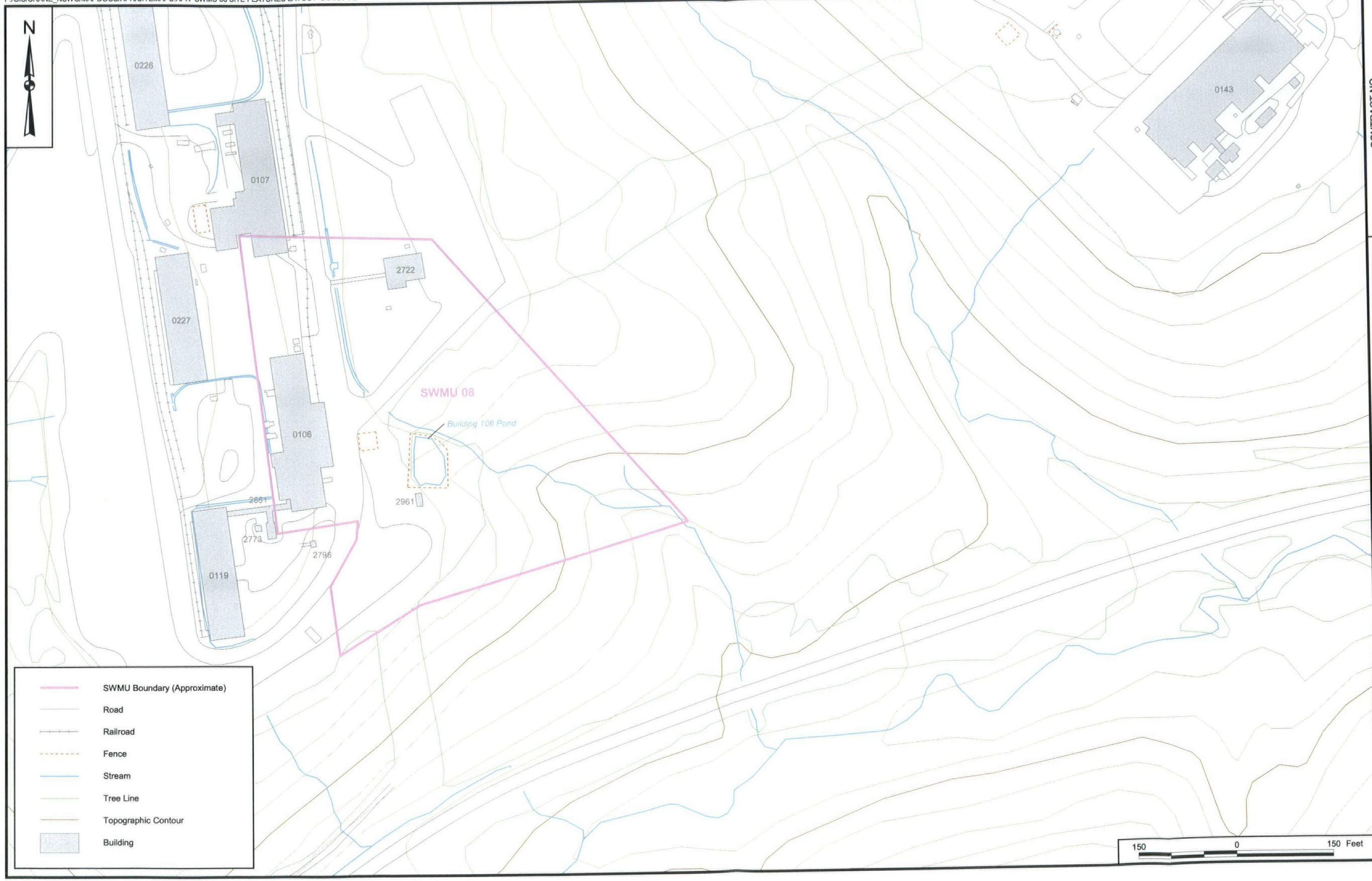
P:\GIS\NSWC_CRANE\MINEFILL_A.APR 8,15,18,19,20, & OGTSL DRAINAGE BASIN LAYOUT 8/04/04 AJ



DRAWN BY	DATE	Tetra Tech NUS, Inc.	CONTRACT NUMBER	OWNER NO.
A. JANOCHA	5/24/04		N1245	CTO 0331
CHECKED BY	DATE	SITE LOCATION MAP	APPROVED BY	DATE
V. PLACHY	8/04/04	OLD GUN TUB STORAGE LOT (OGSTL) AND		
COST/SCHEDULE-AREA		SWMUS 8, 15, 18, 19, AND 20	APPROVED BY	DATE
SCALE		NAVAL SURFACE WARFARE CENTER	DRAWING NO.	REV
AS NOTED		CRANE, INDIANA	FIGURE 1 - 2	0

P:\GIS\NSWC_CRANE\MINEFILL_A.APR 8,15,18,19,20, & OGTSL SITE LOCATION LAYOUT 8/04/04 AJ

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SITEMAPS.APR SWMU 08 SITE FEATURES LAYOUT 8/04/04 AJ



CONTRACT NO. N1245

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 1 - 3

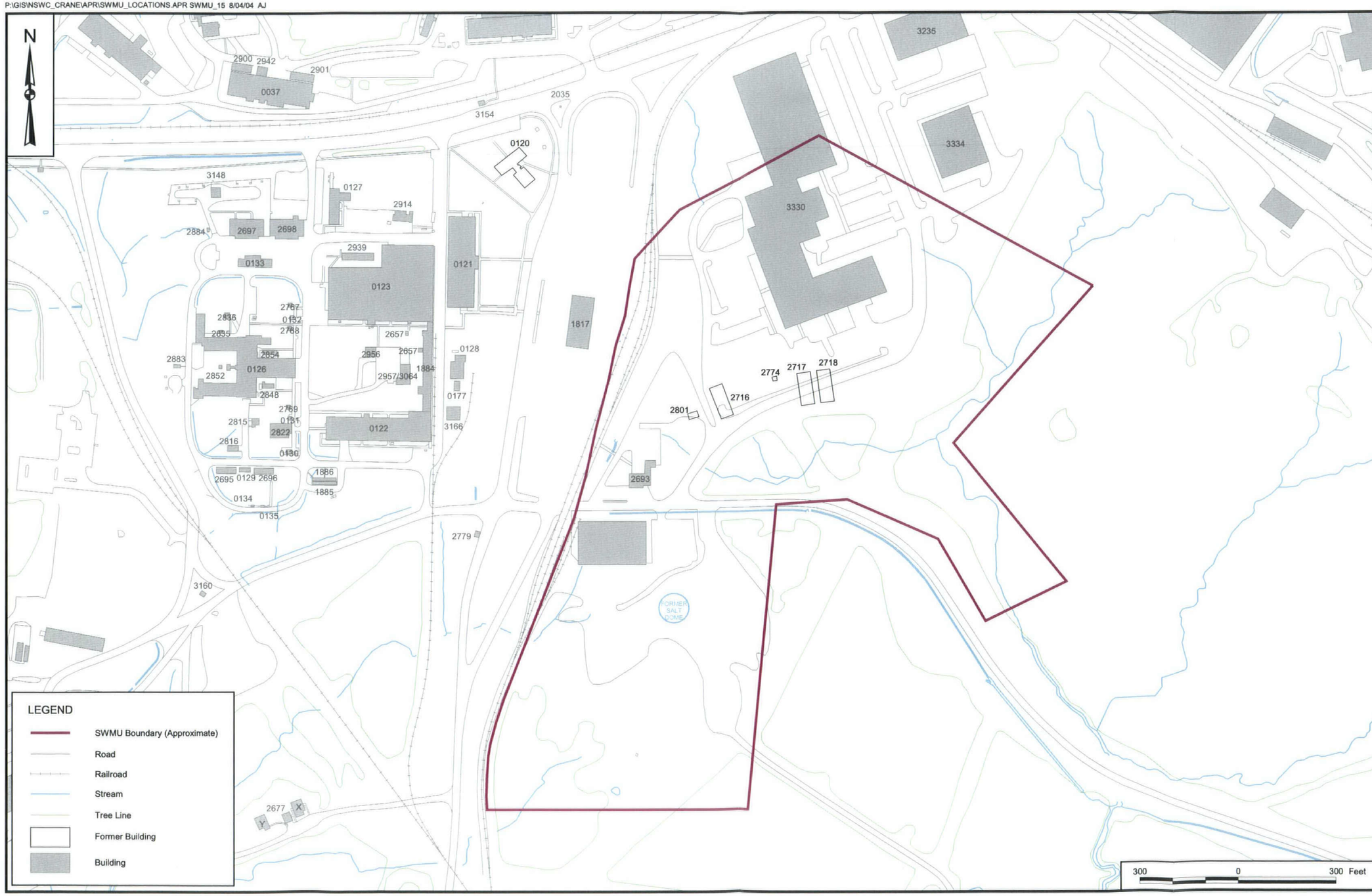
REV 0

SITE FEATURES
SWMU 08 (BUILDING 106 POND)
NSWC CRANE
CRANE, INDIANA

DEPARTMENT OF THE NAVY * SOUTHERN DIV FACILITIES ENGO SUBNETWORK

DRAWN BY A. JANOCHA	DATE 5/27/04
CHECKED BY V. PLACHY	DATE 8/04/04
COST/SCHED-AREA	
	SCALE AS NOTED

P:\GIS\NSWC_CRANE\APR\SWMU_LOCATIONS.APR SWMU_15 8/04/04 AJ



CONTRACT NO.
N1245

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 1 - 4

REV 0

SITE FEATURES
SWMU 15 (ROADS AND GROUNDS AREA)
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

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

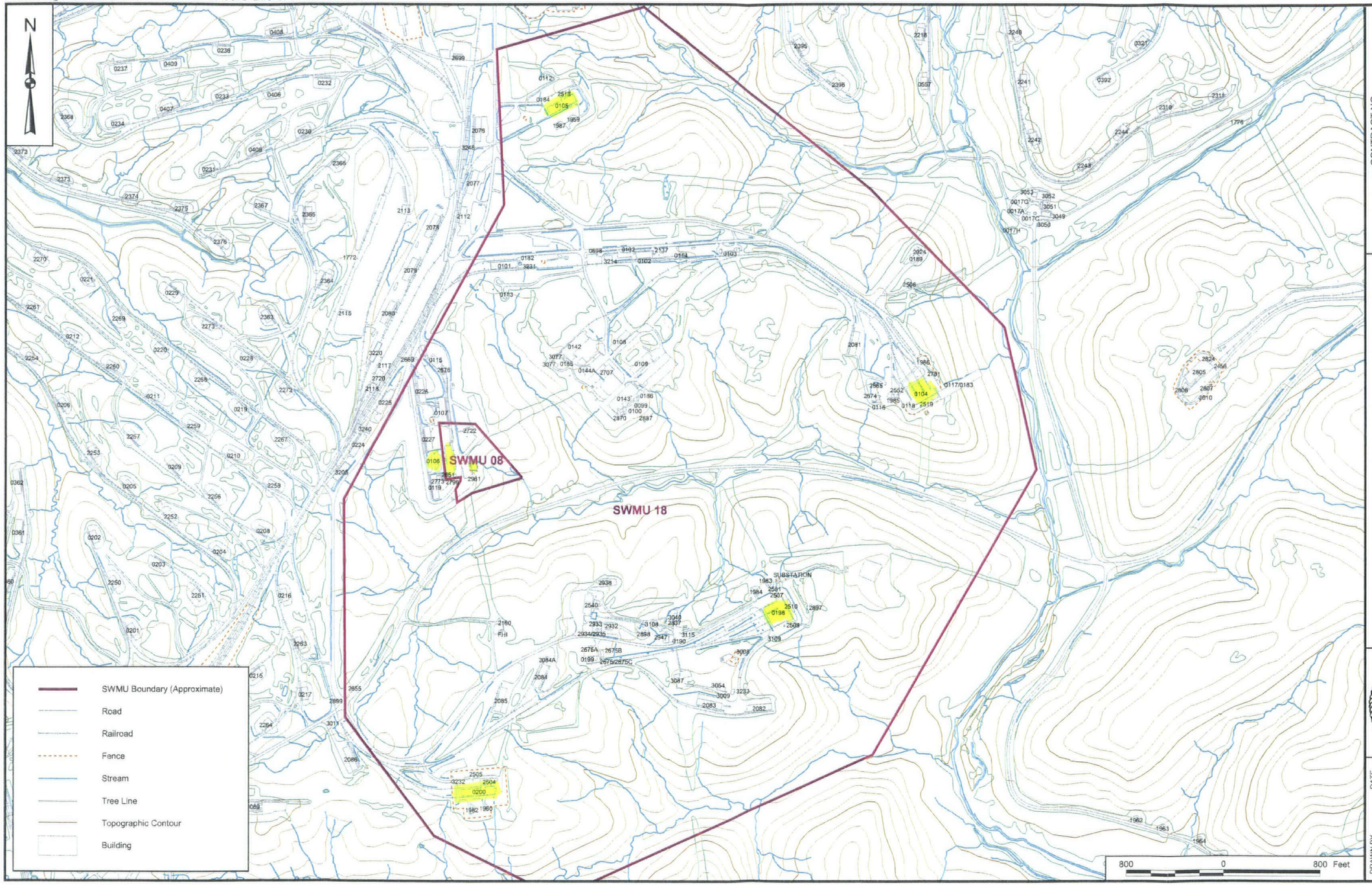
DRAWN BY A. JANOCHA DATE 2/03/04

CHECKED BY V. PLACHY DATE 8/04/04

COST/SCHED-AREA

SCALE AS NOTED

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SITEMAPS.APR SWMU 18 SITE FEATURES LAYOUT 12/22/04 AJ



CONTRACT NO. N1245

APPROVED BY DATE

APPROVED BY DATE

DRAWING NO. FIGURE 1 - 5

REV 0

SITE FEATURES
SWMU 18 (LOAD AND FILL AREA BUILDINGS)
NSWC CRANE
CRANE, INDIANA

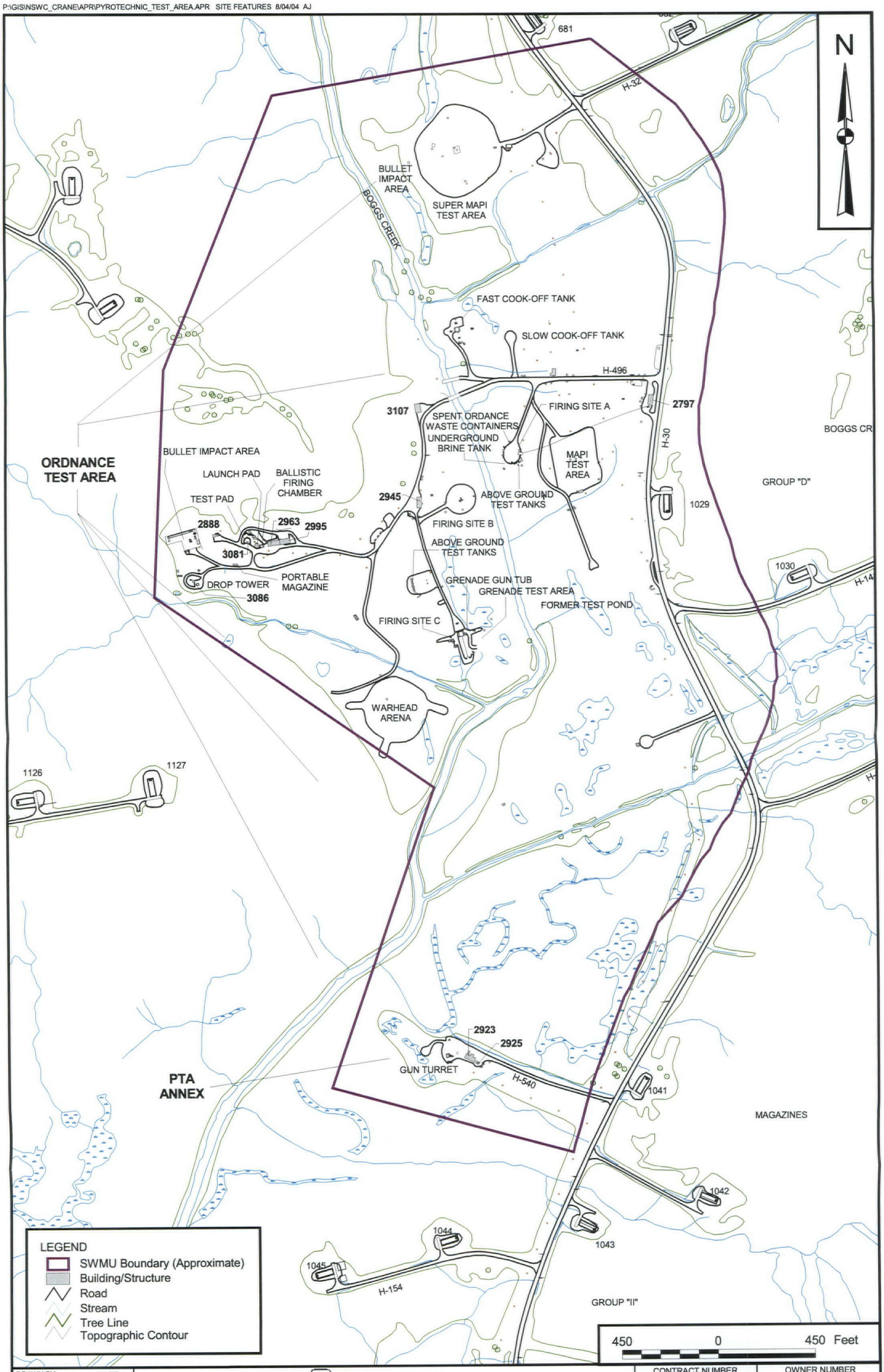
DRAWN BY A. JANOCHA DATE 5/27/04

CHECKED BY R. BASINSKI DATE 12/22/04

COST/SCHED-AREA

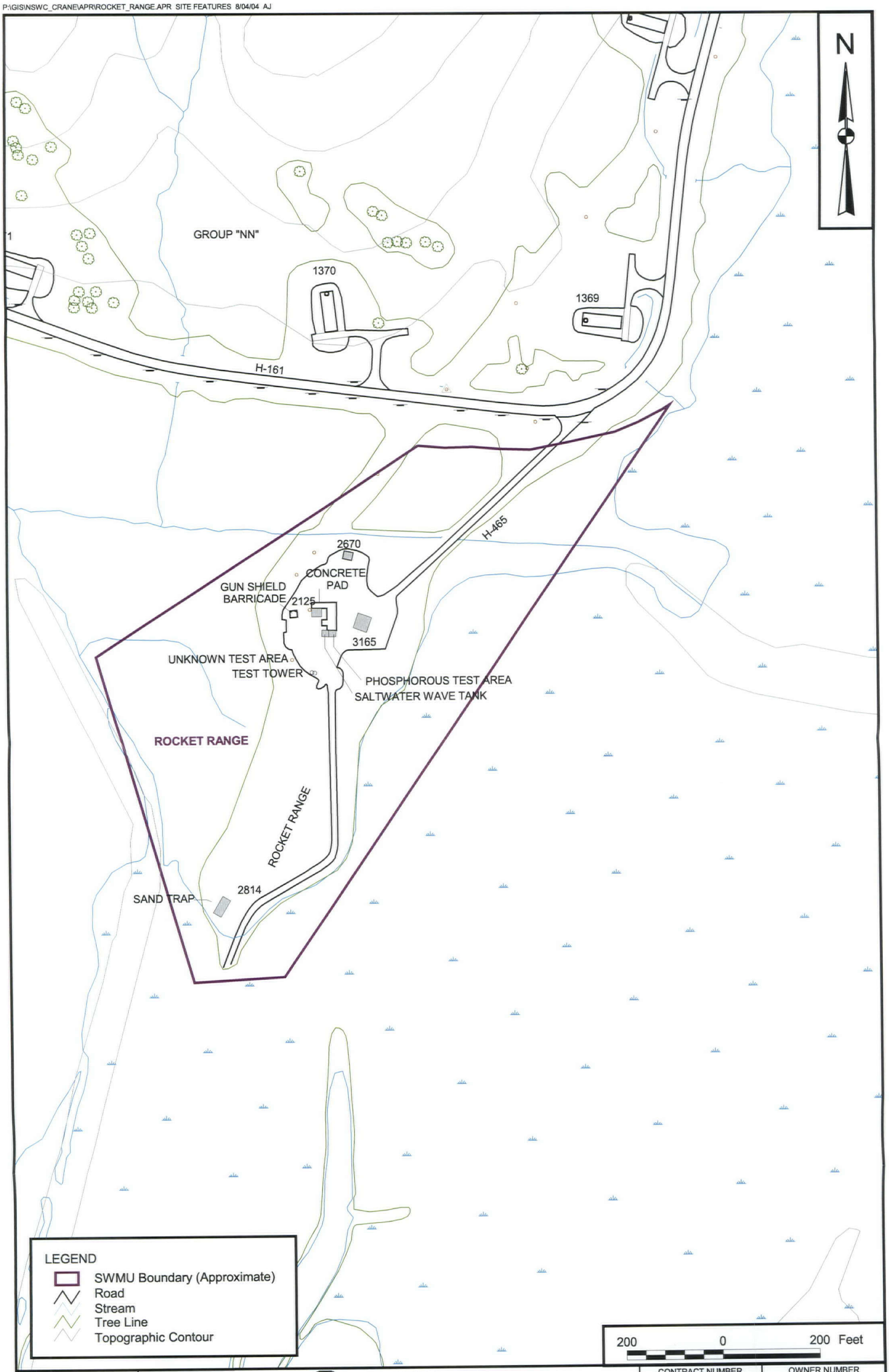
SCALE AS NOTED

P:\GIS\NSWC_CRANE\APR\PYROTECHNIC_TEST_AREA.APR SITE FEATURES 8/04/04 AJ



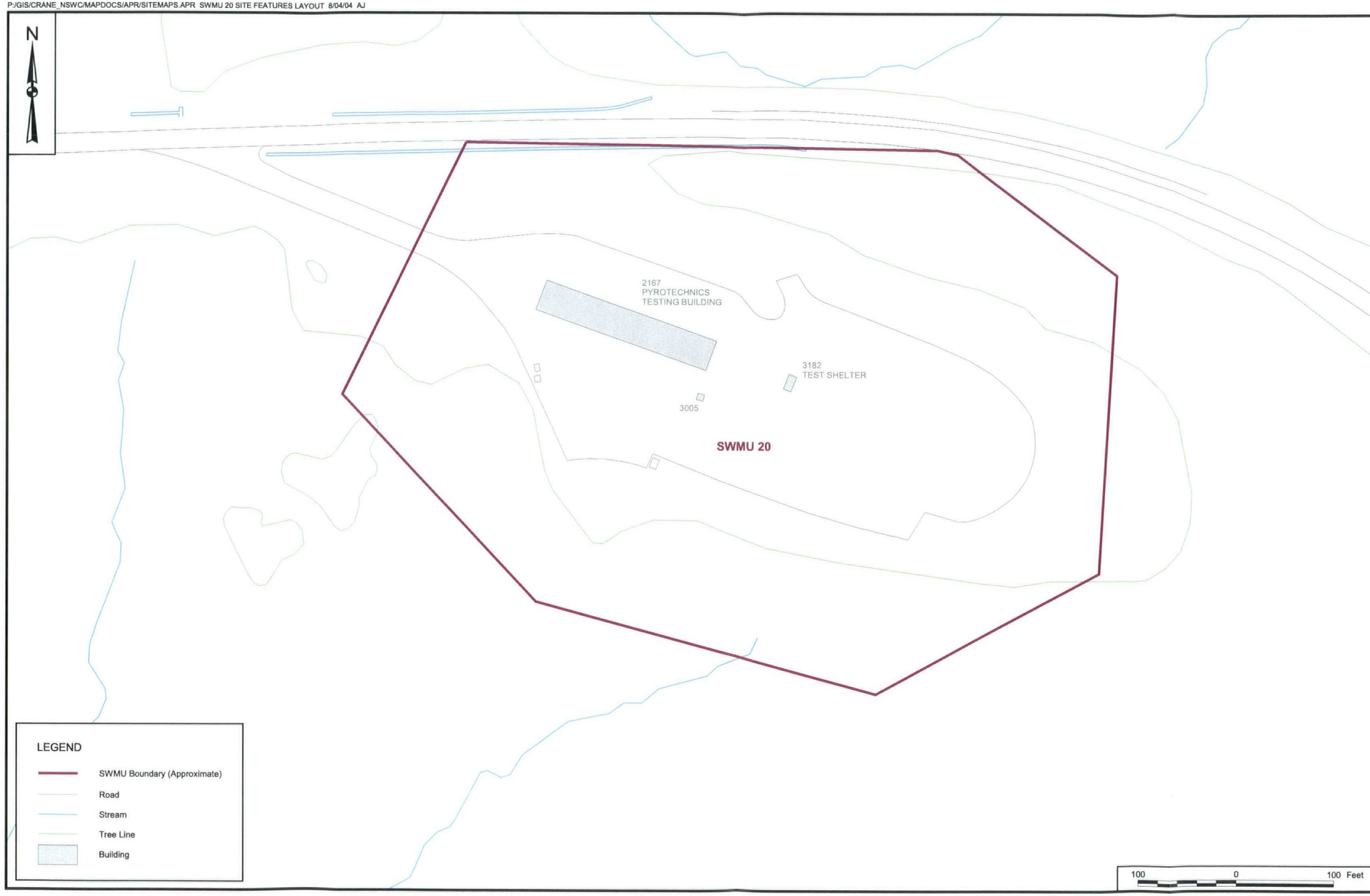
DRAWN BY J. LAMEY DATE 8/22/01	Tetra Tech NUS, Inc.	CONTRACT NUMBER N1245	OWNER NUMBER CTO 0331
CHECKED BY V. PLACHY DATE 8/04/04	SITE FEATURES SWMU 19 [PYROTECHNIC TEST AREA (PTA)] ORDNANCE TEST AREA AND PTA ANNEX NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY —	DATE —
COST/SCHEDULE-AREA		APPROVED BY —	DATE —
SCALE AS NOTED		DRAWING NO. FIGURE 1 - 6	REV 0

P:\GIS\NSWC_CRANE\APR\ROCKET_RANGE.APR SITE FEATURES 8/04/04 AJ



DRAWN BY J. LAMEY DATE 8/17/01	Tetra Tech NUS, Inc.	CONTRACT NUMBER N1245	OWNER NUMBER CTO 0311
CHECKED BY V. PLACHY DATE 8/04/04	SITE FEATURES SWMU 19 [PYROTECHNIC TEST AREA (PTA)] ROCKET RANGE NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY — DATE —	
COST/SCHEDULE-AREA		APPROVED BY — DATE —	
SCALE AS NOTED		DRAWING NO. FIGURE 1 - 7	REV 0

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SITEMAPS.APR SWMU 20 SITE FEATURES LAYOUT 8/04/04 AJ



CONTRACT NO.
N1245

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 1 - 8

REV 0

SITE FEATURES
SWMU 20 (CRANE ARMY AMMUNITION ACTIVITY
QUALITY ASSURANCE/QUALITY CONTROL TEST AREA)
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

DEPARTMENT OF THE NAVY ★ SOUTHERN DIV. FACILITIES ENGINEERING COMD ★

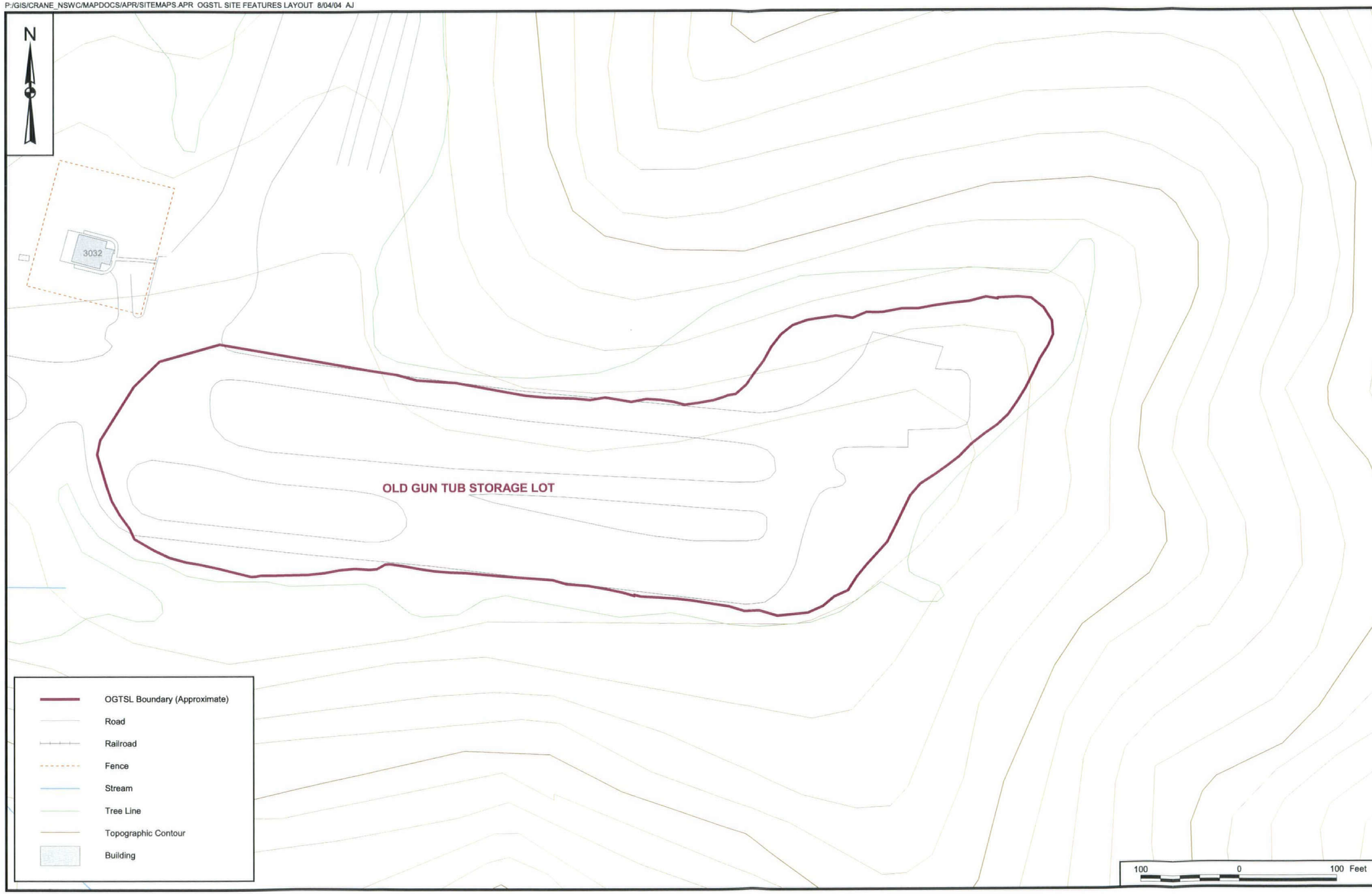
DRAWN BY A. JANOCHA DATE 5/24/04

CHECKED BY V. PLACHY DATE 8/04/04

COST/SCHED-AREA

SCALE AS NOTED

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SITEMAPS.APR OGSTL SITE FEATURES LAYOUT 8/04/04 AJ



CONTRACT NO.
N1245

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 1 - 9

REV 0

SITE FEATURES
OLD GUN TUB STORAGE LOT (OGTSL)
NSWC CRANE
CRANE, INDIANA

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

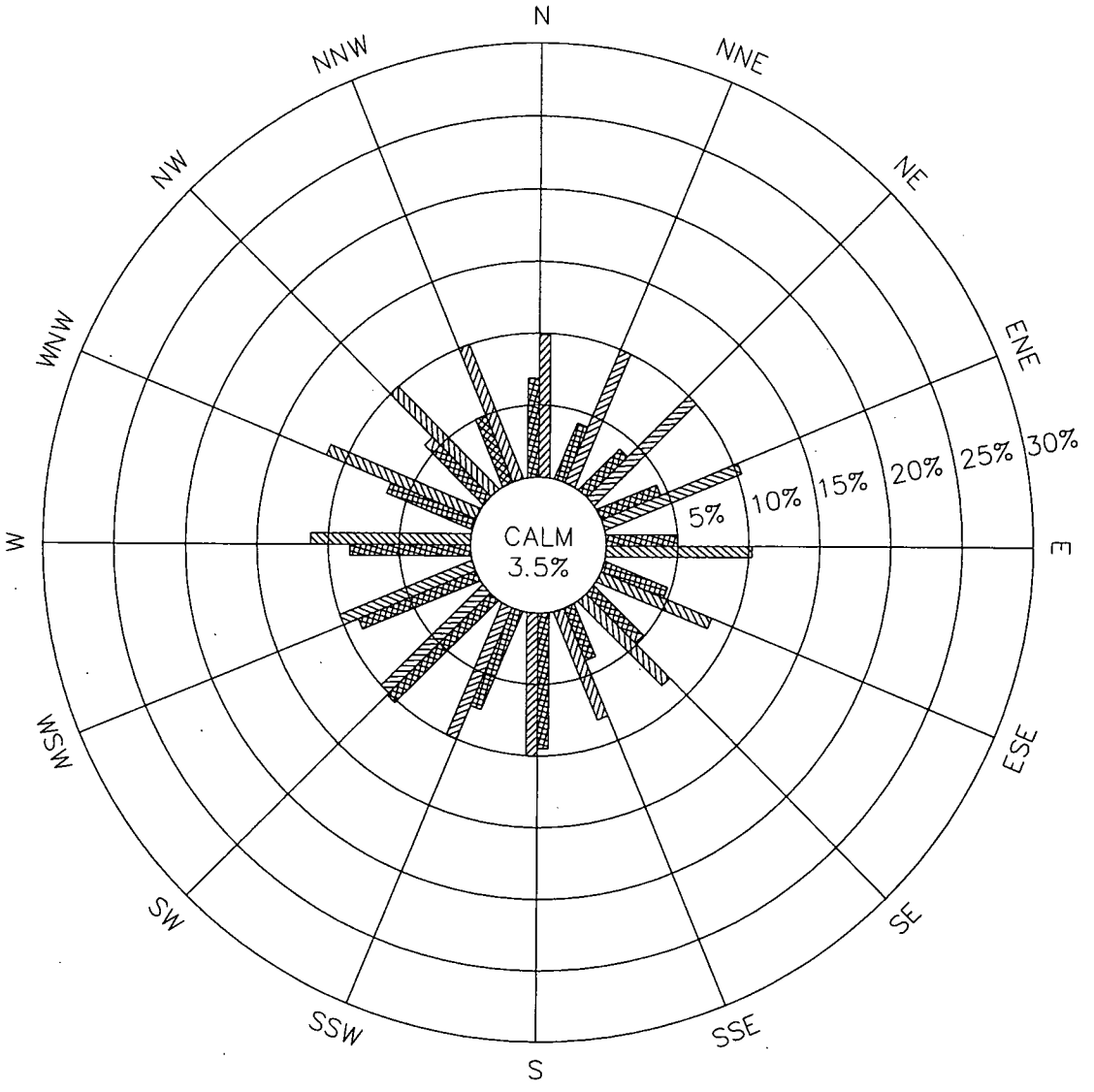
DRAWN BY A. JANOCHA DATE 5/27/04

CHECKED BY V. PLACHY DATE 8/04/04

COST/SCHED-AREA

SCALE AS NOTED

ACAD:1245KM01.dwg 05/18/04 HJB PIT



LEGEND:

WIND DIRECTION FREQUENCY (PERCENT)

MEAN WIND SPEED (MI/HR)

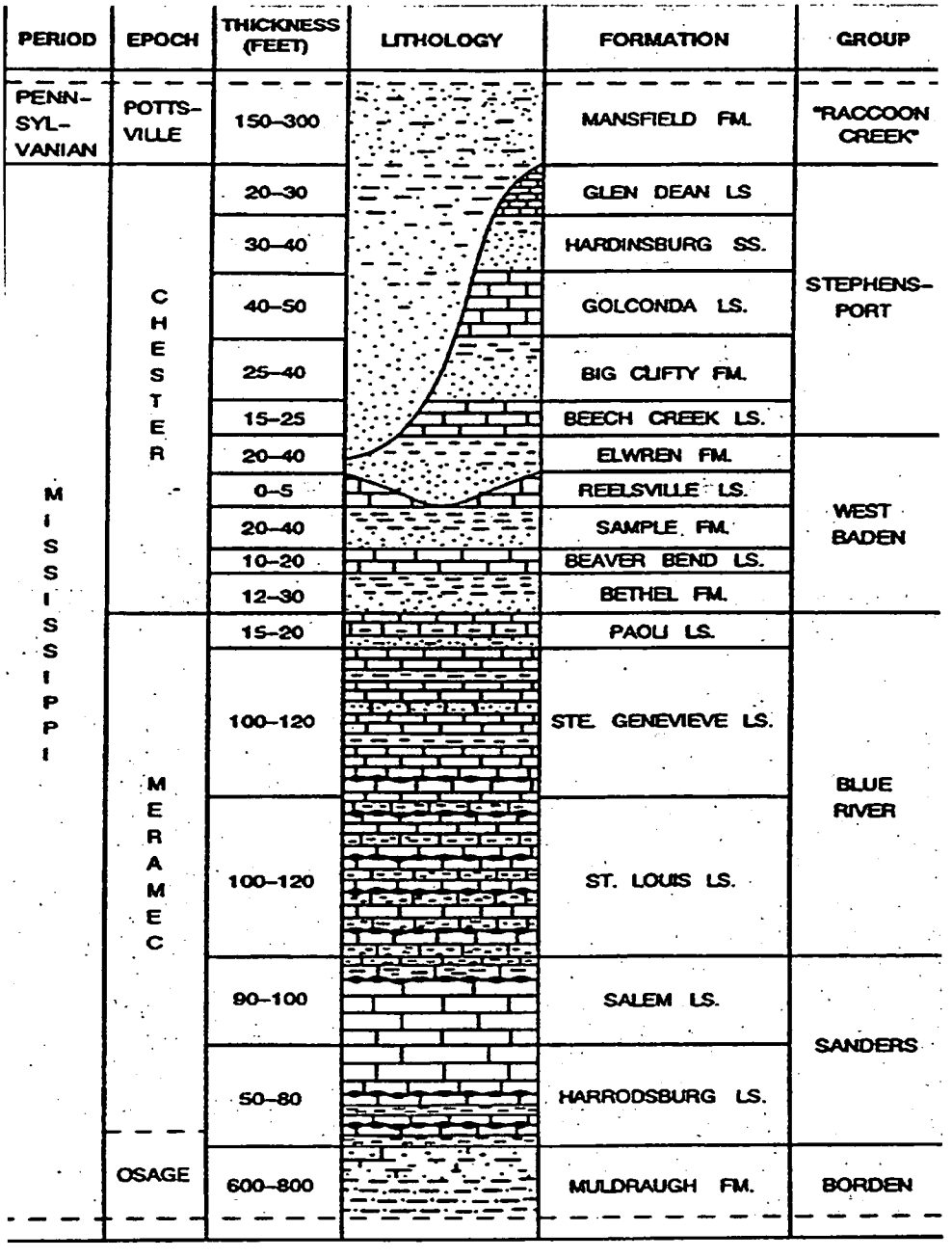
DATA SOURCE: INDIANAPOLIS, INDIANA AIRPORT

PERIOD OF RECORD: 1985–1989

43,824 OBSERVATIONS

DRAWN BY HJB DATE 5/18/04	Tetra Tech NUS, Inc.	CONTRACT NO. 1245	OWNER NO.
CHECKED BY DATE	FIVE YEAR WINDROSE SUMMARY FOR INDIANAPOLIS, INDIANA NSWC CRANE, CRANE, INDIANA	APPROVED BY	DATE
COST/SCHED–AREA		APPROVED BY	DATE
SCALE NOT TO SCALE		DRAWING NO. FIGURE 1–10	REV. 0

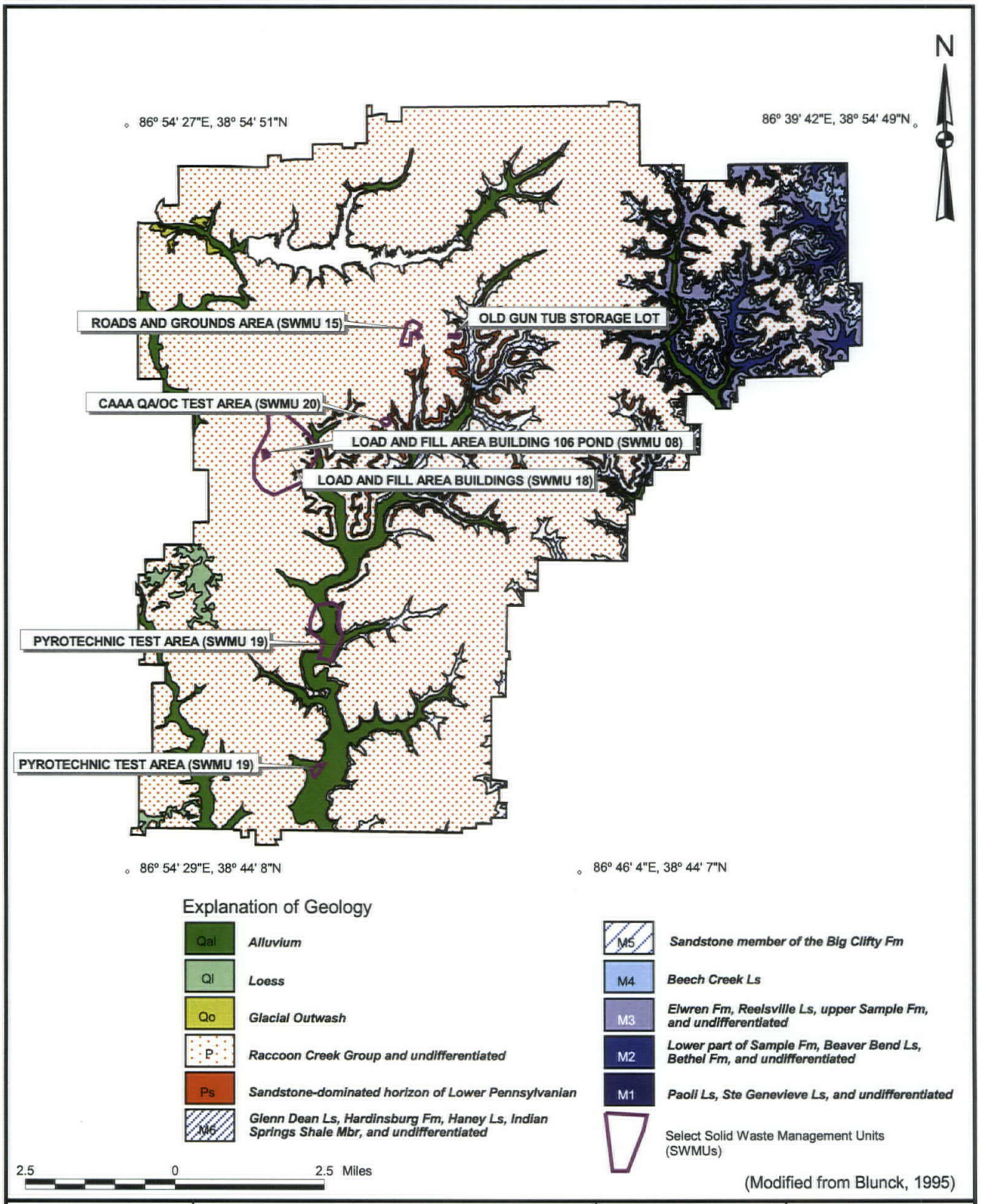
FORM CADD NO. T+NUS_AV.DWG – REV 0 – 1/22/98



Source: Draft Report, RCRA Facility Investigation
Phase II Groundwater Release Assessment, SWMU 06/09
Demolition Area and Phase III Release
Characterization SWMU 07/09 Old Rifle Range
November 1995 - Figure 13
by William L. Murphy and Roy Wade

DRAWN BY J. LAMEY	DATE 8/26/01	Tetra Tech NUS, Inc.	CONTRACT NUMBER 9060	OWNER NO. CTO 0279
CHECKED BY V. PLACHY	DATE 7/12/04	STRATIGRAPHIC COLUMN FOR ROCK UNITS ENCOUNTERED AT THE NAVAL SURFACE WARFARE CENTER NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY	DATE
COST/SCHEDULE-AREA			APPROVED BY	DATE
SCALE AS NOTED			DRAWING NO. FIGURE 1 - 11	REV 0

P:\GIS\NSWC_CRANE\MINEFILL_A.APR STRATIGRAPHIC COLUMN 7/12/04 AJ



DRAWN BY J. LAMEY — DATE 8/27/01	Tetra Tech NUS, Inc.	CONTRACT NUMBER N1245	OWNER NO. CTO 0331
CHECKED BY V. PLACHY — DATE 8/04/04	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 - 12	REV 0

P:\GIS\NSWC_CRANE\MINEFILL_A.APR 8,15,18,19,20, & OGTSL SURFICIAL GEOLOGY LAYOUT 8/04/04 AJ

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

This section presents the project management and organization for an RFI at NSWC Crane SWMUs 8 and 15 and for data collection to support the completion of EI indicator forms (CA725) for SWMUs 18, 19, and 20 and the OGTSL. Staffing and coordination requirements are discussed in the following subsections.

2.1 MANAGEMENT

TtNUS, on behalf of the United States Navy, is responsible for the overall management, implementation of contract field activities, and preparation of the 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 assumed the designated responsibilities to the extent that the specific person is available to perform the stated activities.

2.1.1 Indiana Department of Environmental Management Project Manager

The IDEM Project Manager (PM) (Mr. Doug Griffin) and the IDEM Geologist (Mr. Marty Harmless) will oversee the implementation of the Phase III multimedia RFI at NSWC Crane for SWMUs 8 and 15. The IDEM PM represents the Agency's interests and will provide input from this perspective and lend general technical assistance to NSWC Crane field activities.

2.1.2 U.S. EPA Oversight

The U.S. EPA Region 5 PM, Peter Ramanauskas, represents the Agency's interests and will provide input from this perspective and lend general historical and technical assistance to NSWC Crane field activities. U.S. EPA has delegated the RCRA program to IDEM. U.S. EPA Region 5 will receive the CA725 form data and will complete the forms but will not be involved with data collection.

2.1.3 Navy Project Managers

The Navy Remedial Project Manager (RPM), Mr. Bill Gates, acts as the focal representative for the United States 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, oversight, etc., the Navy RPM is assisted by the NSWC Environmental Site Managers (ESM), Mr. Tom Brent and Ms. Christine Freeman. 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 for each task to ensure its quality, responsiveness, and timeliness
- Review and analyze overall task performance with respect to planned requirements and authorizations
- Review and approve all reports (i.e., deliverables) before their submittal to IDEM
- 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) Project Manager (PM), Ms. Debra Humbert, provides operations, technical, and administrative leadership and oversees and supports quality policies. The PM assigns project Task Order Managers (TOMs) and oversees their performance. The PM 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, PM is assisted by the TOM.

Task Order Manager

The TtNUS TOM, Mr. Ralph Basinski, has overall responsibility for ensuring that the project meets 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 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, the NSWC Crane ESM, TtNUS 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 all subcontractor performance including laboratory drilling, direct push technology, and surveying.
- Coordinating and overseeing work performed by TtNUS field and office technical staff (including data validation, data interpretation, 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, Mr. Edward Sedlmyer, has 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 PMs will report to the Project Chemist. The Project Chemist will report to the TOM. Additional responsibilities of the Project Chemist are as follows:

- 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)
- 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 IDEM, TtNUS, and the analytical laboratories are discussed.

2.2.1 Indiana Department of Environmental Management

The IDEM chemist, Mr. Craig Pender, has the responsibility to review and approve chemistry aspects of 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 United States Navy for project QA. 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
- Ensuring that the QAPP and QAPP revisions meet TtNUS, Navy, and IDEM requirements
- Overseeing the responsibilities of the TtNUS Site QA/QC Advisor
- Preparing QA reports for management

2.2.3 TtNUS Project QA Advisor

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

2.2.4 Laboratory Responsibilities

The subcontracted laboratories are responsible for analyzing all samples in accordance with the analytical methods and additional requirements specified in the attendant QAPP. It will also 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 Laboratory PM will interface directly with the Project Chemist, TtNUS TOM, and QA Advisor and will perform the following:

- Ensuring that method and project-specific requirements are properly communicated and understood by laboratory personnel
- Ensuring that all laboratory resources are available on an as-required basis
- Ensuring compliance with analytical and project QA requirements
- Reviewing data packages for completeness, clarity, and compliance with project requirements
- Informing the TtNUS TOM of project status and any sample receipt or analytical problems
- Overseeing the preparation of and approving final analytical reports before submittal to TtNUS

Laboratory Operations Manager

Responsibilities of the Laboratory Operations Manager include the following:

- Supporting the QA program within the laboratory
- Providing management overview of both production and quality-related laboratory activities
- Maintaining adequate staffing to meet project analytical and quality objectives
- Approving all laboratory SOPs and QA documents
- Supervising in-house COC documentation

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:

- Defining appropriate laboratory QA procedures and monitoring overall laboratory QA
- Stopping work if a condition adverse to the quality of work is encountered, if QA or QC procedures are not followed, or if analytical out-of-control events are encountered that have not been corrected
- Approving and maintaining document control of all QA documents and SOPs
- Performing and/or implementing internal system and performance audits and verifying completion of corrective actions cited in audits
- Directing 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:

- Receiving and inspecting the incoming sample containers
- Recording the conditions of the incoming sample containers
- Signing appropriate documents
- Verifying COC records
- Notifying the laboratory project manager of sample receipt and inspection
- Assigning a unique identification number and customer number and entering each into the sample receiving log
- With the help of the laboratory project manager, initiating transfer of the samples to appropriate lab sections
- Controlling and monitoring 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 unexploded ordnance (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 COC 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 on-site communications link between field staff members, SSO, UXO Specialist, the NSWC Crane ESM, 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 ESM, 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 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 SWMU 19 (PTA, PTA Annex, and PTA Rocket Range). 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 Technical Staff

The technical staff for this project (including field personnel, hydrogeologists, risk assessors, chemists, database specialists, Geographic Information System/Computer-Aided Design and Drafting (GIS/CADD) personnel, etc.) will be drawn from TtNUS' pool of qualified personnel. All of the designated 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 members 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 PROJECT PERSONNEL
SWMUs 8 AND 15 RFI INVESTIGATION
NAMES, PHONE NUMBERS, AND ADDRESSES
NSWC CRANE, CRANE, INDIANA
PAGE 1 OF 2

PERSON / TITLE / ORGANIZATION	ADDRESS	TELEPHONE
Doug Griffin Project Manager 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, Indiana 46206-6015	Phone: (317) 233-2710
Marty Harmless Project Geologist 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
Craig Pender	TBD	Phone: (317) 234-0941 FAX: TBD
Peter Ramanauskas U.S. EPA Oversight U.S. EPA Region 5	EPA Region 5 77 West Jackson Blvd. Chicago, Illinois 60604	Phone: (312) 886-7890 FAX: (312) 353-4788
Bill Gates Remedial Project Manager U.S. Navy NAVFAC EFD SOUTH	Department of Navy NAVFAC EFD SOUTH Code ES31 2155 Eagle Drive Charleston, South Carolina 29406	Phone: (843) 820-7360 FAX: (843) 820-7465
Tom Brent Environmental Site Manager NSWC Crane	NSWC Crane Code RP3-TB B-3245 300 Highway 361 Crane, Indiana 47522-5009	Phone: (812) 854-6160 FAX: (812) 854-3981
Christine Freeman Environmental Site Manager NSWC Crane	NSWC Crane Code RP3-CF B-3245 300 Highway 361 Crane, Indiana 47522-5009	Phone: (812) 854-4423 FAX: (812) 854-3981
Debra Humbert Program Manager Tetra Tech NUS	Tetra Tech NUS 661 Andersen Drive Pittsburgh, Pennsylvania 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, Pennsylvania 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, Pennsylvania 15220-2745	Phone: (412) 921-8912 FAX: (412) 921-4040

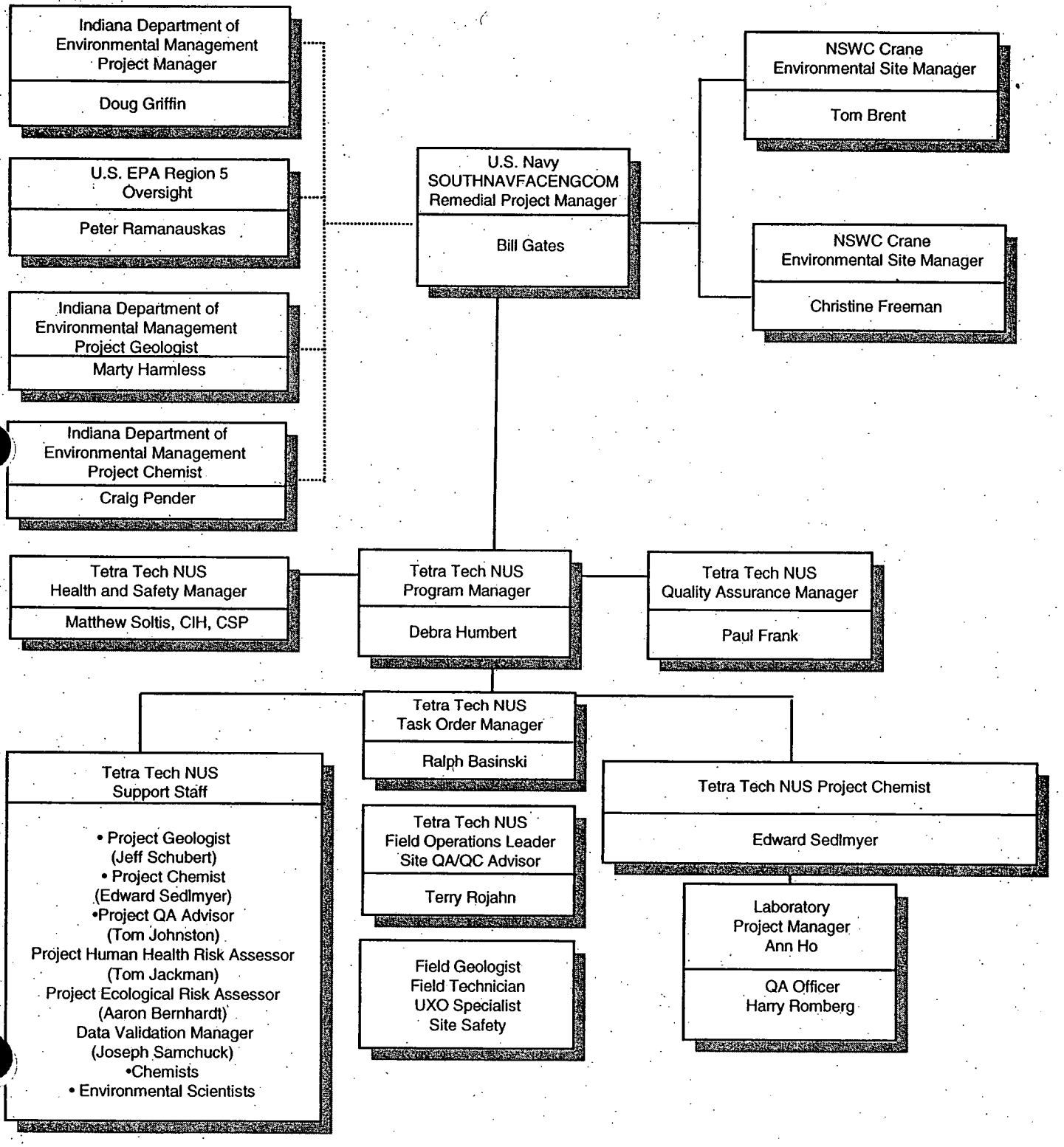
TABLE 2-1

KEY PROJECT PERSONNEL
SWMUs 8 AND 15 RFI INVESTIGATION
NAMES, PHONE NUMBERS, AND ADDRESSES
NSWC CRANE, CRANE, INDIANA

PERSON / TITLE / ORGANIZATION	ADDRESS	TELEPHONE
Ralph Basinski Task Order Manager Tetra Tech NUS	Tetra Tech NUS 661 Andersen Drive Pittsburgh, Pennsylvania 15220-2745	Phone: (412) 921-8308 FAX: (412) 921-4040
Terry Rojahn Field Operations Leader Tetra Tech NUS	Tetra Tech NUS 661 Andersen Drive Pittsburgh, Pennsylvania 15220-2745	Phone: (412) 921-8857 FAX: (412) 921-4040
Joseph Samchuck Data Validation Manager Tetra Tech NUS	Tetra Tech NUS 661 Andersen Drive Pittsburgh, Pennsylvania 15220-2745	Phone: (412) 921-8510 FAX: (412) 921-4040
Keith Henn Program Geologist Tetra Tech NUS	Tetra Tech NUS 661 Andersen Drive Pittsburgh, Pennsylvania 15220-2745	Phone: (412) 921-8146 FAX: (412) 921-4040
Edward Sedlmyer Project Chemist Tetra Tech NUS	Tetra Tech NUS 661 Andersen Drive Pittsburgh, Pennsylvania 15220-2745	Phone: (412) 921-8704 FAX: (412) 921-4040
Dr. Tom Johnston Quality Assurance Advisor Tetra Tech NUS	Tetra Tech NUS 661 Andersen Drive Pittsburgh, Pennsylvania 15220-2745	Phone: (412) 921-8615 FAX: (412) 921-4040
Jeff Schubert Project Geologist Tetra Tech NUS	Tetra Tech NUS 661 Andersen drive Pittsburgh, Pennsylvania 15220-2745	Phone: (412) 921-8794 FAX: (412) 921-4040
Aaron Bernhardt Ecological Risk assessor Tetra Tech NUS	Tetra Tech NUS 661 Andersen drive Pittsburgh, Pennsylvania 15220-2745	Phone: (412) 921-8433 FAX: (412) 921-4040
Tom Jackman Human Health Risk Assessor Tetra Tech NUS	Tetra Tech NUS 661 Andersen drive Pittsburgh, Pennsylvania 15220-2745	Phone: (412) 921-8724 FAX: (412) 921-4040
Anh Ho Project Manager Laucks Testing	Laucks Testing Laboratories, Inc. 940 South Harney Street Seattle, Washington 98108	Phone: (206) 957-2433 FAX: (206) 767-5063
Harry Romberg Lab QA Manager Laucks Testing	Laucks Testing Laboratories, Inc. 940 South Harney Street Seattle, Washington 98108	Phone: (206) 767-5060 FAX: (206) 767-5063
Kathy Krepps Lab Operations Manager Laucks Testing	Laucks Testing Laboratories, Inc. 940 South Harney Street Seattle, Washington 98108	Phone: (206) 767-5060 FAX: (206) 767-5063

FIGURE 2-1

PROJECT ORGANIZATION CHART
SWMUs 8 AND 15 RFI INVESTIGATION
NSWC CRANE, CRANE, INDIANA



3.0 SAMPLING AND ANALYSIS PLAN

3.1 GENERAL APPROACH

This section describes sampling locations and rationales for the Round 1 sampling activities and the equipment and procedures for all phases of the project to be used for collecting, handling, preserving, and shipping samples to the analytical laboratories. Field SOPs (included in Appendix E) and the Health and Safety plan (HASP) are referenced as applicable. Information concerning sampling rounds after Round 1, if necessary, will be added as additional chapters or addenda to this document.

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

Sampling activities at the following sites are described in this SAP:

RFIs

- SWMU 8
- SWMU 15

EI Investigations

- SWMU 18
- SWMU 19
- SWMU 20
- OGTSL

Drilling, sampling, and site characterization work at these five SWMUs and the OGTSL are described in this section.

All measurements (listed in Table 3-1) made with field instruments and visual observations will be recorded on field log sheets. Any encounters with metallic objects, other objects that indicate a potential contaminant source, discolored soil indicative of a potential chemical release, or any above-background

measurements of VOCs will be reported to the FOL and the SSO, and appropriate actions will be taken as specified in this QAPP and the HASP.

3.2 SAMPLE IDENTIFICATION SYSTEM

All samples will be properly labeled with an adhesive-backed sample label affixed to each sample container in accordance with SOP CTO331-01. The sample labels 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 name of the analytical laboratory to which the sample will be submitted.

Each collected sample will be assigned a unique sample tracking number. The sample tracking number for a soil sample is a four-segment, alphanumeric code beginning with the location identification [8, 15, 18, 19, 20 (for the SWMUs) or OGTSL (for the OGTSL)] followed by codes for the type of environmental medium, sample location, and sample depth range. Sample tracking numbers for the other media are a five-segment, alphanumeric codes identifying the SWMU, type of environmental medium, sample location, sampling round, and, as applicable, filtering indicator (for aqueous samples only). These numbering schemes are described in SOP CTO331-02. Any other pertinent information regarding sample identification will be recorded in the field logbooks and on sample log sheets.

The sampling time recorded on the COC 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 (MS) and matrix spike duplicate (MSD) samples will be designated on the field documentation and COC forms (see SOP CTO331-03).

3.3 UNEXPLODED ORDNANCE AVOIDANCE

The activities performed at the PTA Annex, SWMU 19, which included testing of explosives, were performed using good housekeeping practices. Therefore, the potential for encountering UXO is low, and proposed borings have been located in areas with the least likelihood of encountering UXO while still achieving project objectives. Specific boring locations as identified by NSWC Crane may require screening using a magnetometer or other instrument to check for the presence of UXO in accordance with the HASP. Bulk explosives are not magnetic and cannot be detected by a magnetometer. Visual

inspection will be used to detect whether bulk explosives may be present. Prior to the initiation of intrusive site activities, a meeting will be held with NSWC Crane staff to determine whether any boring locations will require UXO screening. This decision will be made by the Crane Environmental Site Manager in concert with the Crane safety staff. UXO screening is not anticipated to be conducted at SWMUs 8, 15, 18, or 20 or at the OGTSL.

If potential ordnance is encountered during investigative activities, the activities will stop and the Crane Environmental Site Manager will be notified.

3.4 SAMPLING LOCATIONS, ANALYSES, AND RATIONALES

This section presents sampling locations, QA/QC samples to be collected, analyses to be performed, and rationales for the sampling and analytical program. Details regarding the preservation, packaging, and shipping of samples are included in Section 3.7. Soil sampling locations are shown on SWMU-specific Figures 3-1 through 3-9.

If obvious soil staining is observed in any borings, the staining will be described in the boring log, and additional samples may be collected at the discretion of the FOL or site geologist to determine the nature and possibly the extent of associated site-related contamination.

3.4.1 Surface and Subsurface Soils

Surface and subsurface soil samples will be collected at SWMUs 8, 15, 18, 19, and 20 and at the OGTSL, as described in the remainder of this section. The analyses to be performed on each soil sample are listed in Table 3-2. The rationales for parameter selection are discussed in Sections 1.5.1, 1.5.2, and 1.5.3 and detailed on Tables 1-2 through 1-4.

For SWMUs 8 and 15, all samples collected from the surface soil interval (0 to 2 feet deep) will be extracted and analyzed according to the normal laboratory protocol. All subsurface samples scheduled for VOC, pH, cyanide, and TOC analyses (See Table 3-2) will also be analyzed according to the normal laboratory protocol. Some subsurface soil samples, however, will be extracted but will not be analyzed for select target chemicals until the laboratory is instructed to do so by the TtNUS TOM or his designee. The samples that fall into this category are identified in Table 3-2 with an "E&H" (extract and hold) designation.

To determine whether the E&H samples are to be analyzed, the laboratory will provide preliminary data from the non-E&H surface soil samples as soon as the analysis of those samples is completed. The preliminary data will be evaluated by TtNUS to determine which, if any, E&H samples must be analyzed and for what parameters to analyze. The determination to analyze E&H samples will be based upon the following considerations:

- Magnitude and prevalence of contamination in surface soil samples across the AOC containing the E&H samples.
- Comparison of contaminant concentrations to RBTLs listed in Table 1-5 (an exceedance of an RBTL alone does not necessitate E&H samples analysis).
- The degree to which surface soil contamination patterns and concentrations indicate that contamination may be present in subsurface soils.
- The potential for contamination in the E&H samples to serve as a source for ground water contamination.

After considering these factors, the laboratory will be instructed via facsimile or e-mail which E&H samples will be analyzed and for which parameters.

Surface and subsurface soil sampling will generally be performed using hand augering and direct push technology (DPT) soil sampling techniques regardless of sampling round. Some borings may be completed using hollow-stem auger (HSA) drilling with split-spoon sampling or other coring technology in Round 2 or subsequent rounds. All soil samples for VOC analyses will be collected with the appropriate number of Encore™ samplers immediately upon opening the hand auger bucket, or DPT sampler sleeve. Details regarding soil sampling equipment and procedures are included in Section 3.5.2 and SOP CTO331-04.

Soil QA/QC samples will be collected at frequencies listed in Table 3-3.

For the RFI investigation at SWMUs 8 and 15, Round 2 soil sampling will be performed where further delineation of the extent of contamination is necessary to achieve project objectives. Furthermore, if contamination is not bounded or sufficiently delineated by the first and second rounds of sampling, further rounds of sampling will be conducted as necessary to satisfactorily delineate the contamination.

3.4.1.1 SWMU 8

Figure 3-1 presents the soil boring locations designated for Round 1 sampling at SWMU 8 during the RFI investigation. Thirteen new soil borings (08SB001 through 08SB013) will be completed within SWMU 8, and one new soil boring (08SB014) will be collected upgradient of the SWMU (see Figure 3-1). The soil samples from these boring will be used to help determine whether contamination is present within various areas at the SWMU. Round 1 will include collecting both surface soil and subsurface soil samples. The soil samples will be analyzed as indicated in Table 3-2. Installation and sampling of ground water wells may also be required if significant contamination is found in the subsurface soils.

Building Areas

One soil boring (08SB001) will be located between Buildings 106 and 107 where a release to surface soil was know to have occurred. One soil boring (08SB002) will be located west of Building 2722 near an existing catch basin. One soil boring (08SB003) will be located near the catch basin into which the cooling water for the Building 107 compressor flows and where staining was identified. Two soil borings (08SB004 and 08SB005) will be located near the underground piping for the Buildings 106 and 107 floor drains.

These soil borings will be advanced to the bedrock-overburden interface or to refusal. Four depth intervals will be sampled in each boring as listed in Table 3-2. The first three samples will be collected from 0 to 2, 2 to 6, and 6 to 10 feet bgs. The fourth sample will be collected between the bottom of the third interval and the bedrock. The samples will be analyzed as detailed in Table 3-2.

Building 106 Pond Area

Four soil borings (08SB006 through 08SB009) will be completed around the perimeter of the Building 106 Pond (see Figure 3-1). These soil borings will be drilled at an angle directed from ground surface near the edge of the pond towards the center of the pond and advanced to the bedrock surface or to refusal. Four depth intervals will be sampled from each boring as listed in Table 3-2. The first three samples will be collected from 0 to 2, 2 to 6, and 6 to 10 feet bgs. The fourth sample will be collected midway between the bottom of the third interval and bedrock. The samples will be analyzed as detailed in Table 3-2.

Former Drum Storage Area

Four soil borings will be completed south of Building 2911 (08SB010 through 08SB013) in the former drum storage area (FDSA) (see Figure 3-1). These soil borings will be advanced to the bedrock-

overburden interface or to refusal. Four samples will be collected from each boring as listed in Table 3-2. The first three samples will be collected from 0 to 2, 2 to 6, and 6 to 10 feet bgs. The fourth sample will be collected midway between the bottom of the third interval and bedrock. The samples will be analyzed as detailed in Table 3-2.

Upgradient Area

One background soil boring (08SB014) will be completed north of SWMU 8 as shown on Figure 3-1 for analysis of geotechnical and geochemical properties. These soil borings will be advanced to the bedrock-overburden interface or to refusal. Four depth intervals will be sampled from this boring as listed in Table 3-2.

Perched Ground Water Samples

To the extent feasible, up to seven perched ground water samples will be collected at SWMU 8 and analyzed as indicated in Table 3-4. Attempts will be made to collect perched ground water samples from the bedrock-overburden interface in the areas discussed above as the Building Areas, the Building 106 Pond Area (specifically, the pond shore areas), the FDSA, and the Upgradient Area. This water is expected to represent precipitation that may have percolated through the overburden or ground water that has migrated along the bedrock-overburden interface, thus accumulating contaminants from the overburden.

A summary of the ground water samples and the associated QC samples to be collected at SWMU 8 is presented in Table 3-5.

3.4.1.2 SWMU 15

Figure 3-2 identifies the soil borings that will be completed as part of the Round 1 sampling activities at various AOCs within SWMU 15 during the RFI. A total of 49 borings (15SB001 through 15SB049) are planned. The soil samples from these borings will be used to determine whether contamination exists within various AOCs at SWMU 15. Round 1 will include the collection of both surface and subsurface soil samples. The soil samples will be analyzed as indicated in Table 3-2. Any obvious soil staining observed at any boring will be described on the boring log.

AOC A — Former Batch Plant Area

Seven soil borings (15SB001 through 15SB007) will be completed within AOC A (see Figure 3-2). These soil borings will be distributed in a grid-like pattern throughout the approximate location of the former Asphalt Batch Plant. Four borings will be located on the upper level of the former Asphalt Batch Plant, and three borings will be located on the lower level of the former Asphalt Batch Plant. Soil will be cored to a depth of 6 feet bgs, and a sample will be collected from each of two sample intervals (0 to 2 and 2 to 6 feet bgs) as listed in Table 3-2.

AOC B — Former UST and Gasoline Pump Area

Three soil borings (15SB008 through 15SB010) will be completed in AOC B (see Figure 3-2). These soil borings will be arranged in a triangular pattern throughout the approximate location of the former UST(s) and gasoline pump(s) located southwest of demolished Building 2801. Soil will be cored to a depth of 10 feet, and a sample will be collected from each of three sample intervals (0 to 2, 2 to 6, and 6 to 10 feet bgs) as listed in Table 3-2. In addition, at the discretion of the site geologist, a boring may be advanced to the bedrock-overburden interface, and a fourth subsurface soil sample may be collected from within 4 feet of the bedrock-overburden interface.

AOC C — Former AST Area Near Former Building 2801

Three soil borings (15SB011 through 15SB013) will be completed in AOC C (see Figure 3-2). These soil borings will be arranged in a triangular pattern throughout the approximate location of the former 5,000 gallon waste oil AST that was located north of demolished Building 2801. Soil will be cored to a depth of 6 feet, and a sample will be collected from each of two sample intervals (0 to 2 and 2 to 6 feet bgs) as listed in Table 3-2.

AOC D — Former Inert Storage (Building 2716)

Five soil borings (15SB014 through 15SB018) will be completed in AOC D (see Figure 3-2). These soil borings will be distributed in a grid-like pattern throughout the approximate location of the former loading dock for demolished Building 2716. Soil will be cored to a depth of 6 feet, and a sample will be collected from each of two sample intervals (0 to 2 and 2 to 6 feet bgs) as listed in Table 3-2.

AOC E — Former Wash Rack and Paint House (Building 2774)

Five soil borings (15SB019 through 15SB023) will be completed in AOC E (see Figure 3-2). These soil borings will be distributed throughout the approximate location of the demolished wash rack and Building 2774 (i.e., Paint House). Soil will be cored to a depth of 6 feet, and a sample will be collected from each of two sample intervals (0 to 2 and 2 to 6 feet bgs) as listed in Table 3-2.

AOC F — Former AST Areas (Former Buildings 2717 and 2718)

Five soil borings (15SB024 through 15SB028) will be completed in AOC F (see Figure 3-2). These soil borings will be distributed in a grid-like pattern throughout the approximate location of the former waste oil ASTs. Two ASTs were located at the northeastern corners of each of the demolished Buildings 2717 and 2718. Soil will be cored to a depth of 6 feet, and a sample will be collected from each of two sample intervals (0 to 2 and 2 to 6 feet bgs) as listed in Table 3-2.

AOC G — Hillside Debris Area South of Former Buildings 2717 and 2718

Nine soil borings (15SB029 through 15SB037) will be completed in AOC G (see Figure 3-2). These soil borings will be arranged throughout the hillside debris area south of demolished Buildings 2717 and 2718. Soil will be cored to a depth of 6 feet, and a sample will be collected from each of two sample intervals (0 to 2 and 2 to 6 feet bgs) as listed in Table 3-2.

In addition, soil boring 15SB031 will be advanced to the bedrock-overburden interface or to refusal. Four depth intervals will be sampled in each boring as listed in Table 3-2. The first three samples will be collected from 0 to 2, 2 to 6, and 6 to 10 feet bgs. The fourth sample will be collected between the bottom of the third interval and the bedrock. The samples will be analyzed as detailed in Table 3-2.

AOC H — Drainage Area Across Intermittent Stream South of Hillside Debris Area

Four soil borings (15SB038 through 15SB041) will be completed in AOC H (see Figure 3-2). These soil borings will be distributed in a grid-like pattern throughout the hillside on the southern side of the intermittent stream south of the debris area at AOC G. Soil will be cored to a depth of 6 feet, and a sample will be collected from each of two sample intervals (0 to 2 and 2 to 6 feet bgs) as listed in Table 3-2.

AOC O — Former Paint Locker

Three soil borings (15SB042 through 15SB044) will be completed in AOC O (see Figure 3-2). These soil borings will be arranged in a triangular pattern throughout the approximate location of the former paint locker. Soil will be cored to a depth of 6 feet, and a sample will be collected from each of two sample intervals (0 to 2 and 2 to 6 feet bgs) as listed in Table 3-2.

AOC U — Hillside Area Northeast of SWMU 15

Five soil borings (15SB045 through 15SB049) will be completed in AOC U (see Figure 3-2). These soil borings will be distributed in a grid-like pattern in the area of the hillside located east of the SWMU and extending to the tree line. Soil will be cored to a depth of 2 feet, and one surface soil sample will be collected from each boring (0 to 2 feet bgs) location as listed in Table 3-2.

In addition, soil borings 15SB045, 15SB046, and 15SB048 will be advanced to the bedrock-overburden interface or to refusal. Four depth intervals will be sampled in each boring as listed in Table 3-2. The first three samples will be collected form 0 to 2, 2 to 6, and 6 to 10 feet bgs. The fourth sample will be collected between the bottom of the third interval and the bedrock. The samples will be analyzed as detailed in Table 3-2.

AOC W — Landfill South of the Salt Dome

Twelve soil borings (15SB050 through 15SB061) will be completed within AOC W (see Figure 3-2). These borings will be distributed throughout the approximate location of the landfill in a 4 by 3 grid pattern.

Prior to commencement of the soil borings, the field crew will visually survey the site to determine if surface features indicate the potential landfill activities (i.e., mounted surface soil, sunken surface soil, etc.). Observations of potential landfill activities will be reported to the TOM. Based upon these observations and the field crew recommendation, soil borings may be relocated to suspected areas where landfill activities may have occurred.

Each soil boring will be initially cored to a depth of 6 foot bgs or refusal. Refusal within the 6-foot depth will be noted in the log. When debris is encountered within the 6 foot core, the following action will be taken:

- The boring will be cored to bedrock or refusal.

- Two samples will be taken from the core. The first sample will be collected from the 0- to 6-foot bgs coring; the second sample will be collected from the 6-foot to bedrock coring as listed in Table 3-2.

- Where ground water is present, one perched ground water sample will be collected from the coring immediately above the bedrock as listed in Table 3-4.

If no debris is encountered in the boring hole, no soil samples will be collected or analyzed.

Perched Ground Water Samples

If perched ground water is sufficient for sample collection in a boring drilled to the bedrock-overburden interface, a perched ground water sample will be collected at the interface.

It is anticipated that perched ground water samples will be obtained at the following borings along the intermittent streams and elsewhere; 15SB002, 15SB036, 15SB037, 15SB47, and 15SB49. As many as 24 samples (two in AOC A, one in AOC B, nine across AOCs G, H, and U, and 12 in AOC W) may be collected and analyzed as indicated in Table 3-4. Aside from the specific locations identified above, additional locations may be selected based on field judgment.

A summary of the ground water samples and the associated QC samples to be collected for SWMU 15 is presented in Table 3-5.

3.4.1.3 SWMU 18

The 1983 IAS and the 1987 Preliminary Review/Visual Site Inspection Reports indicate that Buildings 104, 105, 198, and 200 were the primary locations where activities took place at SWMU 18; therefore, the maximum potential for worker exposure will occur at areas near these buildings (NEESA, 1983, A.T. Kearney, 1987).

Sampling locations at SWMU 18 Buildings 104, 105, 198, and 200 were chosen based upon a February 23, 2004 site tour by NSWC Crane and TtNUS representative, the 1983 IAS, the 1987 Preliminary Review/Visual Site Inspection Report, and deposition patterns.

Figures 3-3 through 3-6 present the surface soil locations for sampling to provide information for completion of the EI Form for Human Health (worker exposures) for surface soil at SWMU 18. The surface soil samples will be analyzed as indicated in Table 3-2.

Building 104 Area

Seven surface soil samples (18SS001 through 18SS007) will be collected around the area of Building 104 (see Figure 3-3). These surface soil samples will be collected at a depth of 0 to 2 feet bgs as listed in Table 3-2.

Soil sample 18SS001 will be collected west of the culvert between the second and third railroad tracks along the northwestern side of Building 104. Soil sample 18SS002 will be collected at the corner of the fence located east of the gate (not visible on Figure 3-3). Soil sample 18SS003 will be collected in the area of bare ground east of the substation, with an alternative location in the exposed gravel area southeast and across the road from Building 104. Soil sample 18SS004 will be collected on the berm near the southwestern corner of Building 104 on an area of higher elevation. Soil sample 18SS005 will be collected downgradient of the sump located south of Building 104 and southwest of the substation. Soil sample 18SS006 will be collected in the area near the electric box southwest of the sump and soil sample 18SS005. Soil sample 18SS007 will be collected from a low grassy area located near the southwestern corner of Building 104 in a berm area.

Building 105 Area

Five surface soil samples (18SS008 through 18SS012) will be collected around the area of Building 105 (see Figure 3-4). These surface soil samples will be collected at a depth of 0 to 2 feet bgs as listed in Table 3-2.

Soil sample 08SS008 will be collected from the drainage ditch located on the western side of Building 105. Soil sample 18SS009 will be located at the drainage ditch located on the western side of Building 184. Soil sample 18SS010 will be collected adjacent to the culvert located across the road and northeast of Building 2518. Soil sample 18SS011 will be collected along the top of the berm located on the northeastern side of Building 105 in alignment with building roof vent. Soil sample 18SS012 will be collected in the drainage ditch located near the southwestern corner of Building 105 and along the southern side of the railroad tracks (R-15) that run parallel to the building.

Building 198 Area

Four surface soil samples (18SS013 through 18SS016) will be collected around the area of Building 198 (see Figure 3-5). These surface soil samples will be collected at a depth of 0 to 2 feet bgs as listed in Table 3-2.

Soil sample 18SS013 will be collected in the area near the sump located between the substation and Building 2551. Soil sample 18SS014 will be collected in the low lying area in alignment with the air conditioning unit located northeast of Building 198. Soil sample 18SS015 will be located in the wet low area located southeast of Building 198. Soil sample 18SS016 will be located in the wet low area located southwest of the sump in the general area south of Building 2508.

Building 200 Area

Five surface soil samples (18SS017 through 18SS021) will be collected around the area of Building 200 (see Figure 3-6). These surface soil samples will be collected at a depth of 0 to 2 feet bgs as listed in Table 3-2.

Soil sample 18SS017 will be located near the culvert situated inside the fence and east of Building 2504. Soil sample 18SS018 will be located near the culvert situated just inside the fence and southeast of Building 200. Soil sample 18SS019 will be located near the catch basin south of Building 200. Soil sample 18SS020 will be located near the culvert inside the fence and southwest of Building 200. Soil sample 18SS021 will be located near the culvert west of Building 200 and between the railroad tracks.

3.4.1.4 SWMU 19

On February 23, 2004 a visit was conducted at SWMU 19 to review site/building operations, release records, and identification of locations with the greatest likelihood of receiving release materials and where the maximum worker exposure would occur. Surface soil sampling locations at SWMU 19 were based upon the information obtained at this site visit.

Figure 3-7 presents the surface soil locations for sampling to provide information for completion of the EI Form for Human Health (worker exposures) for surface soil at SWMU 19. These surface soil samples will be collected at a depth of 0 to 2 feet bgs and analyzed as listed in Table 3-2.

Sample location numbers correspond to sample locations from the October 2003 Draft QAPP for SWMUs 12, 13, 16, and 19 (TtNUS, 2003). Each of the sampling locations was selected to detect contamination if present. Thus, if any features exist that indicate a potential for contamination in the soil, the sample locations should be moved to coincide with the location of potential contamination.

OTA

Six surface soil samples (19SS003, 19SS007, 19SS013, 19SS026, 19SS041, and 19SS070) will be collected in the OTA. These surface soil samples will be collected at a depth of 0 to 2 feet bgs as listed in Table 3-2.

Surface soil sample 19SS003 will be located in a sand trap area that was the leading area for the rocket range in the Super Mapi Towers, Bullet Impact Area. Surface soils sample 19SS007 will be located adjacent to the saltwater wave tank used to test underwater signal flares in the Fast Cook-Off, Hazardous Class IAW Area. Sample 19SS013 will be located on the east-central side of Firing Site A. Surface soil sample 19SS026 will be located on the east-central side of the Practice Bomb Signals Area approximately 110 feet west of Building 2963. Surface soil sample 19SS041 will be located near the northeast edge of the Warhead Arena, Hazardous Class IAW. 19SS070 will be located centrally within the Photoflash Cartridges Area between the wetlands area and the roadway in the Photoflash Cartridges Area.

PTA Annex

Two surface soil samples (19SS047 and 19SS049) will be collected at the PTA Annex. Surface soil sample 19SS047 will be located approximately 60 feet northwest of Building 2923. Surface soil sample 19SS049 will be located approximately 80 feet southwest of Building 2923.

Rocket Range

Two surface soil samples (19SS061 and 19SS064) will be collected at the PTA Rocket Range. Surface soil sample 19SS061 will be located along the southwestern corner of Building 2125. Surface soil sample 19SS064 will be located north of the roadway approximately 100 feet south of Building 2125.

3.4.1.5 SWMU 20

On February 23, 2004 a visit was conducted at SWMU 20 to review site/building operations, release records, and identification of locations wit the greatest likelihood of receiving release materials and where the maximum worker exposure would occur. Surface soil sampling locations at SWMU 20 were based upon the information obtained at this site visit.

Figure 3-8 presents the surface soil locations for sampling to provide information for completion of the EI Form for Human Health (worker exposures) for surface soil at SWMU 20. These surface soil samples will be collected at a depth of 0 to 2 feet bgs and analyzed as listed in Table 3-2.

Vicinity of Building 2167

Five surface soil samples (20SS001 through 20SS005) will be collected in the general vicinity of Building 2167. These surface soil samples will be collected at a depth of 0 to 2 feet bgs as listed in Table 3-2.

Vicinity of Building 3182

Two surface soil samples will be collected around Building 3182, one along the eastern side (20SS001) and the other along the western side (20SS002) of the building. One surface soil sample will be collected approximately 75 feet east of Building 3182 (20SS003). The remaining two samples will be collected near the fence line, one southwest (20SS004) of Building 3182 and the other sample southeast (20SS005) of Building 3182.

3.4.1.6 OGTSL

On February 23, 2004 a visit was conducted at the OGTSL to review site/building operations, release records, and identification of locations with the greatest likelihood of receiving release materials and where the maximum worker exposure would occur. Surface soil sampling locations at the OGSTL were based upon the information obtained at this site visit.

Figure 3-9 presents the surface soil locations for sampling to provide information for completion of the EI Form for Human Health (worker exposures) for surface soil at the OGTSL. These surface soil samples will be collected at a depth of 0 to 2 feet bgs and analyzed as listed in Table 3-2.

OGTSL Parking Area

Five surface soil samples (OGTSLSS001 through OGTSLSS005) will be collected in the parking area in a grid-like pattern as shown on Figure 3-9.

3.4.1.7 Background Samples

The local geology at a particular SWMU may differ from the background areas that were previously identified, sampled, and analyzed to establish representative metals concentrations (TtNUS, 2001). For example, the lower Pennsylvanian bedrock (and associated residual soil) may consist locally of thin black shale, carbonaceous shale, and coal beds. These localized beds may contain elevated concentrations of naturally occurring inorganics (e.g., chromium, arsenic). As a result, residual soil in these localized geological environments may have abnormally high background concentrations for certain inorganics. In these instances, it may be appropriate to collect SWMU-specific background soil samples. The site geologist will note any localized geologic environment, similar to those listed above, that is unique to a specific SWMU and will notify the TOM to determine whether SWMU-specific background samples are warranted. IDEM will be consulted for concurrence in the event that SWMU-specific background soil samples are recommended for collection.

3.4.2 Ground Water

RFI

Perched ground water samples will be collected at SWMUs 8 and 15 during Round 1 at soil borings where ground water is encountered bedrock-overburden interface and for which the perched ground water flow is sufficient for collecting a sample as discussed in Sections 3.4.1.1 and 3.4.1.2. The need to install ground water monitoring wells will be evaluated based upon analysis of the Round 1 soil and perched ground water sampling results as well as the fate and transport properties of detected contaminants. In future sampling rounds, ground water sampling wells will be located in areas where subsurface soil contamination concentrations indicate the potential for ground water contamination.

Should soil contamination not be sufficiently bounded by the first and second round of sampling, further work will be conducted as necessary to define the extent of contamination.

A maximum of seven perched ground water samples will be collected at SWMU 8, and a maximum of 12 perched ground water samples will be collected at SWMU 15.

SWMU 8

Perched ground water samples will be collected within SWMU 8 as detailed in Section 3.4.1.1.

SWMU 15

Perched ground water samples will be collected within SWMU 15 as detailed in Section 3.4.1.2.

Environmental Indicator Investigation

SWMU 18, 19, and 20 and the OGTSL

No ground water samples will be collected in association with the EI Investigation for SWMUs 18, 19, and 20 or the OGTSL.

3.4.3 Surface Water and Sediment

RFI

For the RFI investigation at SWMUs 8 and 15, Round 1 surface water and sediment samples will be collected from intermittent streams as indicated in Table 3-6. Up to two rounds of surface water samples will be collected from the intermittent streams where water flow is sufficient for collecting a sample. One round will be collected during basic flow conditions, the second round will be colleted during storm flow conditions.

Additional sampling rounds will also be performed for surface water and sediment where further delineation of the extent of contamination is needed.

Furthermore, if surface water and/or sediment contamination is not sufficiently bounded by the first and second rounds of sampling, further rounds of sampling will be conducted as necessary to define the extent of contamination.

Summaries of the surface water and sediment samples to be collected and the associated QC samples are presented in Tables 3-7 and 3-8, respectively.

SWMU 8

Figure 3-1 presents the surface water and sediment sampling locations for SWMU 8. Two rounds of surface water samples and one round of sediment samples will be collected from within the SWMU. The four surface water and sediment samples will be collected at locations 08SW/SD002, 08SW/SD003, 08SW/SD004, and 08SW/SD005.

Two rounds of surface water and one round of sediment samples will be collected upgradient and downgradient of the SWMU. The upgradient surface water and sediment samples will be collected at 08SW/SD001, and the downgradient surface water and sediment samples will be collected at locations 08SW/SD006, 08SW/SD007, 08SW/SD008, and 08SW/SD009.

SWMU 15

Figure 3-2 presents the surface water and sediment sampling locations for the various AOCs within SWMU 15. Sampling locations were grouped into AOCs so that multiple drainage channel samples could be classified in a limited number of AOCs with similar characteristics, locations, and influences from SWMU operations.

Although each surface water/sediment sampling location is designated with "SW/SD" in the location identifier, storm sewer samples have "ST" in the sample number, and surface water drainage samples have "SW" in the sample number.

AOC I — Drainage Channels Downgradient of Source Areas

Two rounds of downgradient surface water samples and one round of sediment samples (at locations15SW/SD001 and 15SW/SD002) will be collected.

AOC J — Areas Upgradient of Sources

Two rounds of upgradient storm sewer water samples and one round of sediment samples (at location 15SW/SD003) will be collected.

AOC K — Catch Basin West of Roadway Along West Side of Building 3330

Two rounds of upgradient storm sewer water samples and one round of sediment samples (at location 15SW/SD004) will be collected.

AOC L — Drainageway South of Former Asphalt Batch Plant

Two rounds of downgradient storm sewer water samples and one round of sediment samples (at location 15SW/SD005) will be collected.

AOC M — Drainageways Along the Southern Area of the SWMU

Two rounds of storm sewer samples and one round of sediment samples will be collected at one location (15SW/SD006). Two rounds of surface water samples and one round of sediment samples will be collected at three locations (15SW/SD015, 15SW/SD016, and 15SW/SD017).

AOC N — Catch Basin South of Former Asphalt Batch Plant

Two rounds of storm sewer water samples and one round of sediment samples (at location 15SW/SD007) will be collected.

AOCs P, Q, R, S, T, U, and V — Catch Basin Associated with SWMU 15

Two rounds of storm sewer water samples and one round of sediment samples (at locations 15SW/SD008, 15SW/SD009, and 15SW/SD010) will be collected at AOCs P, Q, and R, respectively.

Two rounds of upgradient storm sewer water samples and one round of upgradient sediment samples (at locations 15SW/SD011 and 15SW/SD012) will be collected at AOCs S and T, respectively. Two rounds of upgradient surface water samples and one round of upgradient sediment samples (at location 15SW/SD014) will be collected at AOC V. Two rounds of upgradient surface water samples and one round of upgradient sediment samples (15SW/SD013) will be collected at AOC U.

AOC W — Landfill South of the Salt Dome

Two rounds of surface water samples and one round of sediment samples (at locations 15SW/SD018 and 05SW/SD019) will be collected.

Environmental Indicator Investigations

<u>SWMUs 18, 19, and 20 and the OGTSL</u>

No surface water or sediment samples will be collected in association with the EI Investigations for SWMUs 18, 19, and 20 or the OGTSL.

3.5 INVESTIGATION EQUIPMENT AND PROCEDURES

3.5.1 UXO Screening of Selected Drilling Sites

Because of the prior uses of the areas to be investigated, there is a very small possibility that UXO could be encountered during field operations at SWMU 19. UXO clearance of drilling sites or other sites where intrusive activities are planned at SWMU 19 will **not** be performed unless specific direction to do so is received from NSWC Crane. If this situation occurs, the activities at the specified location(s) will be conducted in a manner consistent with the UXO procedures discussed in the HASP. In addition, all UXO procedures and borehole clearance activities will be documented in the site logbook.

3.5.2 DPT Sampling for Surface and Subsurface Soil

DPT (e.g., Geoprobe®) will generally be used to collect surface and subsurface soil samples from the unconsolidated overburden. The procedure for soil sampling using DPT is included in SOP CTO331-04. A new acetate liner will be used for each 2- or 4-foot section of soil core. Each removed soil core will be scanned for VOCs (see SOP CTO331-06). The soil core will be visually inspected and logged by the field geologist (see SOP CTO331-07), and the soil texture, grain size (sand, silt, or clay), color (and any unusual discoloration), moisture content, and soil type will be identified by the field geologist. Soil types will be based on the Unified Soil Classification System (USCS). When DPT is not used for sampling, hand augering will be used. Auger holes will be advanced in accordance with SOP CTO331-04.

For samples requiring VOC analysis, the VOC sample will be collected from the point along the soil core that had the greatest PID reading using the required number of Encore™ samplers (see SOP CTO331-08). If no PID readings are greater than background, the VOC sample will be collected from any discolored area of the soil or from the midpoint of the core. However, VOC aliquots will be confined to depths of 0.5 to 2.0 feet bgs in the case of surface soil samples. The Encore™ samples will be collected from each core immediately after PID readings are collected. After the sample for VOC analysis has been collected, the remaining aliquot will be placed in a decontaminated stainless-steel mixing bowl or dedicated disposable plastic bag, rocks, gravel, and other coarse debris will be removed, and the sample will be mixed using a decontaminated stainless-steel spoon or dedicated disposable towel. The appropriate sample jars for remaining analyses will then be filled and properly labeled. The bowl and spoon if employed will be decontaminated between each sample. Details regarding the collection and labeling of soil samples are included in SOP CTO331-01.

Up to three subsurface soil samples will be collected from each soil boring. Soil sample analytical information is presented in Table 3-2, and appropriate containers to be used for each sample aliquot are

listed in Table 3-9. After the samples are containerized, labeled, and bagged (see SOPs CTO331-01 and CTO331-03), they will be placed in a cooler containing ice until they can be packaged and prepared for shipment (Section 3.7).

For each cooler containing soil samples identified for VOC analysis (i.e., Encore™ samplers), a trip blank will also be stored in the cooler and will continuously accompany the VOC samples until they have been analyzed. As samples are added to a cooler, the COC form will be updated to include each new sample (per SOP CTO331-03).

One duplicate soil sample will be collected for every 20 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 PID readings). The duplicate samples will be placed in the same types of containers and handled in the same manner as the regular soil samples. The duplicate samples will be given unique QC sample identifications (see SOP CTO331-02). Rinsate blanks will be collected as indicated on Table 3-3. For soil samples, the rinsate blank will consist of distilled water allowed to flow over dedicated or decontaminated equipment. This process will continue until all the necessary bottles are filled for the rinsate sample.

Soil borings will be backfilled with either the soil cuttings (if visually uncontaminated) or bentonite pellets (if visually contaminated) in accordance with Section 3.11.

When a boring has been sampled and backfilled, it will be identified by a tall wooden lath driven into the soil near the boring. The stake will have brightly colored flagging attached to it to increase visibility and will be labeled using a waterproof marker with a unique soil boring number corresponding to the boring log. This will be done so that the sampling location can be located for surveying.

3.5.3 Well Drilling and Installation

The number of new monitoring wells to be installed at SWMUs 8 and 15 will be developed as part of the Round 2 portion of this RFI. It is anticipated that all new wells installed at SWMUs 8 and 15 will be installed in bedrock. 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. The bedrock holes will be cored using a rotary rig with coring capabilities. Procedures for drilling and logging a boring in rock are included in SOP CTO331-11. The holes will be a minimum diameter of 5 inches prior to well installation activities. The rates of water produced during drilling will be carefully

observed to identify zones that might be fractured and have above-average permeability characteristics. Drilling standby may be required to monitor for the presence of ground water.

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 slotted screen (see SOP CTO331-12). In each well, the screen will be 10 feet long and have a slot size of 0.02 inch (factory slotted). All riser pipe and screen sections will be new and certified clean. Each well will consist of slotted screen and enough solid riser pipe so that the riser will extend approximately 2.5 feet above the ground surface.

A sand filter pack, bentonite seal, and cement-bentonite grout will be placed around the annulus of the well screen, from the bottom of the hole upward, according to SOP CTO331-12. An outer, 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, 4- by 4-foot concrete surface pad will be constructed around the well at the ground surface. In addition, four barrier posts will be installed just off the corners of 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 CTO331-12.

3.5.4 Well Development

All new monitoring wells will be developed in accordance with SOP CTO331-10 to remove fine sediment from inside and around the well screens. The method used to perform well development can be either a vigorous on-and-off pumping or a surge block and pumping, depending on which technique is most effective. Field measurements of pH, specific conductance, temperature, and turbidity will be collected at 5- to 10-minute intervals from the water retrieved from the well, in accordance with SOP CTO331-13. Well development will continue until the well water is clear to the unaided eye and until three subsequent consecutive readings of pH, specific conductance, and temperature are within 10 percent of each other and three consecutive turbidity readings are within 5 nephelometric turbidity units (NTUs) of each other. If the water-quality parameter criteria cannot be met after five well volumes of water have been removed, 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) and discharged into a designated man-hole for treatment at the NSWC Crane water treatment facility (see SOP CTO331-14).

3.5.5 Water-Quality Field Measurements

Temperature, pH, oxidation reduction potential (ORP), dissolved oxygen (DO), specific conductance, and turbidity will be measured for every aqueous sample collected, including all ground water, surface water, and storm water samples. Field measurements of water-quality parameters will be collected from ground water in a flow-through cell attached to the pump discharge line. These measurements, except for DO and ORP will be performed during well development (Section 3.5.4), and all of these measurements will be performed during low-flow well sampling (Section 3.5.6). 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 CTO331-14. These same field water-quality parameters will be measured for each surface water and storm water sample using procedures described in SOP CTO331-19.

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 in field notebooks, as appropriate.

3.5.6 Low-Flow Sampling of Monitoring Wells

During Round 1, ground water samples may be collected while coring and sampling of overburden soils. If ground water is perched on the bedrock surface and flows into a soil boring (i.e., Geoprobe® or hand auger boring), then a "perched" ground water sample will be collected. Perched ground water is water that has percolated down through overburden and accumulated on the bedrock surface. This often occurs because the permeability of the uppermost bedrock is less than the permeability of the lowermost overburden. This type of sample, if contaminated, indicates that contaminants have leached from the soils directly above and/or contaminants have leached from soils farther up the bedrock surface (usually uphill of the sampling point). Thus, this type of ground water sample can be a good indicator of where contaminant sources might currently exist in the overburden soils. Up to seven perched ground water samples will be collected at SWMU 8 and up to nine perched ground water samples will be collected at SWMU 15 during the Round 1 sampling event. The information and analytical results from these samples plus the soil samples will be used to help select drilling locations for monitoring well installation during Round 2 and later rounds. No monitoring wells will be installed or sampled during Round 1. The specific

procedures for collecting a perched ground water sample from overburden soil are included in SOP CTO331-05.

Low-flow sampling procedures will be used to collect ground water samples from new wells and temporary wells (see SOP CTO331-05 and -16). If the depth to ground water is greater than 25 feet, a compressed air bladder pump will be used to slowly pump ground water from the well at about 100 milliliters per minute. If the depth to ground water is less than 25 feet, a peristaltic pump may be used. Low-flow pumping will proceed until readings of temperature, pH, specific conductance, DO, ORP, and turbidity stabilize but for no longer than 4 hours (for permanent wells only). See SOP CTO331-16 for criteria for well stabilization. Appropriate sample bottles will be filled directly from the pump discharge tube. The bottles will be properly labeled, bagged, and placed in an ice-filled cooler as quickly as possible (see SOPs CTO331-01 and CTO331-03). A ground water data log sheet will be completed for each ground water sample collected (see SOP CTO331-05).

To the extent that is practical the wells will be sampled in order of those expected to be least contaminated to those expected to be most contaminated, starting with the upgradient wells, proceeding to the far downgradient wells, and finishing with the source wells. This approach will lessen the possibility of cross contamination between wells. After each ground water sample is collected, the pump will be decontaminated (SOP CTO331-17). Rinsate blanks will be collected from each type of sample device or equipment (e.g., tubing, etc.) to ensure that decontamination of the pump 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 3-10.

For each cooler containing ground water samples identified for VOC analysis, a trip blank will 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 COC form should be updated to include each new sample container (see SOP CTO331-03).

3.5.7 Ground Water-Level Measurements

During subsequent sampling rounds, one synoptic round of water-level measurements and total well depth soundings will be obtained at each of the new monitoring wells (if installed) at SWMUs 8 and 15. All water-level measurements at a single SWMU will be taken within an 8-hour period using an electronic water-level meter. Water-level elevations will be recorded to within 0.01-foot accuracy from a marked reference point on the well riser pipe. Detailed procedures regarding water-level measurements are

included in SOP CTO331-18. Water levels will be recorded on a TtNUS water-level form. A blank water-level form is provided in SOP CTO331-18 for reference purposes. The water-level meter will be decontaminated between each well; decontamination procedures are addressed in SOP CTO331-17.

3.5.8 Surface Water Sampling

A total of 52 surface water samples (24 drainage ditch and 28 storm sewer samples) will be collected as grab samples from SWMUs 8 and 15 in accordance with SOP CTO331-19. It will be assumed that the water flowing at the sample locations is thoroughly mixed. 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 disturbing bottom sediment, a decontaminated shovel will be used to dig a depression (i.e., a small pool) about 2 feet deep in which the water can accumulate and pass through. After suspended sediment in the pool has settled out or is carried downstream, the unfiltered surface water sample, one sample per pool, will be collected. A filtered water sample will also be collected at each sampling location for dissolved metals analysis (see SOP CTO331-19). The bottles will be properly labeled (see SOP CTO331-01), bagged, and placed in an ice-filled cooler.

If no water is present at a sampling location or if the water present is not perceptibly flowing, a surface water sample will not be collected from the location.

If water is pooled in a drainage gulley and a small flow rate of water is observed entering the pool, a surface water sample may be collected from the pool.

Field water-quality measurements (temperature, pH, ORP, DO, specific conductance, and turbidity) will be made at each surface water sampling location immediately after a sample has been collected. These data will be recorded on the surface water sample collection log sheet.

3.5.9 Sediment Sampling

A total of 24 sediment samples will be collected as grab samples from SWMUs 8 and 15, in accordance with SOP CTO331-20. Sampling locations for sediment will be adjusted to positions along stream channels and gullies where surface water is visibly flowing, if possible. At these locations, sediment samples will be collected from beneath the water surface at the water's edge. If water is not visibly present, then the sediment sample will be collected from an area of deposition where the finest sediment is present and where the sediment is moist or wet. VOC samples will be collected with as little disturbance of the sediment as possible (i.e., will not be stirred or homogenized) and with a minimum

exposure to the air. EnCore™ samplers will be used unless the sediment is too fluid for using EnCore™ samplers, in which case glass jars will be used. The appropriate sample jars for other parameters (Table 3-10) will then be filled directly from the sediment surface using disposable plastic spoons or trowels. Sample materials will be collected from 0 to 6 inches beneath the sediment surface.

A 2- by 2-inch wooden stake with attached flagging material will be driven into each sediment sampling location, and the sample identification number will be marked on the stake with a black waterproof marker. Alternatively, stakes may be driven into the stream 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 re-sampling purposes.

In addition, for SWMU 8, two sediment samples (08SD004 and 08SD005) will be collected from the bottom of the Building 106 Pond in accordance with SOP CTO331-25. Sampling locations for sediment will be adjusted to positions along pond bottom as to necessitate safe sampling. To ensure that these sediment samples will be collected from beneath the leaf and other organic material buildup, three depth intervals will be sampled in each boring as listed in Table 3 2. The samples will be collected from 0 to 6, 6 to 12, and 12 to 18 inches beneath the pond sediment surface. The samples will be analyzed as detailed in Table 3-2. Field modification to these intervals may be made if it is determined that collection of sediment at deeper depths is necessary to obtain samples that do not contain significant leaves or organic litter.

VOC samples will be collected with as little disturbance of the sediment as possible (i.e., will not be stirred or homogenized) and with a minimum exposure to the air. EnCore™ samplers will be used unless the sediment is too fluid for using EnCore™ samplers, in which case glass jars will be used. The appropriate sample jars for other parameters (Table 3-10) will then be filled directly from the sediment surface using disposable plastic spoons or trowels.

3.5.10 Staff Gauge Installation and Estimation of Stream Flow

Up to eight staff gauges per SWMU will be installed at surface water/sediment sampling locations at SWMUs 8 and 15. The locations of these gauges will be discretionary and will be determined by field sampling personnel at the time that surface water and sediment samples are collected. Existing permanent structures such as culverts and bridge abutments from which measurements to the water surface can be taken will be used as staff gauges whenever possible. A mark will be placed on these permanent structures denoting the point where measurements will be taken, and the staff gauge number will be noted. If a permanent structure is not available, the staff gauge will consist of a metal pipe

pounded into the sediment with a sledgehammer. The measurements will be taken with a weighted tape measure in reference to the established measuring point on the permanent structure denoting the measurement point. Where there are no permanent structures, a permanent steel stake will be driven a minimum of 2 feet into the ground for a reference marker. All staff gauges will be measured at the same time as water levels in monitoring wells. Staff gauges and monitoring well water levels will be measured once during the field effort described in this QAPP.

The approximate flow rate of surface water at each surface water sampling and staff gauge location will be estimated at the time when the water samples are collected. These estimates will be approximate and will be accomplished by measuring the cross-sectional width of the flowing water, the average depth of the flowing water, and the approximate water velocity, in accordance with SOP CTO331-21. The information will be used to evaluate surface water flow in relation to each site's drainage system and to help evaluate potential impacts to downstream water bodies (e.g., Boggs and Turkey Creeks).

3.5.11 Aquifer Testing

Because well installation is not planned for Round 1, aquifer testing is not scheduled for Round 1. If wells are installed during subsequent rounds, aquifer testing may be performed. This will be documented in the Round 2 sampling plan. Both rising- and falling-head tests will be performed in wells with submerged well screens; only rising-head tests will be performed in wells for which the screened interval intersects the water table. The slug tests will be performed in accordance with SOP CTO331-22.

3.6 QUALITY CONTROL SAMPLES

This section focuses on field QC samples that will be collected as part of this environmental investigation, including field duplicates, source water blanks, equipment rinsate blanks, and trip blanks. Tables 3-3, 3-5, 3-7, and 3-8 present the types and numbers of required field QC samples to be collected for soil, ground water, and surface water and sediment sampling activities, respectively, during the field investigation. Table 3-11 provides an overview of QC sample collection and analysis frequencies and corrective measures to be taken when the QC results are not within expectations. Section 7.0 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 20 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, odor, or analytical data) indicates that contamination is likely to be present in the environmental sample.

Equipment Rinsate Blanks. Equipment rinsate blanks (or 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 surface and subsurface soil sampling activities, rinsate blanks will be collected by running analyte-free water over the decontaminated stainless-steel bowl and spoon used to mix soil before it is placed in sample jars. For ground water samples, analyte-free water will be pumped through a decontaminated pump and tubing 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 new disposable towels 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 blanks 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 will be stored in a sealed container until they are needed. During sampling activities, one trip blank, consisting of two vials, will be placed in each cooler that contains environmental samples destined for VOC analysis. The trip blank will be properly labeled and added to the COC form for the cooler. Trip blanks are only analyzed for VOCs.

3.7 SAMPLE HANDLING, PACKAGING, AND SHIPPING

3.7.1 Sample Preservation

Preservation requirements for each of the parameters of interest are provided in Tables 3-9 and 3-10. All soil and sediment samples are to be cooled to 4°C ± 2°C; no chemical preservatives are necessary. Sample bottles for aqueous samples will contain the proper amounts and types of preservatives before they are shipped to NSWC Crane (Table 3-10). 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.

3.7.2 Sample Labeling

Before samples are packaged, the sample labels will be checked to ensure that all information on the labels is complete and correct (see SOP CTO331-01) and that it matches the information on the sample collection log sheets and the COC form.

3.7.3 Sample Packaging

Each sample container will be placed in a zip-lock bag to prevent cross-contamination and leakage. Each zip-lock bag will be placed in a bubble-wrap sleeve to prevent 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 and around 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 COC document will be signed, placed in a sealed plastic envelope, and taped to the inside lid of the shipping container (see SOP CTO331-03).

SOP CTO331-01 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
- COC forms
- Custody seals for coolers
- Shipping labels for coolers
- Express mail air bills

3.7.4 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 CTO331-01 and -03).

Shipment will be made by a public courier at the next scheduled pickup following completion of sample collection. Copies of the 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.

3.7.5 Sample Custody

Custody of samples must be maintained and documented at all times, in accordance with SOP CTO331-03, beginning with the collection of samples in the field. Sample custody procedures are addressed in Section 4.0.

3.8 RECORD KEEPING

Standard forms, field notebooks, and a field logbook will be used to record all sample collection activities, field measurements, observations concerning site conditions, and other project-related information. Additional field 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 CTO331-03.

3.8.1 Field Log Books

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

3.8.2 Drilling and Well Completion Logs

A drilling log will be completed for every boring drilled during these field activities. A geologist will complete the drilling log, which will include information regarding date, time, personnel present, drilling and sampling equipment, geologic materials encountered, fracture locations and frequency (where appropriate), water yields, color, texture, odors, and readings made with the screening instrument(s) (see SOPs CTO331-07 and CTO331-11).

A well completion log will be completed for every monitoring well constructed. These logs will include information concerning the date, times of events, quantities of construction materials used, lengths, depths, and diameters of riser pipe and well screen placed in the well, and other information, as described in SOP CTO331-12.

3.8.3 Well Development Log Sheets

During the development of each monitoring well, the date, times 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 CTO331-10.

3.8.4 Equipment Calibration Logs

An equipment calibration log sheet will be used to record each time an instrument is calibrated, recalibrated, or checked against a standard or background. The procedures and standards to be used for instrument calibration are discussed in Section 5.1 and SOPs CTO331-06 and CTO331-14.

3.8.5 Sample Collection Logs

All sample log sheets will be completed in accordance with SOP CTO331-03.

3.8.6 Chain-of-Custody Forms

A COC 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 (see SOP CTO331-03). The completed field COC document will be signed, placed in a sealed plastic envelope, and taped to the top

inside lid of the shipping container before it is shipped. A copy of the COC document will be retained by the FOL.

3.8.7 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.

3.8.8 Permanent Record File

At the completion of the field activities, the FOL will 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 the forms and log sheets listed above. The FOL will check these records for legibility and completeness before submitting them to the TOM. These forms, data, and field notes will become part of the permanent project record.

3.9 SURVEYING

The location of every soil boring and surface water and sediment sample location will be marked with a wooden stake and flagging, and a boring hole number or sample ID will be marked on the stake.

The horizontal locations and vertical elevations of all new monitoring wells, soil borings, surface water and sediment sampling locations, and staff gauges will be surveyed. Horizontal locations will be surveyed to the Indiana State Plane Coordinates System within the nearest foot and referenced to the 1983 NAD 83. The vertical elevations of the ground surface and tops of casing for wells, the tops of the staff gauges, and the ground surface for the borings and surface water and sediment sampling locations will be measured to the nearest 0.01 foot and referenced to the North American Vertical Datum (NAVD) of 1988.

3.10 EQUIPMENT DECONTAMINATION

All equipment used to collect soil and ground water samples will be decontaminated in accordance with SOP CTO331-17.

3.11 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/sleeves
- Well development and purge fluids
- Equipment decontamination fluids
- Waste cuttings from soil boring activities

IDW will be handled as described in SOP CTO331-15.

3.12 SAFETY

The health and safety activities described in the following sections will ensure that field activities are performed at a high level of safety.

3.12.1 Health and Safety Plan

A separate HASP has been prepared that describes specific health and safety requirements, concerns, and information related to the site activities. This document will 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.

3.12.2 Health and Safety Training

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

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

3.12.3 Medical Approval and Personal Protective Clothing and Equipment

Workers at the site must be part of a medical monitoring program and must 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.

3.12.4 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.

3.13 ORGANIZATION AND LOGISTICS OF FIELD INVESTIGATIONS

3.13.1 Personnel

The duties, responsibilities, and lines 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 will be intimately familiar with their roles and responsibilities. In addition, they will 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 2.3.3).

3.13.2 Subcontractors

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

3.13.3 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 the following:

- Identification of the QAPP, the HASP, and applicable field SOPs (Appendix E).

- 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 soils data).
- Site-specific particulars of field operations (e.g., locations of utilities, physical access to sampling locations, communication mechanisms, lines of authority and responsibility, scheduling requirements, sample shipping concerns, etc.).
- Laboratory and other subcontractor coordination.
- Site access requirements.
- 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 third-party vendor(s). 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 work areas will be thoroughly checked, and trash will be removed and disposed properly.

TABLE 3-1

FIELD SCREENING AND MEASUREMENTS
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

Parameter	Equipment	SOP	Calibration
Volatile organics	Perkin-Elmer Photovac 2020 Photoionization Detector (or equivalent)	SOP CTO331-06	Per Manufacturer
pH Temperature Oxidation-reduction potential Specific conductance Dissolved Oxygen (water-quality parameters)(1)	YSI 6-Series Environmental Monitoring System (or equivalent)	SOP CTO331-14	Per Manufacturer
Turbidity (water-quality parameters)(1)	LaMotte Turbidity Meter (or equivalent)	SOP CTO331-14	Per Manufacturer
Water-levels	Heron Dipper-T (or equivalent)(2)	SOP CTO331-18	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 sampling location.

2 Any electronic water-level indicator with the capability of measuring to within 0.01-foot accuracy can be used.

SOP - Standard operating procedure.

TABLE 3-2

LISTING OF SOIL SAMPLES AND LABORATORY ANALYSES[1]
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

Area of Concern	Sample Location	Sample Number[2,3]	Extract and Hold[3]	Energetics		Metals		VOCs		SVOCs		Pesticides	Herbicides	PCBs	Miscellaneous Parameters		
				Nitroaromatics / Nitramines	Perchlorate	TAL Metals plus Sn	TAL Metals plus Li and Sr	8260B	8015B	SVOCs (Except PAHs)	PAHs				CEC	pH	TOC
SWMU 8																	
NA	08SB001	08SS0010002		1	1	1		1	1	1	1						
		08SB0010206		1	1	1		1	1	1	1						
		08SB0010610	E&H	1	1	1		1	1	1	1						
		08SB001xxxx	E&H	1	1	1		1	1	1	1						
NA	08SB002	08SS0020002		1	1	1		1	1	1	1						
		08SB0020206		1	1	1		1	1	1	1						
		08SB0020610	E&H	1	1	1		1	1	1	1						
		08SB002xxxx	E&H	1	1	1		1	1	1	1						
NA	08SB003	08SS0030002				1		1	1	1	1			1			
		08SB0030206				1		1	1	1	1			1			
		08SB0030610	E&H			1		1	1	1	1			1			
		08SB003xxxx	E&H			1		1	1	1	1			1			
NA	08SB004	08SS0040002		1	1	1		1	1	1	1						
		08SB0040206		1	1	1		1	1	1	1						
		08SB0040610		1	1	1		1	1	1	1						
		08SB003xxxx		1	1	1		1	1	1	1						
NA	08SB005	08SS0050002		1	1	1		1	1	1	1						
		08SB0050206		1	1	1		1	1	1	1						
		08SB0050610		1	1	1		1	1	1	1						
		08SB005xxxx		1	1	1		1	1	1	1						

TABLE 3-2

LISTING OF SOIL SAMPLES AND LABORATORY ANALYSES[1]
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

Area of Concern	Sample Location	Sample Number[2,3]	Extract and Hold[3]	Energetics		Metals		VOCs		SVOCs		Pesticides	Herbicides	PCBs	Miscellaneous Parameters		
				Nitroaromatics / Nitramines	Perchlorate	TAL Metals plus Sn	TAL Metals plus Li and Sr	8260B	8015B	SVOCs (Except PAHs)	PAHs				CEC	pH	TOC
SWMU 8 (Continued)																	
NA	08SB006[4]	08SS0060002		1	1	1		1	1	1	1			1			
		08SB0060206		1	1	1		1	1	1	1			1			
		08SB0060610		1	1	1		1	1	1	1			1			
		08SB006xxxx		1	1	1		1	1	1	1			1			
NA	08SB007[4]	08SS0070002		1	1	1		1	1	1	1			1			
		08SB0070206		1	1	1		1	1	1	1			1			
		08SB0070610		1	1	1		1	1	1	1			1			
		08SB007xxxx		1	1	1		1	1	1	1			1			
NA	08SB008[4]	08SS0080002		1	1	1		1	1	1	1			1			
		08SB0080206		1	1	1		1	1	1	1			1			
		08SB0080610		1	1	1		1	1	1	1			1			
		08SB008xxxx		1	1	1		1	1	1	1			1			
NA	08SB009[4]	08SS0090002		1	1	1		1	1	1	1			1			
		08SB0090206		1	1	1		1	1	1	1			1			
		08SB0090610		1	1	1		1	1	1	1			1			
		08SB009xxxx		1	1	1		1	1	1	1			1			
NA	08SB010	08SS0100002				1		1	1	1	1	1	1	1			
		08SB0100206				1		1	1	1	1	1	1	1			
		08SB0100610	E&H			1		1	1	1	1	1	1	1			
		08SB010xxxx	E&H			1		1	1	1	1	1	1	1			

TABLE 3-2

LISTING OF SOIL SAMPLES AND LABORATORY ANALYSES[1]
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

Area of Concern	Sample Location	Sample Number[2,3]	Extract and Hold[3]	Energetics		Metals		VOCs		SVOCs		Pesticides	Herbicides	PCBs	Miscellaneous Parameters		
				Nitroaromatics / Nitramines	Perchlorate	TAL Metals plus Sn	TAL Metals plus Li and Sr	8260B	8015B	SVOCs (Except PAHs)	PAHs				CEC	pH	TOC
SWMU 8 (Continued)																	
NA	08SB011	08SS0110002				1		1	1	1	1	1	1	1			
		08SB0110206				1		1	1	1	1	1	1	1			
		08SB0110610	E&H			1		1	1	1	1	1	1	1			
		08SB011xxxx	E&H			1		1	1	1	1	1	1	1			
NA	08SB012	08SS0120002				1		1	1	1	1	1	1	1			
		08SB0120206				1		1	1	1	1	1	1	1			
		08SB0120610	E&H			1		1	1	1	1	1	1	1			
		08SB012xxxx	E&H			1		1	1	1	1	1	1	1			
NA	08SB013	08SS0130002				1		1	1	1	1	1	1	1			
		08SB0130206				1		1	1	1	1	1	1	1			
		08SB0130610	E&H			1		1	1	1	1	1	1	1			
		08SB013xxxx	E&H			1		1	1	1	1	1	1	1			
NA	08SB014 (upgradient)	08SS0140002													1	1	1
		08SB0140206													1	1	1
		08SB0140610													1	1	1
		08SB014xxxx													1	1	1
Total Soil Samples, SWMU 8				**32**	**32**	**52**	**0**	**52**	**52**	**52**	**52**	**16**	**16**	**0**	**4**	**4**	**4**

TABLE 3-2

LISTING OF SOIL SAMPLES AND LABORATORY ANALYSES[1]
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

Area of Concern	Sample Location	Sample Number[2,3]	Extract and Hold[3]	Energetics		Metals		VOCs		SVOCs		Pesticides	Herbicides	PCBs	Miscellaneous Parameters		
				Nitroaromatics / Nitramines	Perchlorate	TAL Metals plus Sn	TAL Metals plus Li and Sr	8260B	8015B	SVOCs (Except PAHs)	PAHs				CEC	pH	TOC
SWMU 15																	
A	15SB001	15SS0010002				1		1	1	1	1		1				
		15SB0010206	E&H			1		1	1	1	1		1				
	15SB002	15SS0020002				1		1	1	1	1		1				
		15SB0020206	E&H			1		1	1	1	1		1				
	15SB003	15SS0030002				1		1	1	1	1		1				
		15SB0030206	E&H			1		1	1	1	1		1				
	15SB004	15SS0040002				1		1	1	1	1		1				
		15SB0040206	E&H			1		1	1	1	1		1				
	15SB005	15SS0050002				1		1	1	1	1		1				
		15SB0050206	E&H			1		1	1	1	1		1				
	15SB006	15SS0060002				1		1	1	1	1		1				
		15SB0060206	E&H			1		1	1	1	1		1				
	15SB007	15SS0070002				1		1	1	1	1		1				
		15SB0070206	E&H			1		1	1	1	1		1				
B	15SB008	15SS0080002				1		1	1	1	1						
		15SB0080206				1		1	1	1	1						
		15SB0080610				1		1	1	1	1						
		15SB008xxxx				1		1	1	1	1						
	15SB009	15SS0090002				1		1	1	1	1						
		15SB0090206				1		1	1	1	1						
		15SB0090610				1		1	1	1	1						
		15SB009xxxx				1		1	1	1	1						
	15SB010	15SS0100002				1		1	1	1	1						
		15SB0100206				1		1	1	1	1						
		15SB0100610				1		1	1	1	1						
		15SB010xxxx				1		1	1	1	1						

TABLE 3-2

LISTING OF SOIL SAMPLES AND LABORATORY ANALYSES[1]
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

Area of Concern	Sample Location	Sample Number[2,3]	Extract and Hold[3]	Energetics		Metals		VOCs		SVOCs		Pesticides	Herbicides	PCBs	Miscellaneous Parameters		
				Nitroaromatics / Nitramines	Perchlorate	TAL Metals plus Sn	TAL Metals plus Li and Sr	8260B	8015B	SVOCs (Except PAHs)	PAHs				CEC	pH	TOC
SWMU 15 (Continued)																	
C	15SB011	15SS0110002						1	1	1	1			1			
		15SB0110206	E&H					1	1	1	1			1			
	15SB012	15SS0120002						1	1	1	1			1			
		15SB0120206	E&H					1	1	1	1			1			
	15SB013	15SS0130002						1	1	1	1			1			
		15SB0130206	E&H					1	1	1	1			1			
D	15SB014	15SS0140002				1						1	1				
		15SB0140206	E&H			1						1	1				
	15SB015	15SS0150002				1						1	1				
		15SB0150206	E&H			1						1	1				
	15SB016	15SS0160002				1						1	1				
		15SB0160206	E&H			1						1	1				
	15SB017	15SS0170002				1						1	1				
		15SB0170206	E&H			1						1	1				
	15SB018	15SS0180002				1						1	1				
		15SB0180206	E&H			1						1	1				
E	15SB019	15SS0190002				1		1	1	1	1	1	1	1			
		15SB0190206	E&H			1		1	1	1	1	1	1	1			
	15SB020	15SS0200002				1		1	1	1	1	1	1	1			
		15SB0200206	E&H			1		1	1	1	1	1	1	1			
	15SB021	15SS0210002				1		1	1	1	1	1	1	1			
		15SB0210206	E&H			1		1	1	1	1	1	1	1			
	15SB022	15SS0220002				1		1	1	1	1	1	1	1			
		15SB0220206	E&H			1		1	1	1	1	1	1	1			
	15SB023	15SS0230002				1		1	1	1	1	1	1	1			
		15SB0230206	E&H			1		1	1	1	1	1	1	1			

TABLE 3-2

LISTING OF SOIL SAMPLES AND LABORATORY ANALYSES[1]
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

Area of Concern	Sample Location	Sample Number[2,3]	Extract and Hold[3]	Energetics		Metals		VOCs		SVOCs		Pesticides	Herbicides	PCBs	Miscellaneous Parameters		
				Nitroaromatics / Nitramines	Perchlorate	TAL Metals plus Sn	TAL Metals plus Li and Sr	8260B	8015B	SVOCs (Except PAHs)	PAHs				CEC	pH	TOC
SWMU 15 (Continued)																	
F	15SB024	15SS0240002								1	1						
		15SB0240206	E&H							1	1						
	15SB025	15SS0250002								1	1						
		15SB0250206	E&H							1	1						
	15SB026	15SS0260002								1	1						
		15SB0260206	E&H							1	1						
	15SB027	15SS0270002								1	1						
		15SB0270206	E&H							1	1						
	15SB028	15SS0280002								1	1						
		15SB0280206	E&H							1	1						
G	15SB029	15SS0290002				1		1	1	1	1	1	1	1			
		15SB0290206	E&H			1		1	1	1	1	1	1	1			
	15SB030	15SS0300002				1		1	1	1	1	1	1	1			
		15SB0300206	E&H			1		1	1	1	1	1	1	1			
	15SB031	15SS0310002				1		1	1	1	1	1	1	1			
		15SB0310206	E&H			1		1	1	1	1	1	1	1			
		15SB0310610	E&H			1		1	1	1	1	1	1	1			
		15SB03110xx	E&H			1		1	1	1	1	1	1	1			
	15SB032	15SS0320002				1		1	1	1	1	1	1	1			
		15SB0320206	E&H			1		1	1	1	1	1	1	1			
	15SB033	15SS0330002				1		1	1	1	1	1	1	1			
		15SB0330206	E&H			1		1	1	1	1	1	1	1			
	15SB034	15SS0340002				1		1	1	1	1	1	1	1			
		15SB0340206	E&H			1		1	1	1	1	1	1	1			
	15SB035	15SS0350002				1		1	1	1	1	1	1	1			
		15SB0350206	E&H			1		1	1	1	1	1	1	1			
	15SB036	15SS0360002				1		1	1	1	1	1	1	1			
		15SB0360206	E&H			1		1	1	1	1	1	1	1			

TABLE 3-2

LISTING OF SOIL SAMPLES AND LABORATORY ANALYSES[1]
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

Area of Concern	Sample Location	Sample Number[2,3]	Extract and Hold[3]	Energetics		Metals		VOCs		SVOCs		Pesticides	Herbicides	PCBs	Miscellaneous Parameters		
				Nitroaromatics / Nitramines	Perchlorate	TAL Metals plus Sn	TAL Metals plus Li and Sr	8260B	8015B	SVOCs (Except PAHs)	PAHs				CEC	pH	TOC
SWMU 15 (Continued)																	
G (Continued)	15SB037	15SS0370002				1		1	1	1	1	1	1	1			
		15SB0370206	E&H			1		1	1	1	1	1	1	1			
H	15SB038	15SS0380002				1		1	1	1	1	1	1	1			
		15SB0380206	E&H			1		1	1	1	1	1	1	1			
	15SB039	15SS0390002				1		1	1	1	1	1	1	1			
		15SB0390206	E&H			1		1	1	1	1	1	1	1			
	15SB040	15SS0400002				1		1	1	1	1	1	1	1			
		15SB0400206	E&H			1		1	1	1	1	1	1	1			
	15SB041	15SS0410002				1		1	1	1	1	1	1	1			
		15SB0410206	E&H			1		1	1	1	1	1	1	1			
O	15SB042	15SS0420002				1		1	1	1	1						
		15SB0420206	E&H			1		1	1	1	1						
	15SB043	15SS0430002				1		1	1	1	1						
		15SB0430206	E&H			1		1	1	1	1						
	15SB044	15SS0440002				1		1	1	1	1						
		15SB0440206	E&H			1		1	1	1	1						
U	15SB045	15SS0450002				1		1	1	1	1	1	1	1			
		15SS0450206				1		1	1	1	1	1	1	1			
		15SS0450610	E&H			1		1	1	1	1	1	1	1			
		15SS04510xx	E&H			1		1	1	1	1	1	1	1			
	15SB046	15SS0460002				1		1	1	1	1	1	1	1			
		15SS0460206				1		1	1	1	1	1	1	1			
		15SS0460610	E&H			1		1	1	1	1	1	1	1			
		15SS04610xx	E&H			1		1	1	1	1	1	1	1			
	15SB047	15SS0470002				1		1	1	1	1	1	1	1			

TABLE 3-2

LISTING OF SOIL SAMPLES AND LABORATORY ANALYSES[1]
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

Area of Concern	Sample Location	Sample Number[2,3]	Extract and Hold[3]	Energetics		Metals		VOCs		SVOCs		Pesticides	Herbicides	PCBs	Miscellaneous Parameters		
				Nitroaromatics / Nitramines	Perchlorate	TAL Metals plus Sn	TAL Metals plus Li and Sr	8260B	8015B	SVOCs (Except PAHs)	PAHs				CEC	pH	TOC
SWMU 15 (Continued)																	
U (Continued)	15SB048	15SS0480002				1		1	1	1	1	1	1	1			
		15SS0480206				1		1	1	1	1	1	1	1			
		15SS0480610	E&H			1		1	1	1	1	1	1	1			
		15SS04810xx	E&H			1		1	1	1	1	1	1	1			
	15SB049	15SS0490002				1		1	1	1	1	1	1	1			
W	15SB050	15SS05002xx				1		1	1	1	1	1	1	1			
		15SS050xxxx				1		1	1	1	1	1	1	1			
	15SB051	15SS05102xx				1		1	1	1	1	1	1	1			
		15SS051xxxx				1		1	1	1	1	1	1	1			
	15SB052	15SS05202xx				1		1	1	1	1	1	1	1			
		15SS052xxxx				1		1	1	1	1	1	1	1			
	15SB054	15SS05402xx				1		1	1	1	1	1	1	1			
		15SS054xxxx				1		1	1	1	1	1	1	1			
	15SB055	15SS05502xx				1		1	1	1	1	1	1	1			
		15SS055xxxx				1		1	1	1	1	1	1	1			
	15SB056	15SS05602xx				1		1	1	1	1	1	1	1			
		15SS056xxxx				1		1	1	1	1	1	1	1			
	15SB057	15SS05702xx				1		1	1	1	1	1	1	1			
		15SS057xxxx				1		1	1	1	1	1	1	1			
	15SB058	15SS05802xx				1		1	1	1	1	1	1	1			
		15SS058xxxx				1		1	1	1	1	1	1	1			
	15SB059[5]																
	15SB060[5]																
	15SB061[5]																
	15SB062[5]																
Total Soil Samples, SWMU 15				0	0	110	0	106	106	116	116	78	92	74	0	0	0

TABLE 3-2

LISTING OF SOIL SAMPLES AND LABORATORY ANALYSES[1]
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

Area of Concern	Sample Location	Sample Number[2,3]	Extract and Hold[3]	Energetics		Metals		VOCs		SVOCs		Pesticides	Herbicides	PCBs	Miscellaneous Parameters		
				Nitroaromatics / Nitramines	Perchlorate	TAL Metals plus Sn	TAL Metals plus Li and Sr	8260B	8015B	SVOCs (Except PAHs)	PAHs				CEC	pH	TOC
SWMU 18																	
Bldg 104	18SS001	18SS0010002		1		1											
	18SS002	18SS0020002		1		1											
	18SS003	18SS0030002		1		1											
	18SS004	18SS0040002		1		1											
	18SS005	18SS0050002		1		1											
	18SS006	18SS0060002		1		1											
	18SS007	18SS0070002		1		1											
Bldg 105	18SS008	18SS0080002		1		1											
	18SS009	18SS0090002		1		1											
	18SS010	18SS0100002		1		1											
	18SS011	18SS0110002		1		1											
	18SS012	18SS0120002		1		1											
Bldg 198	18SS013	18SS0130002		1		1											
	18SS014	18SS0140002		1		1											
	18SS015	18SS0150002		1		1											
	18SS016	18SS0160002		1		1											
Bldg 200	18SS017	18SS0170002		1		1											
	18SS018	18SS0180002		1		1											
	18SS019	18SS0190002		1		1											
	18SS020	18SS0200002		1		1											
	18SS021	18SS0210002		1		1											
Total Soil Samples, SWMU 18				**21**	**0**	**21**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

TABLE 3-2

LISTING OF SOIL SAMPLES AND LABORATORY ANALYSES[1]
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

Area of Concern	Sample Location	Sample Number[2,3]	Extract and Hold[3]	Energetics		Metals		VOCs		SVOCs		Pesticides	Herbicides	PCBs	Miscellaneous Parameters		
				Nitroaromatics / Nitramines	Perchlorate	TAL Metals plus Sn	TAL Metals plus Li and Sr	8260B	8015B	SVOCs (Except PAHs)	PAHs				CEC	pH	TOC
SWMU 19																	
OTA	19SS003	19SS0030002		1	1		1										
	19SS007	19SS0070002		1	1		1	1		1	1						
	19SS013	19SS0130002		1	1		1										
	19SS026	19SS0260002		1	1		1										
	19SS041	19SS0410002		1	1		1										
	19SS070	19SS0700002		1	1		1										
PTA Annex	19SS047	19SS0470002		1	1		1										
	19SS049	19SS0490002		1	1		1										
PTA RR	19SS061	19SS0610002		1	1		1										
	19SS064	19SS0640002		1	1		1										
Total Soil Samples, SWMU 19				10	10	0	10	1	0	1	1	0	0	0	0	0	0
SWMU 20																	
NA	20SS001	20SS0010002		1	1	1											
NA	20SS002	20SS0020002		1	1	1											
NA	20SS003	20SS0030002		1	1	1											
NA	20SS004	20SS0040002		1	1	1											
NA	20SS005	20SS0050002		1	1	1											
Total Soil Samples, SWMU 20				5	5	5	0	0	0	0	0	0	0	0	0	0	0

TABLE 3-2

LISTING OF SOIL SAMPLES AND LABORATORY ANALYSES[1]
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

Area of Concern	Sample Location	Sample Number[2,3]	Extract and Hold[3]	Energetics		Metals		VOCs		SVOCs		Pesticides	Herbicides	PCBs	Miscellaneous Parameters		
				Nitroaromatics / Nitramines	Perchlorate	TAL Metals plus Sn	TAL Metals plus Li and Sr	8260B	8015B	SVOCs (Except PAHs)	PAHs				CEC	pH	TOC
OGTSL																	
NA	OGTSLSB001	OGTSLSS0010002				1				1	1			1			
NA	OGTSLSB002	OGTSLSS0020002				1				1	1			1			
NA	OGTSLSB003	OGTSLSS0030002				1				1	1			1			
NA	OGTSLSB004	OGTSLSS0040002				1				1	1			1			
NA	OGTSLSB005	OGTSLSS0050002				1				1	1			1			
Total Soil Samples, OGTSL				0	0	5	0	0	0	5	5	0	0	5	0	0	0

1 See Table 1-5 of this QAPP for specific analysis requirements and analyte lists.
2 Samples for VOC analysis will be collected from the point in the designated interval where the highest PID measurement occurs or from the center of the interval if no PID reading
3 Unless otherwise noted for SWMUs 8 and 15, samples deeper than 2 feet bgs that are scheduled for any analyses other than VOCs, pH, and cyanide will be collected and prepared for analysis only. The need for analysis will be determined by sample based upon whether contaminants are detected in the 0-2 foot bgs sample. All samples scheduled for VOC, pH, and cyanide analyses will be analyzed regardless of depth.
Samples identified as E&H samples will extracted and held for analyses for appropriate parameters (i.e., CEC, energetics, metals, SVOCs, pesticides, herbicides, and/or PCBs).
4 These borings will be drilled at an angle from the pond bank towards the center of the pond.

CEC — Cation exchange capacity.
E&H — Extract and hold.
Li — Lithium.
NA — Not applicable.
OGTSL — Old Gun Tub Storage Lot.
OTA — Ordnance Test Area.
PAHs — Polynuclear aromatic hydrocarbons.
PCBs — Polychlorinated biphenyls.
PID — Photoionization Detector.
PTA — Pyrotechnic Test Area.
QAPP — Quality Assurance Project Plan.
RR — Rocket Range.
Sr — Strontium.
SVOCs — Semivolatile organic compounds.
SWMU — Solid Waste Management Unit.
TAL — U.S. EPA Contract Laboratory Program Target Analyte List.
TOC — Total organic carbon.
VOCs — Volatile organic compounds.
xxx — To be determined in the field. Corresponds to the depth midway between the bottom of the interval above this interval and the top of bedrock.

TABLE 3-3

SUMMARY OF SOIL ANALYSES AND QUALITY CONTROL SAMPLES
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

Parameters [1]	Energetics		Metals		VOCs		SVOCs					Miscellaneous Parameters		
Sample Type	Nitroaromatics / Nitramines	Perchlorate	TAL Metals plus Sn	TAL Metals plus Li and Sr	8260B	8015B	SVOCs (Except PAHs)	PAHs	Pesticides	Herbicides	PCBs	CEC	pH	TOC
Samples SWMU 8	32	32	52	0	52	52	52	52	16	16	0	4	4	4
Samples SWMU 15	0	0	110	0	106	106	116	116	78	92	74	0	0	0
Samples SWMU 18	21	0	21	0	0	0	0	0	0	0	0	0	0	0
Samples SWMU 19	10	10	0	10	1	0	1	1	0	0	0	0	0	0
Samples SWMU 20	5	5	5	0	0	0	0	0	0	0	0	0	0	0
Samples OGTSL	0	0	5	0	0	0	5	5	0	0	5	0	0	0
Total Samples All SWMUs	**68**	**47**	**193**	**10**	**159**	**158**	**174**	**174**	**94**	**108**	**79**	**4**	**4**	**4**
Field Duplicates [2]	4	3	10	1	8	8	9	9	5	6	4	1	1	1
Trip Blanks [3]	0	0	0	0	16	16	0	0	0	0	0	0	0	0
Rinsate Blanks [4]	4	3	10	1	8	8	9	9	5	6	4	1	1	1
Ambient Condition Blanks [5]	1	1	1	1	1	1	1	1	1	1	1	NA	NA	NA
Matrix Spikes [6]	4	3	10	1	8	8	9	9	5	6	4	1	NA	NA
Matrix Spike Duplicates [7]	4	3	NA	NA	8	8	9	9	5	6	4	NA	NA	NA

1 See Table 1-5 of this QAPP for specific analysis requirements and analyte lists.
2 Field duplicates will be collected at a frequency of one per every 20 environmental samples (minimum of one field duplicate per fraction).
3 Trip blanks will be submitted for analysis at a frequency of one per cooler containing samples for volatile analysis. Because the number of sample coolers shipped may vary, the number of trip blanks is estimated.
4 Rinsate blanks will be collected at a miminum frequency of one per sampling device or instrument. These amounts are estimates and may vary. Rinsate blanks will not be collected for VOC samples that are collected using EnCoreTM samplers.
5 Ambient condition blanks are optional samples that may be collected based on the judgment of the Field Operations Leader.
6 Matrix spikes are collected for all organic and inorganic parameters at a frequency of one per every 20 field samples per matrix.
7 Matrix spike duplicates are collected for all organic parameters. Laboratory duplicates are analyzed for inorganic parameters in lieu of matrix spike duplicates. Matrix spike duplicates are collected at a frequency of one per every 20 field samples per matrix per fraction.

CEC — Cation exchange capacity.
Li — Lithium.
NA — Not applicable.
OGTSL — Old Gun Tub Storage Lot.
PAHs — Polynuclear aromatic hydrocarbons.
QAPP — Quality Assurance Project Plan.
Sn — Tin.
Sr — Strontium.
SVOCs — Semivolatile organic compounds.
SWMU — Solid Waste Management Unit.
TAL — Target Analyte List.
TOC — Total organic carbon.
VOCs — Volatile organic compounds.

TABLE 3-4

LISTING OF GROUND WATER SAMPLES AND LABORATORY ANALYSES[1][2]
SWMUs 8 AND 15
NSWC CRANE, CRANE, INDIANA
PAGE 1 OF 2

Area of Concern	Sample Location	Sample Number[3]	Energetics		Metals				VOCs		SVOCs		Pesticides	Herbicides	PCBs	Misc Parameters		
			Nitroaromatics / Nitramines	Perchlorate	TAL Metals (total)	TAL Metals plus Tin (total)	TAL Metals (dissolved)	TAL Metals plus Tin (dissolved)[4]	8260B	8015B	SVOCs (except PAHs)	PAHs				Fecal Coliform	pH	Water Quality Parameters[5]
SWMU 8[6][7]																		
NA	08TW001	08GWTW001	1	1		1		1	1	1	1	1				1	1	1
	08TW002	08GWTW002	1	1		1		1	1	1	1	1				1	1	1
	08TW003	08GWTW003	1	1		1		1	1	1	1	1				1	1	1
	08TW004	08GWTW004	1	1		1		1	1	1	1	1				1	1	1
	08TW005	08GWTW005	1	1		1		1	1	1	1	1				1	1	1
	08TW006	08GWTW006	1	1		1		1	1	1	1	1				1	1	1
	08TW007	08GWTW007	1	1		1		1	1	1	1	1				1	1	1
Total Ground Water Samples, SWMU 8			7	7		7		7	7	7	7	7				7	7	7
SWMU 15																		
A	15TWxxx	15GWTWxxx				1		1	1	1	1	1			1			1
	15TWxxx	15GWTWxxx				1		1	1	1	1	1			1			
B	15TWxxx	15GWTWxxx				1		1	1	1	1	1			1			
G/H/U	15TWxxx	15GWTWxxx				1		1	1	1	1	1	1	1	1			1
	15TWxxx	15GWTWxxx				1		1	1	1	1	1	1	1	1			1
	15TWxxx	15GWTWxxx				1		1	1	1	1	1	1	1	1			1
	15TWxxx	15GWTWxxx				1		1	1	1	1	1	1	1	1			1
	15TWxxx	15GWTWxxx				1		1	1	1	1	1	1	1	1			1
	15TWxxx	15GWTWxxx				1		1	1	1	1	1	1	1	1			1
1	15TWxxx	15GWTWxxx				1		1	1	1	1	1	1	1	1			1
	15TWxxx	15GWTWxxx				1		1	1	1	1	1	1	1	1			1
	15TWxxx	15GWTWxxx				1		1	1	1	1	1	1	1	1			1

TABLE 3-4

LISTING OF GROUND WATER SAMPLES AND LABORATORY ANALYSES[1][2]
SWMUs 8 AND 15
NSWC CRANE, CRANE, INDIANA

Area of Concern	Sample Location	Sample Number[3]	Energetics		Metals				VOCs		SVOCs		Pesticides	Herbicides	PCBs	Misc Parameters		
			Nitroaromatics / Nitramines	Perchlorate	TAL Metals (total)	TAL Metals plus Tin (total)	TAL Metals (dissolved)	TAL Metals plus Tin (dissolved)[4]	8260B	8015B	SVOCs (except PAHs)	PAHs				Fecal Coliform	pH	Water Quality Parameters[5]
SWMU 15 (Cont.)																		
W	15TWxxx	15GWTWxxx				1		1	1	1	1	1	1	1	1			1
	15TWxxx	15GWTWxxx				1		1	1	1	1	1	1	1	1			1
	15TWxxx	15GWTWxxx				1		1	1	1	1	1	1	1	1			1
	15TWxxx	15GWTWxxx				1		1	1	1	1	1	1	1	1			1
	15TWxxx	15GWTWxxx				1		1	1	1	1	1	1	1	1			1
	15TWxxx	15GWTWxxx				1		1	1	1	1	1	1	1	1			1
	15TWxxx	15GWTWxxx				1		1	1	1	1	1	1	1	1			1
	15TWxxx	15GWTWxxx				1		1	1	1	1	1	1	1	1			1
	15TWxxx	15GWTWxxx				1		1	1	1	1	1	1	1	1			1
	15TWxxx	15GWTWxxx				1		1	1	1	1	1	1	1	1			1
	15TWxxx	15GWTWxxx				1		1	1	1	1	1	1	1	1			1
Total Ground Water Samples, SWMU 15						24		24	24	24	24	24	21	21	24			22

1 See Table 1-5 of this QAPP for specific analysis requirements and analyte lists.
2 Perched ground water samples will not be taken at SWMUs 18, 19, and 20 or the OGTSL.
3 Unless otherwise noted, samples deeper than 2 feet bgs that are scheduled for any analyses other than VOCs will be collected and prepared for analysis only. The need for analysis will be determined by
4 Sample aliquot for dissolved metals will only be collected and analyzed if turbidity of ground water exceeds 10 Nephelometric Turbidity Units (NTUs).
5 Water quality parameters are presented in Table 3-1.
6 An attempt to collect a perched ground water sample will be made at all soil borings that extend to the bedrock - ground water interface.
7 The four borings corresponding with soil samples 08SB006 through 08SB009 will be angled from the Building 106 Pond shore towards the center of the pond.

Misc Parameters — Miscellaneous parameters.
NA — Not applicable.
OGTSL — Old Gun Tub Storage Lot.
OTA — Ordnance Test Area.
PAHs — Polynuclear aromatic hydrocarbons.
PCBs — Polychlorinated biphenyls.
QAPP — Quality Assurance Project Plan.
SVOCs — Semivolatile organic compounds.
SWMU — Solid Waste Management Unit.
TAL — Target Analyte List.
VOCs — Volatile organic compounds.

TABLE 3-5

SUMMARY OF GROUND WATER ANALYSES AND QUALITY CONTROL SAMPLES
SWMUs 8 AND 15[1]
NSWC CRANE, CRANE, INDIANA

Parameter [2]	Energetics		Metals				VOCs		SVOCs					Miscellaneous		
Sample Type	Nitroaromatics / Nitramines	Perchlorate	TAL Metals (total)	TAL Metals plus Tin (total)	TAL Metals (dissolved)	TAL Metals plus Tin (dissolved)[3]	8260B	8015B	SVOCs (Except PAHs)	PAHs	Pesticides	Herbicides	PCBs	Fecal Coliform	pH	Water Quality Parameters[4]
Samples SWMU 8	7	7	7	7	0	7	7	7	7	7	0	0	0	7	7	7
Samples SWMU 15	0	0	1	10	1	10	24	24	24	24	21	21	24	0	22	0
Total Samples All SWMUs	**7**	**7**	**8**	**17**	**1**	**17**	**31**	**31**	**31**	**31**	**21**	**21**	**24**	**7**	**29**	**7**
Field Duplicates [5]	1	1	1	1	1	1	2	2	2	2	2	2	2	1	2	1
Trip Blanks [6]	NA	NA	NA	NA	NA	NA	1	1	NA	NA	NA	NA	NA	NA	NA	NA
Rinsate Blanks [7]	1	1	1	1	1	1	4	4	4	4	3	3	3	1	3	1
Ambient Condition Blanks [8]	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Matrix Spikes [9]	1	1	1	1	1	1	2	2	2	2	2	2	2	1	2	1
Matrix Spike Duplicates [10]	1	NA	NA	NA	NA	NA	2	2	2	2	2	2	2	NA	NA	NA

1 Perched ground water samples will not be taken at SWMUs 18, 19, and 20 or the OGTSL.
2 See Table 1-5 of this QAPP for specific analysis requirements and analyte lists.
3 Sample aliquot for dissolved metals will only be collected and analyzed if turbidity of ground water exceeds 10 Nephelometric Turbidity Units (NTUs).
4 Water quality parameters are presented in Table 3-1.
5 Field duplicates will be collected at a frequency of one per every 20 environmental samples per SWMU (minimum of one field duplicate per fraction).
6 Trip blanks will be submitted for analysis at a frequency of one per cooler containing samples for volatile analysis. Because the number of sample coolers shipped may vary, the number of trip blanks are estimated.
7 Rinsate blanks will be collected at a frequency of one per sampling device or instrument. These amounts are estimates and may vary.
8 Amibient condition blanks are optional samples that may be collected based on the judgment of the Field Operations Leader.
9 Matrix spikes are collected for all organic and inorganic parameters at a frequency of one per every 20 field samples per matrix per fraction.
10 Matrix spike duplicates are collected for all organic parameters. Laboratory duplicates are analyzed for inorganic parameters in lieu of matrix spike duplicates. Matrix spike duplicates are collected at a frequency of one per every 20 field samples per matrix per fraction.

NA — Not applicable.
OGTSL — Old Gun Tub Storage Lot.
PAHs — Polynuclear aromatic hydrocarbons.
PCBs — Polychlorinated biphenyls.
QAPP — Quality Assurance Project Plan.
SVOCs — Semivolatile organic compounds.
SWMU — Solid Waste Management Unit.
TAL — Target Analyte List.
TOC — Total organic carbon.
VOCs — Volatile organic compounds.

TABLE 3-6

LISTING OF SURFACE WATER AND SEDIMENT SAMPLES AND LABORATORY ANALYSES[1]
SWMUs 8 AND 15
NSWC CRANE, CRANE, INDIANA
PAGE 1 OF 3

Area of Concern	Sample Location	Sample Number[2]	Energetics		Metals				VOCs		SVOCs		Pesticides	Herbicides	PCBs	Misc Parameters	
			Nitroaromatics / Nitramines	Perchlorate	TAL Metals (total)	TAL Metals plus Tin (total)	TAL Metals (dissolved)	TAL Metals plus Tin (dissolved)	8260B	8015B	SVOCs (except PAHs)	PAHs				Cyanide	Water Quality Parameters
SWMU 8																	
N/A	08SW/SD001 (upgradient)	08SW00101	1	1	1		1		1	1	1	1					1
		08SW00102	1	1	1		1		1	1	1	1					1
		08SD001010006	1	1					1	1	1	1					
N/A	08SW/SD002	08SW00201	1	1	1		1		1	1	1	1					1
		08SW00202	1	1	1		1		1	1	1	1					1
		08SD002010006	1	1					1	1	1	1					
N/A	08SW/SD003	08SW00301	1	1	1		1		1	1	1	1					1
		08SW00302	1	1	1		1		1	1	1	1					1
		08SD003010006	1	1					1	1	1	1					
NA	08SW/SD004	08SW00401	1	1	1		1		1	1	1	1					1
		08SW00402	1	1	1		1		1	1	1	1					1
		08SD004010006	1	1					1	1	1	1					
		08SD004010612	1	1					1	1	1	1					
		08SD004011218	1	1					1	1	1	1					
NA	08SW/SD005	08SW00501	1	1	1		1		1	1	1	1					1
		08SW00502	1	1	1		1		1	1	1	1					1
		08SD005010006	1	1					1	1	1	1					
		08SD005010612	1	1					1	1	1	1					
		08SD005011218	1	1					1	1	1	1					
NA	08SW/SD006 (downgradient)	08SW00601	1	1	1		1		1	1	1	1			1		1
		08SW00602	1	1	1		1		1	1	1	1			1		1
		08SD006010006	1	1					1	1	1	1			1		
NA	08SW/SD007 (downgradient)	08SW00701	1	1	1		1		1	1	1	1			1		1
		08SW00702	1	1	1		1		1	1	1	1			1		1
		08SD007010006	1	1					1	1	1	1			1		
NA	08SW/SD008 (downgradient)	08SW00801	1	1	1		1		1	1	1	1			1		1
		08SW00802	1	1	1		1		1	1	1	1			1		1
		08SD008010006	1	1					1	1	1	1			1		
NA	08SW/SD009 (downgradient)	08SW00901	1	1	1		1		1	1	1	1			1		1
		08SW00902	1	1	1		1		1	1	1	1			1		1
		08SD009010006	1	1					1	1	1	1			1		
Total Surface Water Samples, SWMU 8			**18**	**18**	**18**		**18**		**18**	**18**	**18**	**18**			**8**		**18**
Total Sediment Samples, SWMU 8			**13**	**13**					**13**	**13**	**13**	**13**			**4**		

TABLE 3-6

LISTING OF SURFACE WATER AND SEDIMENT SAMPLES AND LABORATORY ANALYSES[1]
SWMUs 8 AND 15
NSWC CRANE, CRANE, INDIANA

Area of Concern	Sample Location	Sample Number[2]	Energetics		Metals				VOCs		SVOCs		Pesticides	Herbicides	PCBs	Misc Parameters	
			Nitroaromatics / Nitramines	Perchlorate	TAL Metals (total)	TAL Metals plus Tin (total)	TAL Metals (dissolved)	TAL Metals plus Tin (dissolved)	8260B	8015B	SVOCs (except PAHs)	PAHs				Cyanide	Water Quality Parameters
SWMU 15																	
I	15SW/SD001 (downgradient)	15SW00101				1		1	1	1	1	1	1	1	1		1
		15SW00102				1		1	1	1	1	1	1	1	1		1
		15SD001010006				1			1	1	1	1	1	1	1	1	
	15SW/SD002 (downgradient)	15SW00201				1		1	1	1	1	1	1	1	1		1
		15SW00202				1		1	1	1	1	1	1	1	1		1
		15SD002010006				1			1	1	1	1	1	1	1	1	
J	15SW/SD003 (upgradient)	15ST00301				1		1	1	1	1	1	1	1	1		1
		15ST00302				1		1	1	1	1	1	1	1	1		1
		15SD003010006				1			1	1	1	1	1	1	1	1	
K	15SW/SD004 (upgradient)	15ST00401				1		1	1	1	1	1	1	1	1		1
		15ST00402				1		1	1	1	1	1	1	1	1		1
		15SD004010006				1			1	1	1	1	1	1	1	1	
L	15SW/SD005	15ST00501				1		1	1	1	1	1			1		1
		15ST00502				1		1	1	1	1	1			1		1
		15SD005010006				1			1	1	1	1			1	1	
M	15SW/SD006	15ST00601				1		1	1	1	1	1	1	1	1		1
		15ST00602				1		1	1	1	1	1	1	1	1		1
		15SD006010006				1			1	1	1	1	1	1	1		
	15SW/SD015	15ST01501				1		1	1	1	1	1	1	1	1		1
		15ST01502				1		1	1	1	1	1	1	1	1		1
		15SD015010006				1			1	1	1	1	1	1	1		
	15SW/SD016	15ST01601				1		1	1	1	1	1	1	1	1		1
		15ST01602				1		1	1	1	1	1	1	1	1		1
		15SD016010006				1			1	1	1	1	1	1	1		
	15SW/SD017	15ST01701				1		1	1	1	1	1	1	1	1		1
		15ST01702				1		1	1	1	1	1	1	1	1		1
		15SD017010006				1			1	1	1	1	1	1	1		
N	15SW/SD007	15SW00701				1		1	1	1	1	1			1		1
		15SW00702				1		1	1	1	1	1			1		1
		15SD007010006				1			1	1	1	1			1		
P	15SW/SD008	15ST00801				1		1	1	1	1	1	1	1	1		1
		15ST00802				1		1	1	1	1	1	1	1	1		1
		15SD008010006				1			1	1	1	1	1	1	1		

TABLE 3-6

LISTING OF SURFACE WATER AND SEDIMENT SAMPLES AND LABORATORY ANALYSES[1]
SWMUs 8 AND 15
NSWC CRANE, CRANE, INDIANA

Area of Concern	Sample Location	Sample Number[2]	Energetics		Metals				VOCs		SVOCs		Pesticides	Herbicides	PCBs	Misc Parameters	
			Nitroaromatics / Nitramines	Perchlorate	TAL Metals (total)	TAL Metals plus Tin (total)	TAL Metals (dissolved)	TAL Metals plus Tin (dissolved)	8260B	8015B	SVOCs (except PAHs)	PAHs				Cyanide	Water Quality Parameters
SWMU 15 (Continued)																	
Q	15SW/SD009	15ST00901				1		1	1	1	1	1			1		1
		15ST00902				1		1	1	1	1	1			1		1
		15SD009010006				1			1	1	1	1			1		
R	15SW/SD010	15ST01001				1		1	1	1	1	1	1	1	1		1
		15ST01002				1		1	1	1	1	1	1	1	1		1
		15SD010010006				1			1	1	1	1	1	1	1		
S	15SW/SD011 (upgradient)	15ST01101				1		1	1	1	1	1	1	1	1		1
		15ST01102				1		1	1	1	1	1	1	1	1		1
		15SD011010006				1			1	1	1	1	1	1	1		
T	15SW/SD012 (upgradient)	15ST01201				1		1	1	1	1	1	1	1	1		1
		15ST01202				1		1	1	1	1	1	1	1	1		1
		15SD012010006				1			1	1	1	1	1	1	1		
U	15SW/SD013 (upgradient)	15ST01301				1		1	1	1	1	1	1	1	1		1
		15ST01302				1		1	1	1	1	1	1	1	1		1
		15SD013010006				1			1	1	1	1	1	1	1		
V	15SW/SD014 (upgradient)	15ST01401				1		1	1	1	1	1	1	1	1		1
		15ST01402				1		1	1	1	1	1	1	1	1		1
		15SD014010006				1			1	1	1	1	1	1	1		
W	15SW/SD018 (downgradient)	15SW01801				1		1	1	1	1	1	1	1	1		1
		15SW01802				1		1	1	1	1	1	1	1	1		1
		15SD018010006				1			1	1	1	1	1	1	1		
	15SW/SD019 (downgradient)	15SW01901				1		1	1	1	1	1	1	1	1		1
		15SW01902				1		1	1	1	1	1	1	1	1		1
		15SD019010006				1			1	1	1	1	1	1	1		
Total Surface Water Samples, SWMU 15						38		38	38	38	38	38	32	32	38		38
Total Sediment Samples, SWMU 15						19			19	19	19	19	16	16	19	5	

1 See Table 1-5 of this QAPP for specific analysis requirements and analyte lists.

2 Samples for VOC analysis will be collected from the point in the designated interval where the highest PID measurement occurs, or the center of the interval if no PID reading exceeds background.

Misc Parameters — Miscellaneous parameters.
PAHs — Polynuclear aromatic hydrocarbons.
PCBs — Polychlorinated biphenyls.
QAPP — Quality Assurance Project Plan.
Sn — Tin.
SVOCs — Semivolatile organic compounds.
SWMU — Solid Waste Management Unit.
TAL — Target Analyte List.
VOCs — Volatile organic compounds.

TABLE 3-7

SUMMARY OF SURFACE WATER ANALYSES AND QUALITY CONTROL SAMPLES
SWMUs 8 AND 15[1]
NSWC CRANE, CRANE, INDIANA

Parameters [2]	Energetics		Metals				VOCs		SVOCs					Miscellaneous	
Sample Type	Nitroaromatics / Nitramines	Perchlorate	TAL Metals (total)	TAL Metals plus Tin (total)	TAL Metals (dissolved)	TAL Metals plus Tin (dissolved)	8260B	8015B	SVOCs (except PAHs)	PAHs	Pesticides	Herbicides	PCBs	Cyanide	Water Quality Parameters
Samples SWMU 8	18	18	18	0	18	0	18	18	18	18	0	0	8	0	18
Samples SWMU 15	0	0	0	38	0	38	38	38	38	38	32	32	38	0	38
Total Samples All SWMUs	**18**	**18**	**18**	**38**	**18**	**38**	**56**	**56**	**56**	**56**	**32**	**32**	**46**	**0**	**56**
Field Duplicates [3]	1	1	1	2	1	2	3	3	3	3	2	2	3	0	3
Trip Blanks [4]	NA	NA	NA	NA	NA	NA	1	1	NA	NA	NA	NA	NA	NA	NA
Rinsate Blanks [5]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ambient Condition Blanks [6]	1	1	1	1	1	1	1	1	1	1	1	1	1	NA	NA
Matrix Spikes [7]	1	1	1	2	1	2	3	3	3	3	2	2	3	NA	NA
Matrix Spike Duplicates [8]	1	1	NA	NA	NA	NA	3	3	3	3	2	2	3	NA	NA

1 Surface water samples will not be taken at SWMUs 18, 19, and 20 or the OGTSL.
2 See Table 1-5 of this QAPP for specific analysis requirements and analyte lists.
3 Field duplicates will be collected at a frequency of one per every 20 environmental samples per SWMU (minimum of one field duplicate per fraction).
4 Trip blanks will be submitted for analysis at a frequency of one per cooler containing samples for volatile analysis. Because the number of sample coolers shipped may vary, the number of trip blanks is estimated.
5 Environmental samples will be collected by directly filling the sample bottle. Therefore, no rinsate blanks are required for this matrix.
6 Ambient condition blanks are optional samples that may be collected based on the judgment of the Field Operations Leader.
7 Matrix spikes are collected for all organic and inorganic parameters at a frequency of one per every 20 field samples per matrix.
8 Matrix spike duplicates are collected for all organic parameters. Laboratory duplicates are analyzed for inorganic parameters in lieu of matrix spike duplicates. Matrix spike duplicates are collected at a frequency of one per every 20 field samples per matrix per fraction.

Misc — Miscellaneous parameters.
NA — Not applicable.
OGTSL — Old Gun Tub Storage Lot.
PAHs — Polynuclear aromatic hydrocarbons.
PCBs — Polychlorinated biphenyls.
QAPP — Quality Assurance Project Plan.
SVOCs — Semivolatile organic compounds.
SWMU — Solid Waste Management Unit.
TAL — Target Analyte List.
VOCs — Volatile organic compounds.

TABLE 3-8

SUMMARY OF SEDIMENT ANALYSES AND QUALITY CONTROL SAMPLES
SWMUs 8 AND 15[1]
NSWC CRANE, CRANE, INDIANA

Parameters [2]	Energetics		Metals				VOCs		SVOCs					Miscellaneous	
Sample Type	Nitroaromatics / Nitramines	Perchlorate	TAL Metals (total)	TAL Metals plus Tin (total)	TAL Metals (dissolved)	TAL Metals plus Tin (dissolved)	8260B	8015B	SVOCs (except PAHs)	PAHs	Pesticides	Herbicides	PCBs	Cyanide	Water Quality Parameters
Samples SWMU 8	13	13	0	0	0	0	13	13	13	13	0	0	4	0	0
Samples SWMU 15	0	0	0	19	0	0	19	19	19	19	16	16	19	5	0
Total Samples All SWMUs	**13**	**13**	**0**	**19**	**0**	**0**	**32**	**32**	**32**	**32**	**16**	**16**	**23**	**5**	**0**
Field Duplicates [3]	1	1	0	1	0	0	2	2	2	2	1	1	2	1	0
Trip Blanks [4]	NA	NA	NA	NA	NA	NA	2	2	NA	NA	NA	NA	NA	NA	NA
Rinsate Blanks [5]	1	1	0	1	0	0	2	2	2	2	1	1	2	NA	NA
Ambient Condition Blanks [6]	1	1	1	1	1	1	1	1	1	1	1	1	1	NA	NA
Matrix Spikes [7]	1	1	0	1	0	0	2	2	2	2	1	1	2	NA	NA
Matrix Spike Duplicates [8]	1	0	NA	NA	NA	NA	2	2	2	2	1	1	NA	NA	NA

1 Sediment samples will not be taken at SWMUs 18, 19, and 20 or the OGTSL.
2 See Table 1-5 of this QAPP for specific analysis requirements and analyte lists.
3 Field duplicates will be collected at a frequency of one per every 20 environmental samples (minimum of one field duplicate per fraction).
4 Trip blanks will be submitted for analysis at a frequency of one per cooler containing samples for volatile analysis. Because the number of sample coolers shipped may vary, the number of trip blanks is estimated.
5 Rinsate blanks will be collected at a frequency of one per sampling device or instrument. These amounts are estimates and may vary.
6 Ambient condition blanks are optional samples that may be collected based on the judgment of the Field Operations Leader.
7 Matrix spikes are collected for all organic and inorganic parameters at a frequency of one per every 20 field samples per matrix per fraction.
8 Matrix spike duplicates are collected for all organic parameters. Laboratory duplicates are analyzed for inorganic parameters in lieu of matrix spike duplicates. Matrix spike duplicates are collected at a frequency of one per every 20 field samples per matrix per fraction.

NA — Not applicable.
OGTSL — Old Gun Tub Storage Lot.
PAHs — Polynuclear aromatic hydrocarbons.
PCBs — Polychlorinated biphenyls.
QAPP — Quality Assurance Project Plan.
Sn — Tin.
SVOCs — Semivolatile organic compounds.
SWMU — Solid Waste Management Unit.
TAL — Target Analyte List.
VOCs — Volatile organic compounds.

TABLE 3-9

SUMMARY OF SAMPLE ANALYSES, CONTAINER TYPES AND VOLUMES, PRESERVATION REQUIREMENTS, AND HOLDING TIMES FOR SOILS AND SEDIMENTS SWMUS 8, 15, 18, 19 AND 20 AND THE OGTSL NSWC CRANE, CRANE, INDIANA

Parameter	Analyte/Methodology	Sample Container	Container Volume	Preservation	Maximum Holding Time[1]
Explosives (Nitroaromatics and Nitramines)	SW-846 8330	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	Extraction within 14 days; analysis within 40 days of extraction.
Perchlorate	EPA Method 314.0	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	28 days to analysis.
TAL Metals plus Sn (with and without Li and Sr)	SW-846 6020, 7471A	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	Analysis within 180 days; mercury analysis within 28 days.
Volatile Organic Compounds[2]	SW-846 8260B	3 Encore™ samplers	Four 5-gram	Cool to 4 °C	48 hours to preservation[3]; 14 days to analysis.
	SW-846 8015B	2 Encore™ samplers	Four 5-gram	Cool to 4 °C	48 hours to preservation[4]; 7 days to analysis.
Semivolatile Organic Compounds	SW-846 8270C	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	Extraction within 14 days; analysis within 40 days of extraction.
	SW-846 8270C Selected Ion Monitoring	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	Extraction within 14 days; analysis within 40 days of extraction.
Pesticides	SW-846 8081	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	Extraction within 14 days; analysis within 40 days of extraction.
Herbicides (plus pentachlorophenol and hexachlorophene)	SW-846 8151A	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	Extraction within 14 days; analysis within 40 days of extraction.
PCBs	SW-846 8082	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	Extraction within 14 days; analysis within 40 days of extraction.
Total Organic Carbon	Llyod Khan	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	28 days to analysis.
pH	SW-846 9045C	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	Within 24 hours of sample reciept

TABLE 3-9

SUMMARY OF SAMPLE ANALYSES, CONTAINER TYPES AND VOLUMES, PRESERVATION REQUIREMENTS, AND HOLDING TIMES FOR SOILS AND SEDIMENTS SWMUS 8, 15, 18, 19 AND 20 AND THE OGTSL NSWC CRANE, CRANE, INDIANA

Parameter	Analyte/Methodology	Sample Container	Container Volume	Preservation	Maximum Holding Time[1]
Cation Exchange Capacity	SW-846 9081	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	As soon as possible.
Cyanide	SW-846 9012A	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	14 days to analysis.

1 All holding times are from date of collection.
2 Sediment samples collected from areas with no standing water will be collected and containerized in this manner. Sediment samples collected from areas under standing water will be containerized using a 4-ounce clear wide mouth glass jar and cooled to 4°C.
3 One Encore™ extruded into 5 mL H_2O and frozen. Second Encore™ frozen as received. Third Encore™ preserved with methanol for medium level analysis.
4 One Encore™ extruded into 5 mL H_2O and frozen. Second Encore™ frozen as received.

°C — Degrees Centigrade.
H_2O — Water.
Li — Lithium.
mL — Milliliters.
PCBs — Polychlorinated biphenyls.
Sn — Tin.
Sr — Strontium.
™ — Trade mark.

TABLE 3-10

SUMMARY OF SAMPLE ANALYSES, CONTAINER TYPES AND VOLUMES, PRESERVATION REQUIREMENTS, AND HOLDING TIMES FOR AQUEOUS SAMPLES SWMUs 8, 15, 18, 19, AND 20 AND THE OGSTL NSWC CRANE, CRANE, INDIANA

Parameter	Analyte/Methodology	Sample Container	Container Volume[1]	Preservation[2]	Maximum Holding Time[3]
Explosives (nitroaromatics and nitramines)	SW-846 8330	Amber glass, Teflon-lined cap	(2) 1000 mL	Cool to 4 °C, dark	Extraction within 7 days; analysis within 40 days of extraction.
Perchlorate	EPA Method 314.0	Polyethylene, plastic cap w/ plastic liner	500 mL	Cool to 4 °C, dark	28 days to analysis.
TAL Metals plus Sn (with or without Li and Sr)	Total SW-846 6020, 7470A	Polyethylene, plastic cap w/ plastic liner	1000 mL	HNO_3 to pH <2	Analysis within 180 days; mercury within 28 days.
	Dissolved SW-846 6020, 7470A	Polyethylene, plastic cap w/ plastic liner	1000 mL	Filter with 0.45 µm membrane; HNO_3 to pH <2	Analysis within 180 days; mercury within 28 days.
Volatile Organic Compounds	SW-846 8260B	Glass, black phenolic plastic screw cap, Teflon-lined septum	(3) 40 mL	Cool to 4 °C, dark, zero headspace, HCl to pH <2	14 days to analysis.
	SW-846 8015B	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.
Semivolatile Organic Compounds	SW-846 8270C	Amber glass, Teflon-lined cap	(2) 1000 mL	Cool to 4 °C, dark	Extraction within 7 days; analysis within 40 days of extraction.
	Selected Ion Monitoring SW-846 8270C	Amber glass, Teflon-lined cap	(2) 1000 mL	Cool to 4 °C, dark	Extraction within 7 days; analysis within 40 days of extraction.
Pesticides	SW-846 8081	Amber glass, Teflon-lined cap	(2) 1000 mL	Cool to 4 °C, dark	Extraction within 7 days; analysis within 40 days of extraction.
Herbicides (plus pentachlorophenol and hexachlorophene)	SW-8468151A	Amber glass, Teflon-lined cap	(2) 1000 mL	Cool to 4 °C, dark	Extraction within 7 days; analysis within 40 days of extraction.
PCBs	SW-846 8082	Amber glass, Teflon-lined cap	(2) 1000 mL	Cool to 4 °C, dark	Extraction within 7 days; analysis within 40 days of extraction.

TABLE 3-10

SUMMARY OF SAMPLE ANALYSES, CONTAINER TYPES AND VOLUMES, PRESERVATION REQUIREMENTS, AND HOLDING TIMES FOR AQUEOUS SAMPLES SWMUs 8, 15, 18, 19, AND 20 AND THE OGSTL NSWC CRANE, CRANE, INDIANA

Parameter	Analyte/Methodology	Sample Container	Container Volume(1)	Preservation(2)	Maximum Holding Time(3)
Fecal Coliform	9222D Standard Methods	Polyethylene, plastic cap w/ plastic liner	125 mL	Cool to 4° C dark, sodium thiosulfate	24 hours
Cyanide	SW-846 9012A	Polyethylene, plastic cap w/ plastic liner	500 mL	Cool to 4° C, NaOH to pH > 12	14 days to analysis.
Nitrate + Nitrite as Nitrate	EPA Method 353.2	Polyethylene, plastic cap w/ plastic liner	500 mL	Cool to 4 °C, H_2SO_4 to pH < 2	28 days to analysis.
Total Organic Carbon	SW-846 9060	Amber glass, septa cap	125 mL	Cool to 4 °C, H_2SO_4 to pH < 2	28 days to analysis.

Note: Aqueous samples include ground water and surface water.

1 The number in parenthesis indictes the sample container quantity.

2 HCl = Hydrochloric acid, H_2SO_4 = Sulfuric Acid, HNO_3 = Nitric Acid , NaOH = Sodium Hydroxide.

3 All holding times are from date of collection.

°C — Degrees centigrade.
Li — Litihum.
mL — Milliliters.
PCBs — Polychlorinated biphenyls.
Sn — Tin.
Sr — Strontium.

TABLE 3-11

NON-CALIBRATION QC SAMPLE USAGE FREQUENCIES, ACCEPTANCE LIMITS AND CORRECTIVE ACTIONS SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL NSWC CRANE, CRANE, INDIANA

QC Sample Type	Collection Frequency	Acceptance Limits	Corrective Action
Field Duplicate	One per 20 investigative samples collected.	Aqueous = 30% RPD Soil/Sediment = 50% RPD	Qualify data according to data validation requirements.
Equipment Rinsate Blank	One per each type of 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.	< RL (soil and water)	Identify source of contamination, if possible. Qualify data according to validation requirements. Qualify use of data if contamination appears to have adversely affected its usability.
Source Water Blank	One 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 requirements. Qualify use of data if contamination appears to have adversely affected its usability.
Ambient Condition Blank	At discretion of FOL.	< RL (soil and water)	Identify source of contamination, if possible. Qualify data according to validation requirements. Qualify use of data if contamination appears to have adversely affected its usability.
Trip Blank	One per cooler containing samples for volatile organics analysis.	< RL (soil and water)	Identify source of volatiles contamination, if possible. Qualify data according to validation requirements. 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 11.3.
Laboratory Control Sample	One per 20 environmental samples per matrix per analytical fraction	See Tables 7-1 and 7-2.	Laboratory action taken per LTL-1008. TtNUS action taken per validation protocols, and Section11.3.
Laboratory Duplicate	One per 20 environmental samples analyzed for inorganic target analytes	See Table 7-1.	Laboratory action taken per LTL-1008. TtNUS action taken per validation protocols, and Section 11.3.

TABLE 3-11

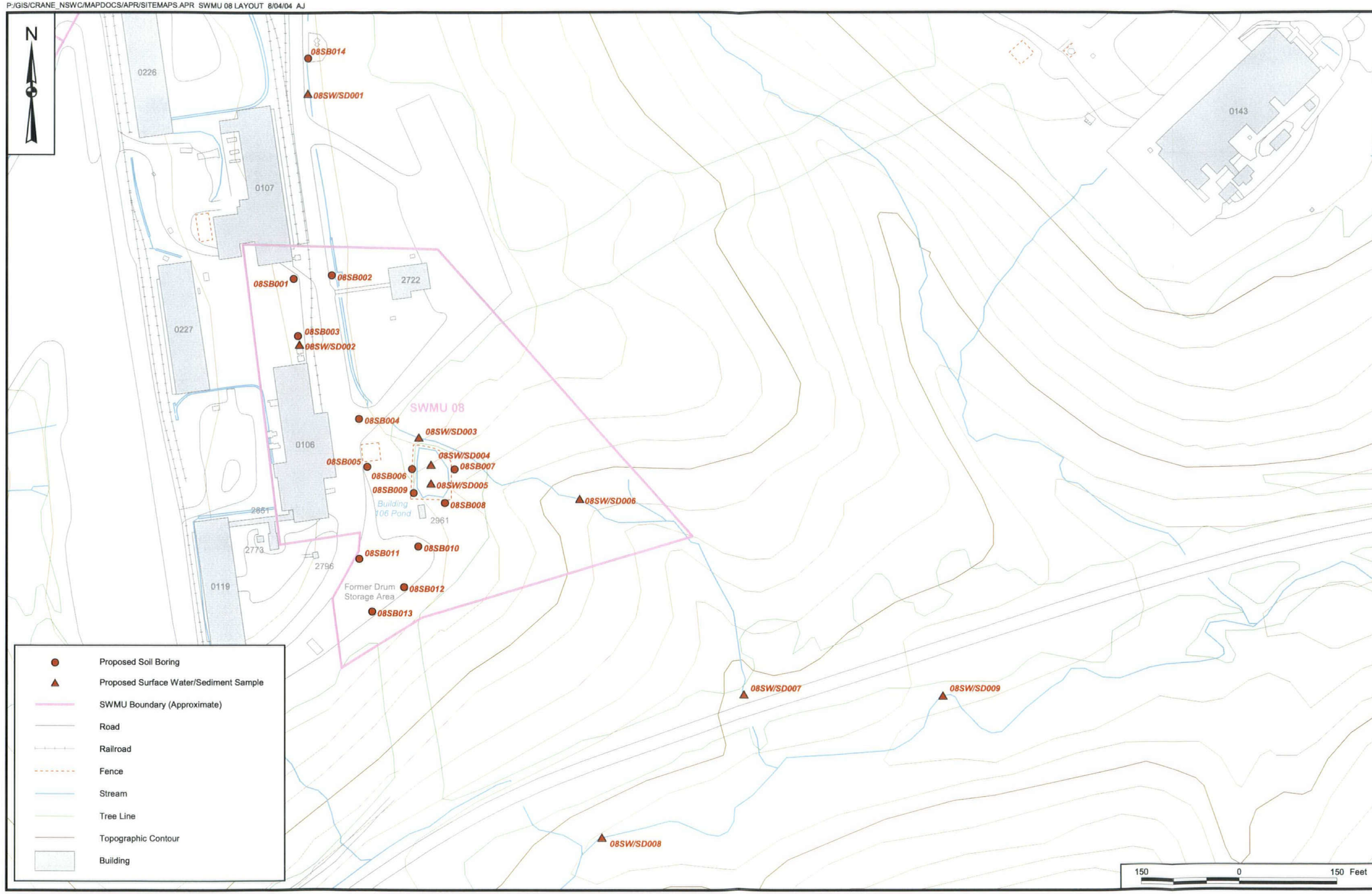
NON-CALIBRATION QC SAMPLE USAGE FREQUENCIES, ACCEPTANCE LIMITS AND CORRECTIVE ACTIONS SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL NSWC CRANE, CRANE, INDIANA

QC Sample Type	Collection Frequency	Acceptance Limits	Corrective Action
Laboratory Method Blank	One 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 11.3.
Matrix Spike(1)	One per analytical fraction per 20 environmental samples for organic target analytes	See Table 7-2.	Laboratory action taken per LTL-1008. TtNUS action taken per validation protocols, and Section 11.3.
Matrix Spike Duplicate(1)	One per analytical fraction per 20 environmental samples analyzed for organic target analytes	See Table 7-1.	Laboratory action taken per LTL-1008. TtNUS action taken per validation protocols, and Section 11.3.
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 11.3.
Surrogate	At least one per sample for organic chromatographic analyses (GC, GC/MS, and HPLC)	See Table 7-2.	Laboratory action taken per LTL-1008. TtNUS action taken per validation protocols, and Section 11.3.
Temperature Blank	One blank per sample cooler.	4 ± 2 °C	Laboratory action taken per LTL-1008. TtNUS action taken per validation protocols, and Section 11.3.

1 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.

FOL — Field Operations Leader.
GC/MS — Gas chromatography/mass spectrometry.
HPLC — High-performance liquid chromatography.
°C — Degrees Centigrade.
RL — Reporting limit.
RPD — Relative percent difference.

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SITEMAPS.APR SWMU 08 LAYOUT 8/04/04 AJ



CONTRACT NO. N1245

APPROVED BY ____ DATE ____

APPROVED BY ____ DATE ____

DRAWING NO. FIGURE 3 - 1

REV 0

PROPOSED SOIL, SURFACE WATER, AND SEDIMENT SAMPLING LOCATIONS
SWMU 08 (BUILDING 106 POND)
NSWC CRANE
CRANE, INDIANA

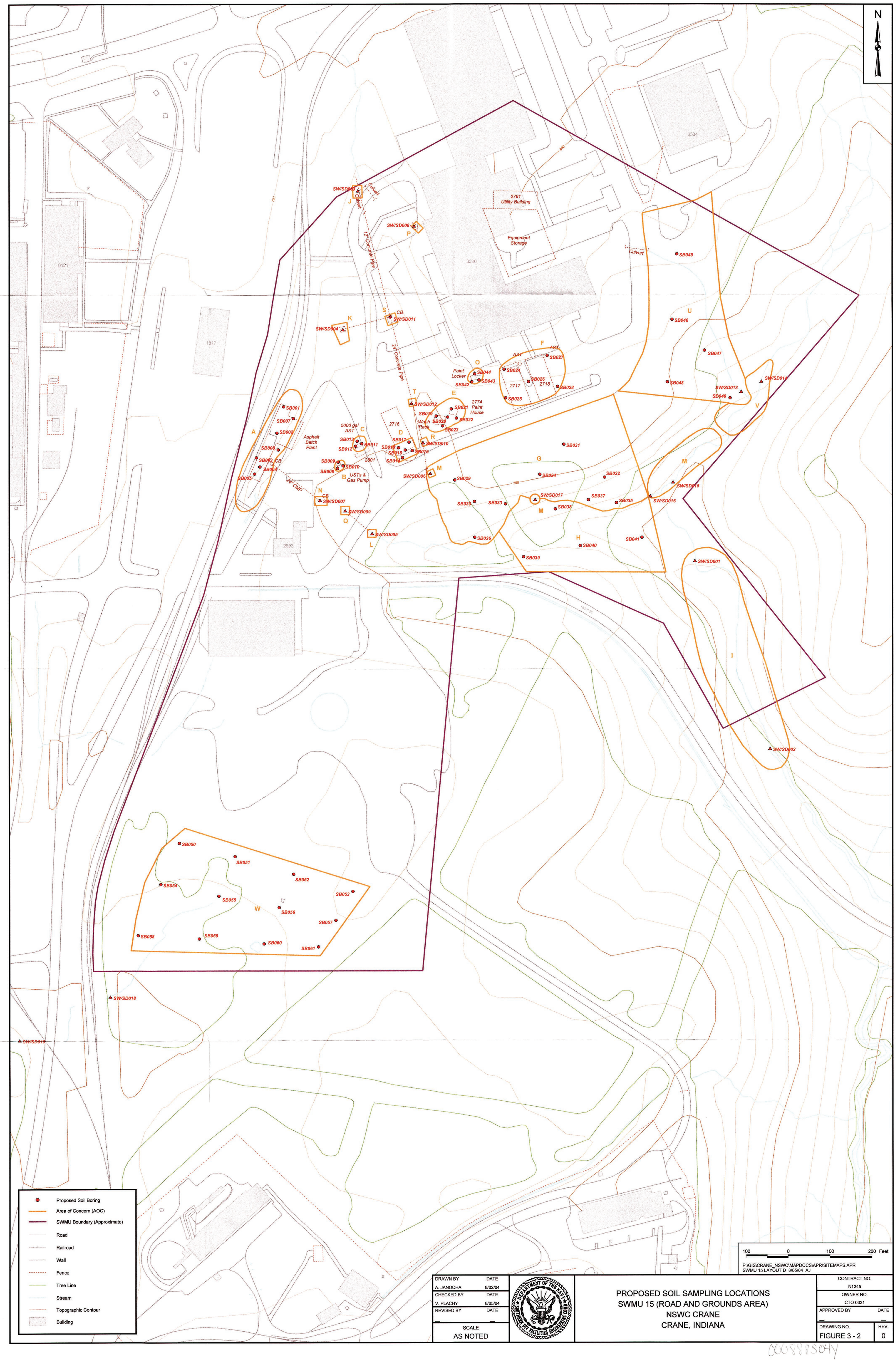
DEPARTMENT OF THE NAVY • NAVAL FACILITIES ENGINEERING COMMAND • SOUTHERN DIVISION

DRAWN BY A. JANOCHA DATE 5/17/04

CHECKED BY V. PLACHY DATE 8/04/04

COST/SCHED-AREA

SCALE AS NOTED



DRAWN BY	DATE
A. JANOCHA	8/02/04
CHECKED BY	DATE
V. PLACHY	8/05/04
REVISED BY	DATE
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SCALE	
AS NOTED	

DEPARTMENT OF THE NAVY
SOUTHERN DIV FACILITIES ENGINEERING COMD

PROPOSED SOIL SAMPLING LOCATIONS
SWMU 15 (ROAD AND GROUNDS AREA)
NSWC CRANE
CRANE, INDIANA

CONTRACT NO.	
N1245	
OWNER NO.	
CTO 0331	
APPROVED BY	DATE
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DRAWING NO.	REV.
FIGURE 3 - 2	0

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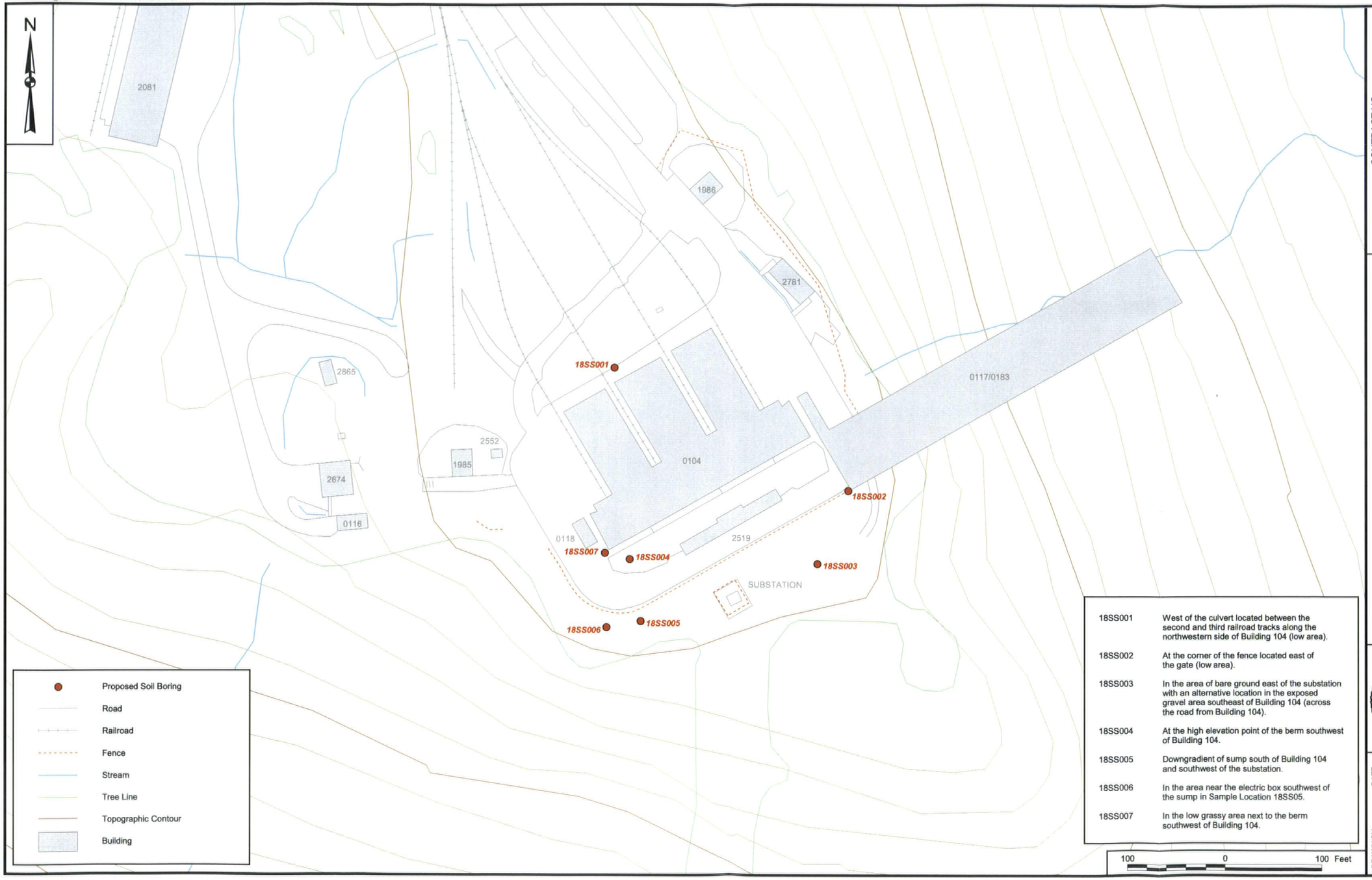
P:/GIS/CRANE_NSWC/MAPDOCS/APR/SITEMAPS.APR SWMU 18 BLDG 104 LAYOUT 7/16/04 AJ



18SS001	West of the culvert located between the second and third railroad tracks along the northwestern side of Building 104 (low area).
18SS002	At the corner of the fence located east of the gate (low area).
18SS003	In the area of bare ground east of the substation with an alternative location in the exposed gravel area southeast of Building 104 (across the road from Building 104).
18SS004	At the high elevation point of the berm southwest of Building 104.
18SS005	Downgradient of sump south of Building 104 and southwest of the substation.
18SS006	In the area near the electric box southwest of the sump in Sample Location 18SS05.
18SS007	In the low grassy area next to the berm southwest of Building 104.

CONTRACT NO. N1245

APPROVED BY ____ DATE ____

APPROVED BY ____ DATE ____

DRAWING NO. FIGURE 3 - 3

REV 0

PROPOSED SOIL SAMPLING LOCATIONS
SWMU 18 BUILDING 104 (LOAD AND FILL AREA)
NSWC CRANE
CRANE, INDIANA

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

DRAWN BY A. JANOCHA	DATE 5/17/04	CHECKED BY V. PLACHY	DATE 7/16/04
COST/SCHED-AREA		SCALE AS NOTED	

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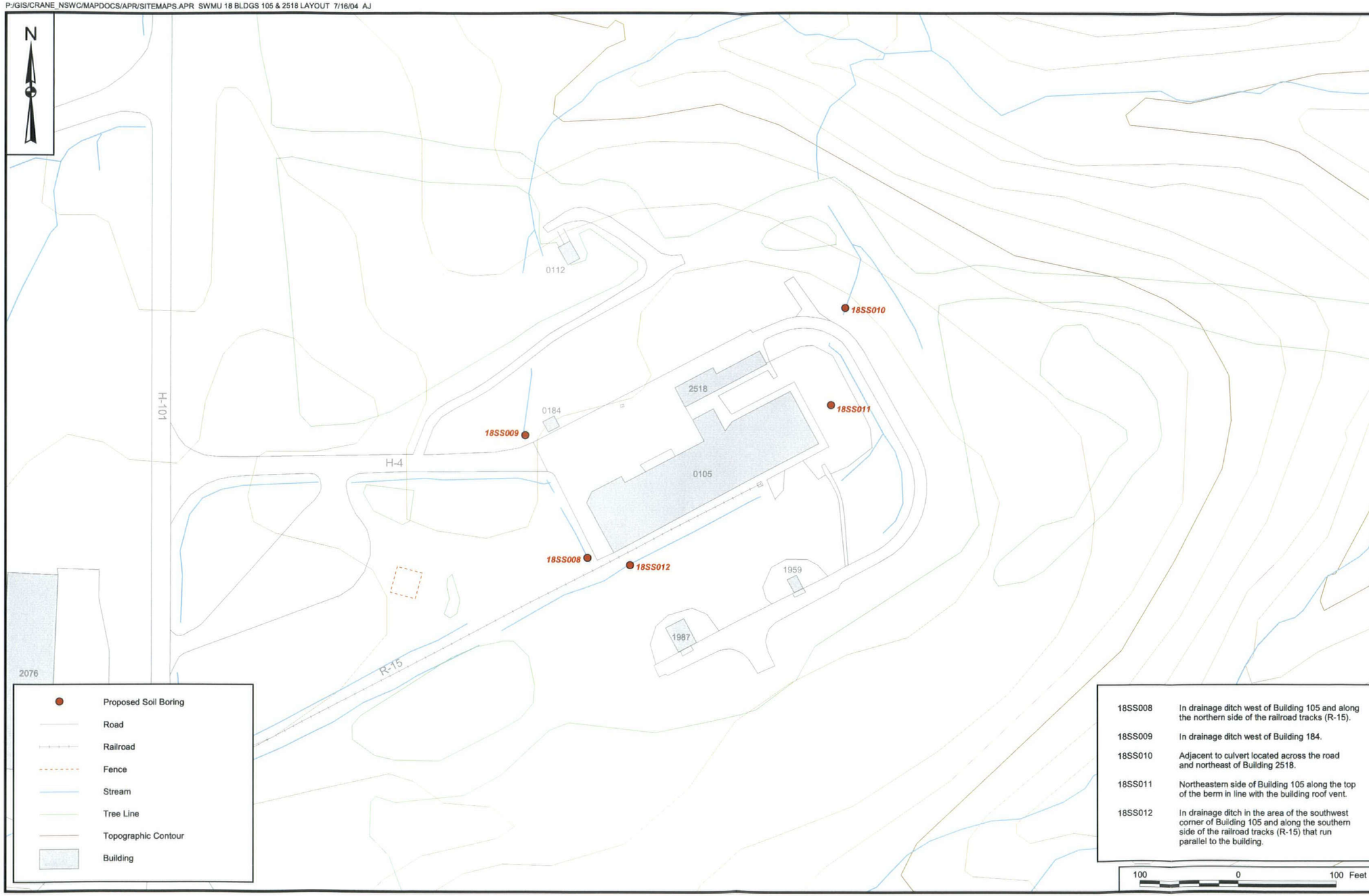


18SS008	In drainage ditch west of Building 105 and along the northern side of the railroad tracks (R-15).
18SS009	In drainage ditch west of Building 184.
18SS010	Adjacent to culvert located across the road and northeast of Building 2518.
18SS011	Northeastern side of Building 105 along the top of the berm in line with the building roof vent.
18SS012	In drainage ditch in the area of the southwest corner of Building 105 and along the southern side of the railroad tracks (R-15) that run parallel to the building.

CONTRACT NO. N1245

APPROVED BY ____ DATE ____

APPROVED BY ____ DATE ____

DRAWING NO. FIGURE 3 - 4

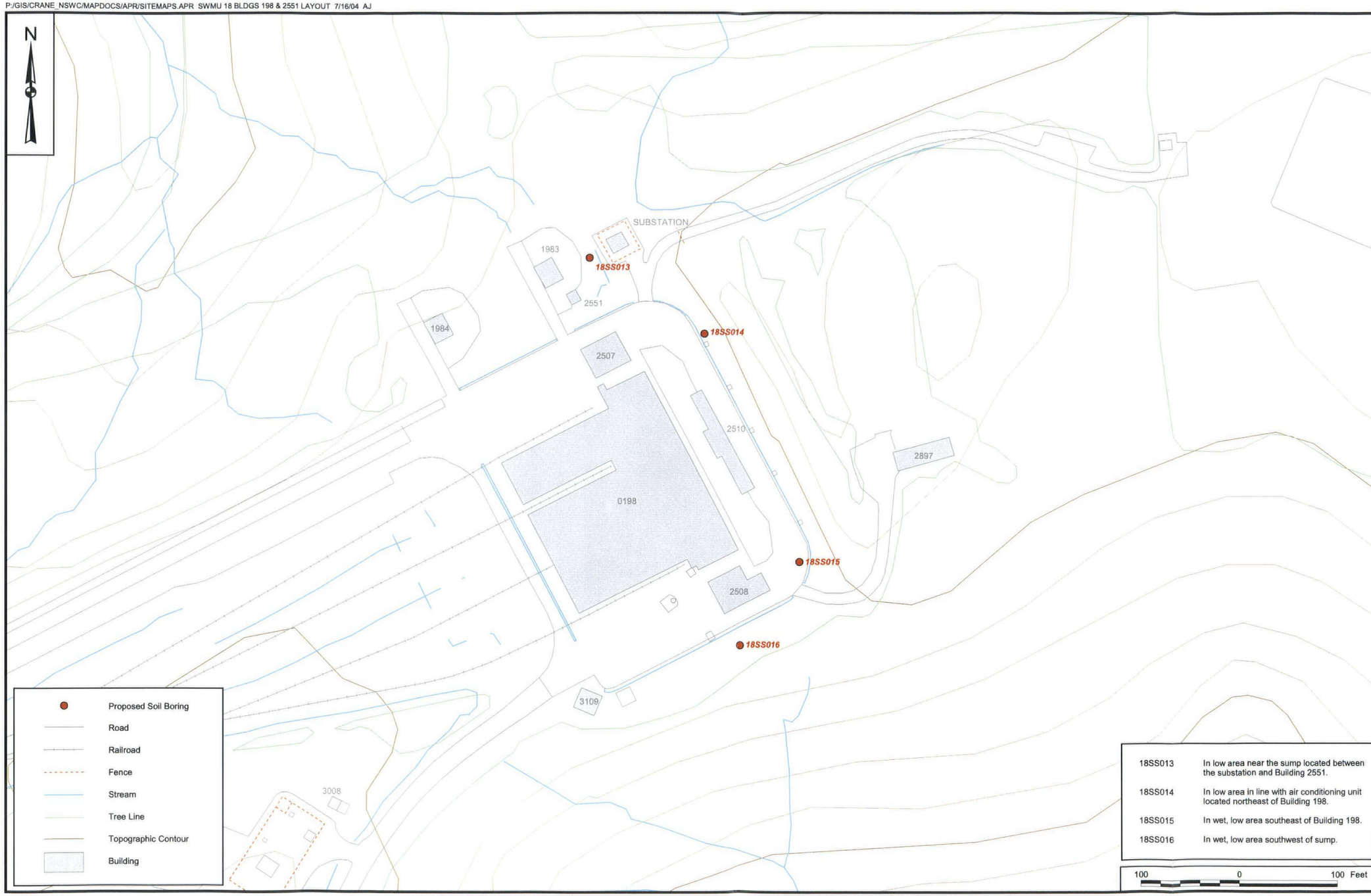
REV 0

PROPOSED SOIL SAMPLING LOCATIONS
SWMU 18 BUILDING 105 (LOAD AND FILL AREA)
NSWC CRANE
CRANE, INDIANA

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

DRAWN BY A. JANOCHA	DATE 5/17/04
CHECKED BY V. PLACHY	DATE 7/16/04
COST/SCHED-AREA	
SCALE AS NOTED	

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SITEMAPS.APR SWMU 18 BLDGS 198 & 2551 LAYOUT 7/16/04 AJ



18SS013	In low area near the sump located between the substation and Building 2551.
18SS014	In low area in line with air conditioning unit located northeast of Building 198.
18SS015	In wet, low area southeast of Building 198.
18SS016	In wet, low area southwest of sump.

CONTRACT NO. N1245

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 3 - 5

REV 0

PROPOSED SOIL SAMPLING LOCATIONS
SWMU 18 BUILDING 198 (LOAD AND FILL AREA)
NSWC CRANE
CRANE, INDIANA

DEPARTMENT OF THE NAVY ★ SOUTHERN DIV FACILITIES ENGINEERING COMD ★

DRAWN BY A. JANOCHA	DATE 5/17/04	CHECKED BY V. PLACHY	DATE 7/16/04
COST/SCHED-AREA		SCALE AS NOTED	

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SITEMAPS.APR SWMU 18 BLDG 200 LAYOUT 7/16/04 AJ

18SS017	Near culvert inside the fence and east of Building 2504.
18SS018	Near culvert inside the fence and southeast of Building 200.
18SS019	Near catch basin south of Building 200.
18SS020	Near culvert inside the fence, southwest of Building 200.
18SS021	Near culvert west of Building 200 and between the railroad tracks.

CONTRACT NO. N1245

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 3 - 6

REV 0

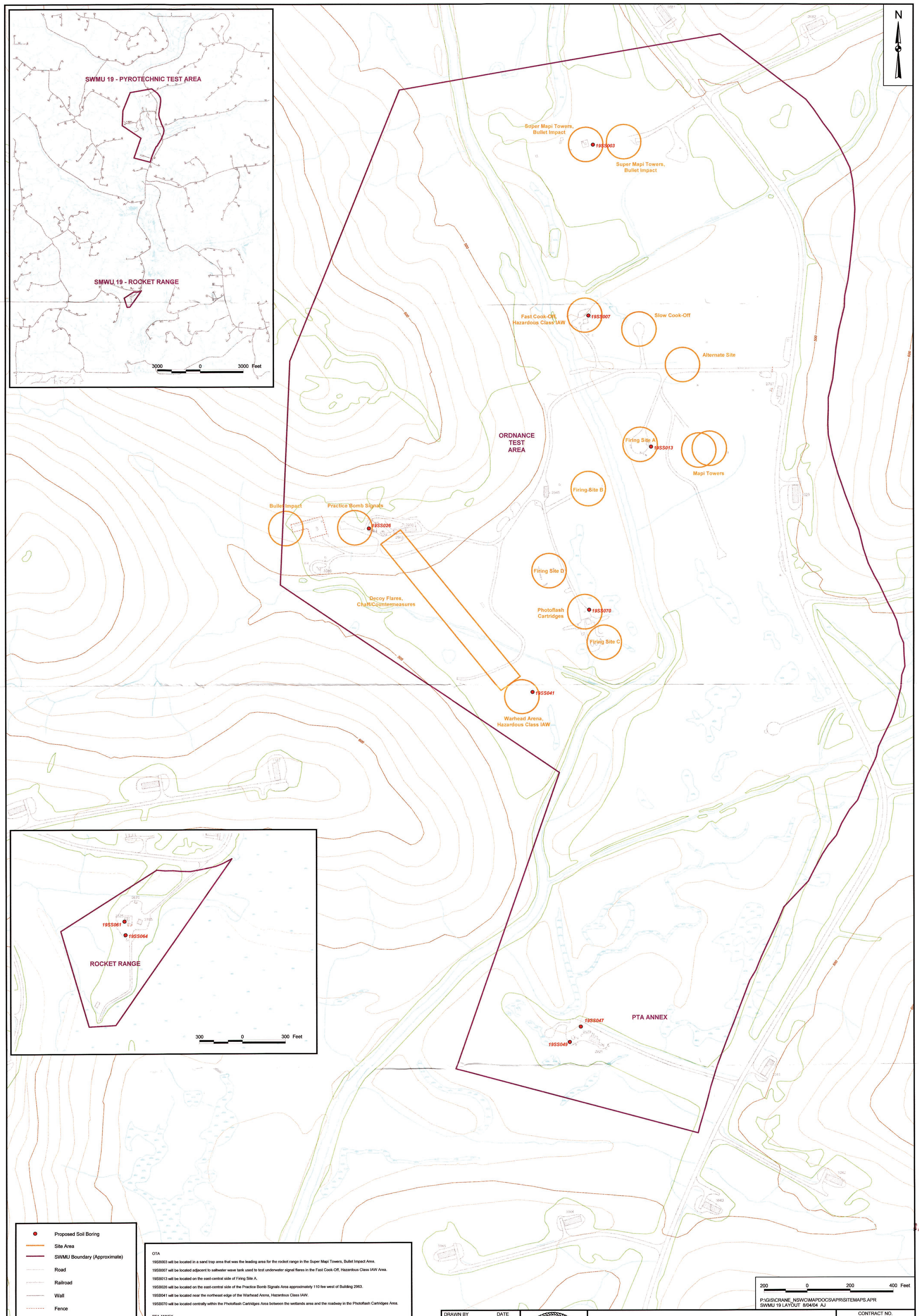
PROPOSED SOIL SAMPLING LOCATIONS
SWMU 18 BUILDING 200 (LOAD AND FILL AREA)
NSWC CRANE
CRANE, INDIANA

DRAWN BY A. JANOCHA DATE 5/17/04

CHECKED BY V. PLACHY DATE 7/16/04

COST/SCHED-AREA

SCALE AS NOTED



OTA

19SB003 will be located in a sand trap area that was the leading area for the rocket range in the Super Mapi Towers, Bullet Impact Area.

19SB007 will be located adjacent to saltwater wave tank used to test underwater signal flares in the Fast Cook-Off, Hazardous Class IAW Area.

19SB013 will be located on the east-central side of Firing Site A.

19SB026 will be located on the east-central side of the Practice Bomb Signals Area approximately 110 fee west of Building 2963.

19SB041 will be located near the northeast edge of the Warhead Arena, Hazardous Class IAW.

19SB070 will be located centrally within the Photoflash Cartridges Area between the wetlands area and the roadway in the Photoflash Cartridges Area.

PTA ANNEX

19SB047 will be located approximately 60 feet northwest of Building 2923.

19SB049 will be located approximately 80 feet southwest of Building 2923.

ROCKET RANGE

19SB061 will be located along the southwestern corner of Building 2125.

19SB064 will be located north of the roadway approximately 100 feet south of Building 2125.

DRAWN BY	DATE
A. JANOCHA	5/17/04
CHECKED BY	DATE
V. PLACHY	8/04/04
REVISED BY	DATE
—	—
SCALE	
AS NOTED	

DEPARTMENT OF THE NAVY ★ SOUTHERN DIV FACILITIES ENGINEERING COMD

PROPOSED SOIL SAMPLING LOCATIONS
SWMU 19 [PYROTECHNIC TEST AREA (PTA)]
NSWC CRANE
CRANE, INDIANA

CONTRACT NO.	
N1245	
OWNER NO.	
CTO 0331	
APPROVED BY	DATE
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DRAWING NO.	REV.
FIGURE 3 - 7	0

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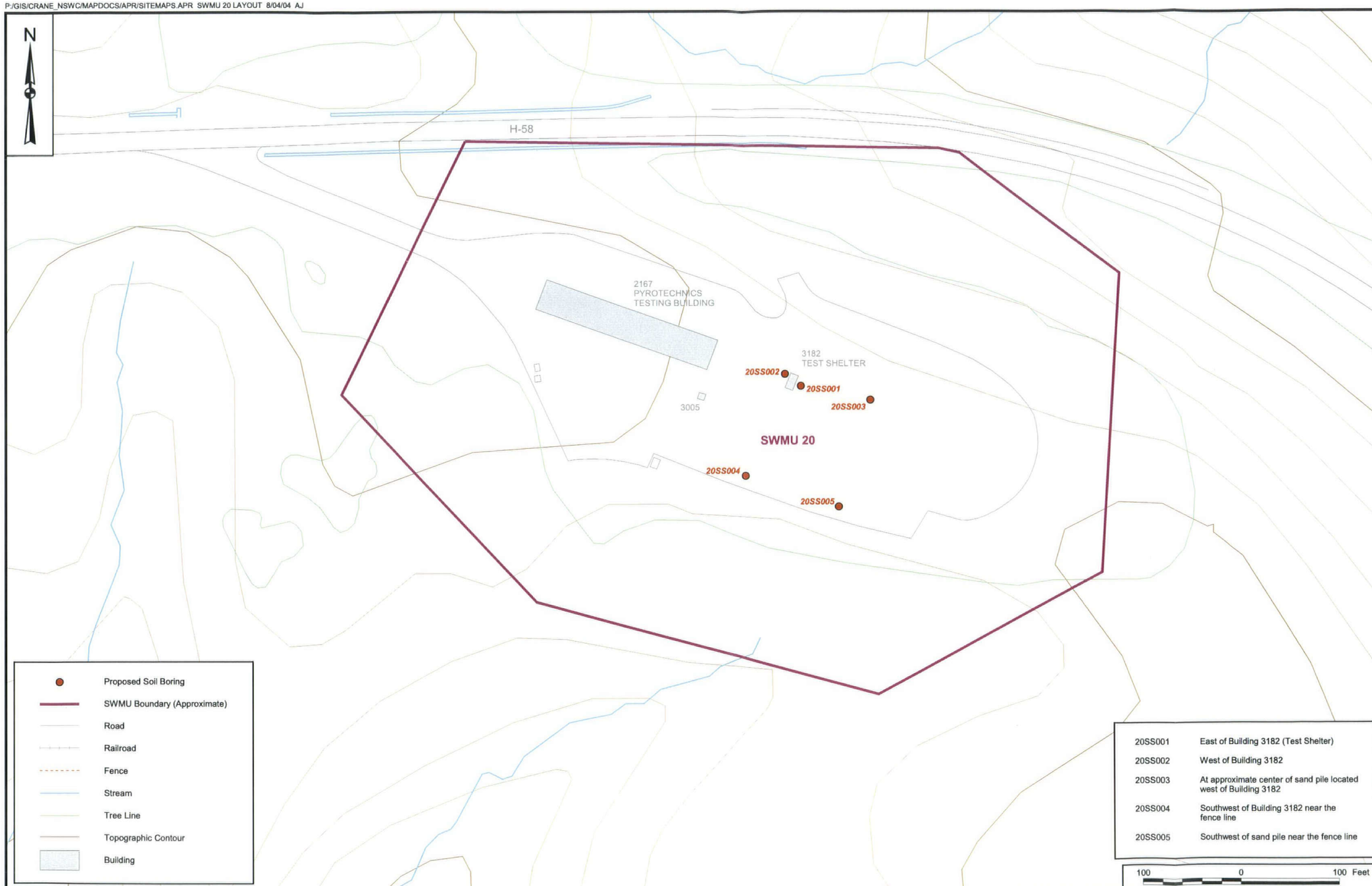


20SS001	East of Building 3182 (Test Shelter)
20SS002	West of Building 3182
20SS003	At approximate center of sand pile located west of Building 3182
20SS004	Southwest of Building 3182 near the fence line
20SS005	Southwest of sand pile near the fence line

CONTRACT NO. N1245

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 3 - 8

REV 0

PROPOSED SOIL SAMPLING LOCATIONS
SWMU 20 BUILDING 3182 AREA (CAAA QA/QC TEST AREA)
NSWC CRANE
CRANE, INDIANA

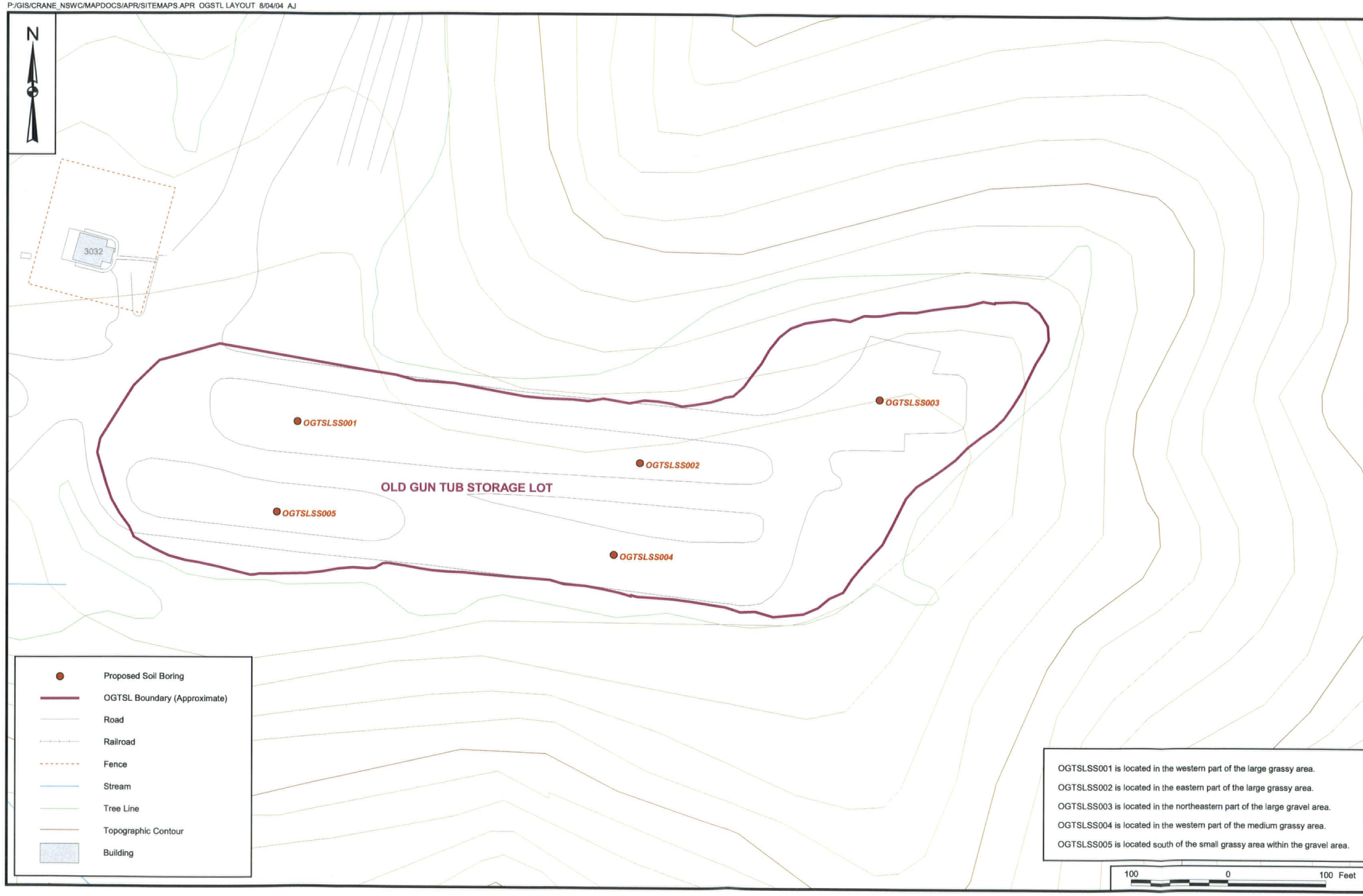
DRAWN BY A. JANOCHA DATE 5/17/04

CHECKED BY V. PLACHY DATE 8/04/04

COST/SCHED-AREA

SCALE AS NOTED

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SITEMAPS.APR OGSTL LAYOUT 8/04/04 AJ



OGTSLSS001 is located in the western part of the large grassy area.
OGTSLSS002 is located in the eastern part of the large grassy area.
OGTSLSS003 is located in the northeastern part of the large gravel area.
OGTSLSS004 is located in the western part of the medium grassy area.
OGTSLSS005 is located south of the small grassy area within the gravel area.

CONTRACT NO. N1245

APPROVED BY ____ DATE ____

APPROVED BY ____ DATE ____

DRAWING NO. FIGURE 3 - 9

REV 0

PROPOSED SOIL SAMPLING LOCATIONS
OLD GUN TUB STORAGE LOT
NSWC CRANE
CRANE, INDIANA

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

DRAWN BY A. JANOCHA DATE 5/17/04

CHECKED BY V. PLACHY DATE 8/04/04

COST/SCHED-AREA

SCALE AS NOTED

4.0 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 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, air carrier, 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.

4.1 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 will be completed to the fullest extent possible for each sample cooler used for shipment. The forms will be legibly completed with waterproof ink and signed (and dated) by the sampler(s). 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 CTO331-03 (Appendix E).

Information similar to that contained on the COC form is provided on the sample label, which is securely attached to the sample bottle. Sample labels 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, sample number, and a space for the laboratory sample number. The procedures for sample numbering by TtNUS are described in SOP CTO331-02 (Appendix E).

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 and activities such as weather conditions, dates and 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 will be recorded. Field logbook assignments will be recorded in the site logbook or other central file, the location of which will be known by the FOL and the TOM. All field logbook assignments, use, control, and archiving are governed by SOP CTO331-03 (Appendix E). Examples of all forms to be used during sampling activities are also provided in SOP CTO331-03 or in individual SOPs (Appendix E). 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 CTO331-05, 331-06, 331-08, 331-19, and 331-20 (Appendix E) describe procedures for sample screening, packaging, and shipment. A temperature blank will be included in each cooler containing samples. Each cooler that contains samples to be analyzed for VOCs will also include a trip blank. Each cooler will be taped shut with strapping tape in at least two places to prevent tampering. Custody seals will be attached as described in SOP CTO331-03 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 FOL 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 4.2).

4.2 LABORATORY CUSTODY PROCEDURES

When the laboratory receives a shipment of samples, the 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 and in laboratory-specific documents, as appropriate. 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 laboratory SOPs governing sample handling and tracking.

4.3 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 the custody of the NSWC Crane site manager. The control file will include the following 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 50 years. Prior to disposal of all Administrative Records, the records will be offered to IDEM.

5.0 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. For this investigation, field instrument calibration is described in Section 5.1, and laboratory instrument calibration is outlined in Section 5.2.

5.1 FIELD INSTRUMENT CALIBRATION

Various instruments will be required for field measurements during this investigation and will include the following:

- Multi-parameter water-quality meter
- LaMotte turbidity meter
- Electronic water-level meter
- PID

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 CTO331-06 and 331-14 of Appendix E). 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 a negative 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.

Accuracy checks include one or more of the following: 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.

5.2 LABORATORY INSTRUMENT CALIBRATION

Calibration procedures for metals analyses by inductively coupled plasma/mass spectroscopy (ICP/MS) 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 or 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 than 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 concentrations. 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 (e.g., perchlorate) begin with a daily calibration via a number of calibration standards at varying concentrations for each analyte. After an acceptable calibration linearity is established, an initial calibration verification 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 will 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 will 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.

6.0 ANALYTICAL AND MEASUREMENT PROCEDURES

Field measurement and laboratory analytical procedures are presented in this section.

6.1 FIELD MEASUREMENT PROCEDURES

Chemical and physical parameters to be measured using field instrumentation are listed in Table 1-1. The field target parameters and the rationales for including them in the SWMU-specific analysis schemes are presented in Tables 1-3, 1-4, and 1-5. Measurement of field parameters is described in detail in Section 3.0. Calibration of field instruments is discussed in Section 5.0 and in individual field measurement SOPs (Appendix E).

6.2 LABORATORY ANALYTICAL AND MEASUREMENT PROCEDURES

The laboratory analyses will be performed by Laucks Testing Laboratories. Laucks Testing Laboratories has successfully completed the laboratory evaluation process required as part of the Naval Facilities Engineering Services Command (NFESC) QA Program and described in the Navy Installation Restoration Laboratory Quality Assurance Guide (NFESC, 1996). Table 6-1 provides a summary of the laboratory analytical methods and associated laboratory SOPs to be used during this investigation.

6.2.1 List of Project Target Compounds and Detection Limits

A list of the laboratory target analytes, project-specific RBTLs, and laboratory-specific TVs for organic compounds and miscellaneous parameters, IDLs for metals, and RLs is provided in Table 1-5. The TVs are defined as the lowest value at which the laboratory can reliably detect and confirm the presence of target compounds. The TVs are based on laboratory experience and MDLs that have been experimentally determined using the applicable laboratory SOP(s). This procedure is 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 the applicable laboratory SOP. 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, TV, 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.

6.2.2 List of Associated Quality Control Samples

Field and laboratory QC samples to be analyzed in support of this project are identified in Section 3.0 and Section 7.0. The analytical SOPs address minimum QC requirements for each associated analytical method. The SOPs include calibration QC requirements. Details on QC sample usage are provided in Section 7.0.

TABLE 6-1

SUMMARY OF ORGANIC, INORGANIC, AND MISCELLANEOUS ANALYTICAL PROCEDURES FOR SOLID AND AQUEOUS SAMPLES
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

Analytical Parameter [1]	Preparation Method [2,3,4]	Analytical Method	Preparation/Analytical SOP(s)
ENERGETICS			
SW-846 8330	Aqueous SW-846 8330 Solid SW-846 8330	SW-846 8330	Aqueous LTL-3077 / LTL-8330 Solid LTL-3161 / LTL-8330
Perchlorate	EPA Method 314.0	EPA Method 314.0	Aqueous LTL-9136 Solid LTL-9136
METALS			
Metals (except Antimony, Tin, and Mercury)	Aqueous SW-846 Methods 3010A (**no** HCl) or 3015 (**no** HCl) Solid SW-846 Method 3050B (include H_2O_2 but **no** HCl)	SW-846 Method 6020	Aqueous LTL-7009 or LTL-7010/ LTL-7202 Solid LTL-7015/ LTL-7202
Antimony and Tin	Aqueous SW-846 Methods 3010A or 3015 (**no** H_2O_2) Solid SW-846 Method 3050B (include HCl but **no** H_2O_2)	SW-846 Method 6020	Aqueous LTL-7009 or LTL-7010/ LTL-7202 Solid LTL-7015/ LTL-7202
Mercury	Aqueous SW-846 Method 7470A Solid SW-846 Method 7471A	Aqueous SW-846 Method 7470A Solid SW-846 Method 7471A	Aqueous LTL-7501 Solid LTL-7501

TABLE 6-1

SUMMARY OF ORGANIC, INORGANIC, AND MISCELLANEOUS ANALYTICAL PROCEDURES
FOR SOLID AND AQUEOUS SAMPLES
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

Analytical Parameter [1]	Preparation Method [2,3,4]	Analytical Method	Preparation/Analytical SOP(s)
VOLATILES			
SW-846 8260B	Aqueous SW-846 Method 8260B (25 mL purge) Solid SW-846 Method 5035 (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
SW-846 8015B	Aqueous SW-846 Method 8015B (25 mL purge) Solid SW-846 Method 5035 (5 g purge)	SW-846 Method 8015B	LTL-8019
SEMIVOLATILES			
SW-846 8270C	Aqueous SW-846 Method 3520C Solid SW-846 Method 3550B	SW-846 Method 8270C	Aqueous LTL-3000 / LTL-8279 Solid LTL-3100 / LTL-8279
Selective Ion Monitoring SW-846 Methods 8270C	Aqueous SW-846 Method 3520C Solid SW-846 Method 3550B	SW-846 Methods 8270C-SIM	Aqueous LTL-3001 / LTL-8277 Solid LTL-3450 / LTL-8277
Hexachlorophene and Pentachlorophenol	SW-846 Method 8151A	SW-846 Method 8151A	Aqueous LTL-3510 / LTL-8151 Solid LTL-3011 / LTL-8151

TABLE 6-1

SUMMARY OF ORGANIC, INORGANIC, AND MISCELLANEOUS ANALYTICAL PROCEDURES
FOR SOLID AND AQUEOUS SAMPLES
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

Analytical Parameter [1]	Preparation Method [2,3,4]	Analytical Method	Preparation/Analytical SOP(s)
PESTICIDES			
Pesticides	SW-846 Method 8081	SW-846 Method 8081	Aqueous LTL-3202 / LTL-8084 Solid LTL-3302 / LTL-8084
PCBs			
PCBs SW-846 8082	SW-846 Method 8082	SW-846 Method 8082	Aqueous LTL-3202 / LTL-8084 Solid LTL-3302 / LTL-8084
HERBICIDES			
Herbicides	SW-846 Method 8151	SW-846 Method 8151	Aqueous LTL-3510 / LTL-8151 Solid LTL-3011 / LTL-8151
MISCELLANEOUS PARAMETERS			
Total organic carbon	Aqueous SW-846 9060 Solid Lloyd Kahn	Aqueous SW-846 9060 Solid Lloyd Kahn	Aqueous LTL-9115 Solid LTL-9116
Hardness	Standard Method 2340B	Standard Method 2340B	Calculation
pH	SW-846 Method 9045C	SW-846 Method 9045C	Solid LTL-9113
Cation exchange capacity	SW-846 Method 9081	SW-846 Method 9081	Solid LTL-6006
Cyanide	SW-846 Method 9012A	SW-846 Method 9012A	Aqueous and Solid LTL-9104
Nitrate + nitrite as nitrate	EPA 353.2	EPA 353.2	Aqueous LTL-9125

TABLE 6-1

SUMMARY OF ORGANIC, INORGANIC, AND MISCELLANEOUS ANALYTICAL PROCEDURES FOR SOLID AND AQUEOUS SAMPLES SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL NSWC CRANE, CRANE, INDIANA

TBD – To be determined.

1 Reference Table 1-5 of Section 1.0 for the specific compounds.
2 U.S. EPA, 1986. Test methods for Evaluating Solid Wastes, Physical/Chemical Methods. SW-846, Third Edition and subsequent updates.
3 U.S. EPA Chemical Analyses of Water and Wastewater, March 1983.
4 Standard Method for the Analysis of Waters and Wastewaters, American Public Health Association and others, 20th edition, 1998.

7.0 INTERNAL QUALITY CONTROL CHECKS

Field and laboratory QC samples will be routinely analyzed to evaluate overall data quality. This section provides information regarding those internal QC checks. The overall QA objective for this project is to develop and implement procedures for field sampling, COC, 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 1.0 of this QAPP. The manner in which decision making will be based on data comparisons is described in Sections 1.5.4 and 8.0. Specific procedures for sampling, COC, 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 to provide direct insight into the variability of target analyte data in soils and ground water.

The precision, accuracy, representativeness, comparability, and completeness (PARCC) parameters are qualitative and quantitative statements regarding the quality characteristics of the data used to support project objectives and, ultimately, environmental decisions. These parameters are described in the remainder of this section. Equations used to compute accuracy, precision, and completeness values are provided in Section 8.0.

7.1 PRECISION

7.1.1 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, discounting 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 and sediment duplicate samples have been assigned accordingly in Table 7-1. Results outside these limits will trigger corrective actions, which are presented in Table 3-11.

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.

7.1.2 Field Precision Objectives

Field precision is assessed by collecting and measuring field duplicate samples. Acceptance limits for field duplicate precision are provided in Table 3-11. 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 than laboratory duplicate precision, the underlying cause will be investigated to determine whether the observed difference could be a result of artifacts of sampling and analysis. Considerations given to this effort include the following:

- 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

7.1.3 Laboratory Precision Objectives

Laboratory precision QC samples [i.e., laboratory duplicates for inorganic chemicals and MSDs for organic chemicals] will be analyzed with a minimum frequency of five percent (i.e., one QC sample per 20 environmental samples). Laboratory precision is measured by comparing RPD values with precision control limits specified in Table 7-1.

7.2 ACCURACY

7.2.1 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 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 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 8.0. The equations in Section 8.0 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 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 3-11.

7.2.2 Field Accuracy Objectives

Field test kits are used in accordance with the manufacturer's accompanying instructions. Accuracy requirements for field measurements are typically ensured through control over sample collection and handling and through routine instrument calibration. In addition, after field measurements are completed 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 E). Accuracy of grain size and depositional environment classifications is ensured by requiring that a qualified field person 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 will 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 will be assured qualitatively through adherence to all sample handling, preservation, and holding-time requirements.

7.2.3 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 will be spiked with representative target analytes for the analysis being performed to ensure that accuracy measures are obtained for each target analyte. Spiking concentrations will 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 one per 20 associated samples of like matrix. Laboratory accuracy is assessed via comparison of calculated %R values to accuracy control limits specified in Table 7-2.

7.3 COMPLETENESS

7.3.1 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.

7.3.2 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 percent applies to these measurements. However, the 100 percent completeness criterion for depositional environment and grain size may be reduced, depending on whether these factors are significant for background comparisons, as determined based on the Base-Wide Background Soil Investigation for NSWC Crane. Furthermore, grain size and depositional environment information not documented in the field may be recoverable by inspecting field logs and site maps or through laboratory measurement after the samples are received by the laboratory. Failure to obtain 100 percent 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 before aqueous samples are collected to establish attainment of equilibrium, and its completeness criterion is 100 percent. There are no completeness criteria for DO, flow rate, ORP, water level, pH, specific conductance, and temperature. These are non-critical parameters 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.

7.3.3 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 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.

7.4 REPRESENTATIVENESS

7.4.1 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 3.0) and use of standardized sample collection, 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 8.0. Any anomalies will be investigated to assess their impact on statistical computations.

7.4.2 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 3.0) 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 3-1) will be monitored to ensure that ground water wells have attained equilibrium prior to sampling. Upstream surface water and sediment samples will be collected under conditions that are judged to best represent site characteristics in the absence of impacts from the SWMU.

7.4.3 Measures to Ensure Representativeness of Laboratory 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 generated data included consideration of past operations, 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 1.0 and 3.0.

7.5 COMPARABILITY

7.5.1 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 Table 1-5. 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.

7.5.2 Measures to Ensure Comparability of Field Data

Comparability depends upon the proper design of the sampling program and will be achieved by ensuring that Section 3.0 of this QAPP is followed and that proper sampling techniques are used. The rationale behind the SAP design is found in Sections 1.0 and 3.0.

7.5.3 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 described in Section 8.0 of this QAPP.

7.6 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. Each type of field QC sample, except trip blanks, 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 3-11. The types and numbers of QC samples to be collected in the field are presented in Table 3-3, 3-5, 3-7, and 3-8.

Laboratory QC encompasses a host of other checks performed during sample preparation and analysis. Frequencies for laboratory QC checks are provided in Table 3-11 and in the method-specific laboratory SOPs.

7.7 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 3-11. Some of the samples are identified in Table 3-11 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. Target precision and accuracy values, as applicable, for field QC samples are presented in Table 3-11.

7.7.1 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.

7.7.2 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 composite samples, field duplicates will be taken after the sample locations are mixed together in order to verify that the soils were sufficiently combined prior to sampling. 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.

7.7.3 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.

7.7.4 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.

7.7.5 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.

7.7.6 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.

7.8 LABORATORY QUALITY CONTROL CHECKS

The analytical laboratory operates a QC program that assures data users of the reliability and validity of the data generated through chemical analyses. The 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. Table 6-1 lists the SOPs associated with each analytical procedure. In addition, the laboratories maintain SOPs regarding general laboratory QA operations.

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 7-1 and 7-2. The applicable analytical SOPs should be consulted for calibration QC measures.

7.8.1 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 (for soil and sediment analyses) or blank spikes (for 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.

Based on NFESC QA program requirements, if recovery of an LCS falls outside the control limits (see Table 7-2), the laboratory will reject the data for the analytical batch and take corrective action. The associated samples, extracts, or digestates may be re-analyzed 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 re-analysis is not possible, the data will be flagged, and the sample delivery group (SDG) narrative will include details of the failed LCS.

7.8.2 Laboratory Duplicates

Laboratory duplicates will be analyzed for metals and miscellaneous parameters 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 the sample is mixed. If chemical analysis RPD values exceed QC limits for laboratory duplicates (Table 7-1), 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.

7.8.3 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 percent to +100 percent from the associated 12-hour calibration standard.

7.8.4 Laboratory Method Blanks

Laboratory method blanks or preparation blanks are analyte-free matrices 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, Teflon® beads, or glass beads) 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. Under no circumstances should laboratory method blank contaminant values be subtracted from environmental sample analytical results.

7.8.5 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 effect of the sample matrix on the sample preparation and measurement methodology.

MSs, 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. If the MS recovery is not within applicable control limits (as listed in Table 7-2), 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 batch QC elements 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 re-preparation and re-analysis will not be required. If any of the batch QC elements 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 volume is available, or if holding times have passed, the laboratory will flag the associated data. Details of non-compliant and laboratory duplicate results will be included in the SDG narrative.

7.8.6 Matrix Spike Duplicates

MSDs are duplicates of MSs 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 prevents the calculation of RPD values. Precision criteria for lab duplicates (inorganics only) and MSDs are presented in Table 7-1.

7.8.7 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 MS recovery falls outside control limits. Comparing accuracy (%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.

7.8.8 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 non-compliant surrogate recoveries are provided in the relevant SOPs. Details of non-compliant surrogate recoveries will be included in the SDG narrative. Accuracy criteria for surrogates are included in Table 7-2.

7.8.9 Additional Laboratory QC Checks

Additional internal laboratory QC checks include mass tuning for GC/MS analysis, second-column confirmation for GC and HPLC analyses, etc. Specific QC requirements for each of these QC checks are provided in the applicable SOPs.

TABLE 7-1

AQUEOUS AND SOLID RELATIVE PERCENT DIFFERENCE QUALITY CONTROL LIMITS FOR LABORATORY CONTOL SAMPLES, MATRIX SPIKES, AND LABORATORY DUPLICATES
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	AQUEOUS[1]			SOLID[1]		
		LCSD RPD	MSD RPD	LABDUP RPD	LCSD RPD	MSD RPD	LABDUP RPD
EXPLOSIVES (NITROAROMATICS AND NITRAMINES) SW-846 METHOD 8330							
1,3,5-Trinitrobenzene	99-35-4	NA	30	NA	NA	50	NA
1,3-Dinitrobenzene	99-65-0	NA	30	NA	NA	50	NA
2,4,6-Trinitrotoluene (TNT)	118-96-7	NA	30	NA	NA	50	NA
2,4-Dinitrotoluene	121-14-2	NA	30	NA	NA	50	NA
2,6-Dinitrotoluene	606-20-2	NA	30	NA	NA	50	NA
2-Amino-4,6-dinitrotoluene	35572-78-2	NA	30	NA	NA	50	NA
2-Nitrotoluene	88-72-2	NA	30	NA	NA	50	NA
3-Nitrotoluene	99-08-1	NA	30	NA	NA	50	NA
4-Amino-2,6-dinitrotoluene	1946-51-0	NA	30	NA	NA	50	NA
4-Nitrotoluene	99-99-0	NA	30	NA	NA	50	NA
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4	NA	30	NA	NA	50	NA
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	479-45-8	NA	30	NA	NA	50	NA
Nitrobenzene	98-95-3	NA	30	NA	NA	50	NA
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0	NA	30	NA	NA	50	NA
APPENDIX IX HERBICIDES (SW-846 METHOD 8151A)							
2,4-D	94-75-7	NA	35	NA	NA	44	NA
2,4,5-T	93-76-5	NA	40	NA	NA	43	NA
2,4,5-TP (Silvex)	93-72-1	NA	36	NA	NA	51	NA
Dinoseb[11]	88-85-7	NA	40	NA	NA	65	NA
Pentachlorophenol	87-86-5	NA	50	NA	NA	50	NA
Hexachlorophene	70-30-4	NA	36	NA	NA	50	NA
ORGANOCHLORINE PESTICIDES (SW-846 METHOD 8081A)							
Aldrin	309-00-2	NA	30	NA	NA	28	NA
Alpha-BHC	319-84-6	NA	37	NA	NA	34	NA
Alpha-chlordane	5103-71-9	NA	30	NA	NA	48	NA

TABLE 7-1

AQUEOUS AND SOLID RELATIVE PERCENT DIFFERENCE QUALITY CONTROL LIMITS FOR LABORATORY CONTOL SAMPLES, MATRIX SPIKES, AND LABORATORY DUPLICATES
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	AQUEOUS[1]			SOLID[1]		
		LCSD RPD	MSD RPD	LABDUP RPD	LCSD RPD	MSD RPD	LABDUP RPD
Beta-BHC	319-85-7	NA	32	NA	NA	30	NA
4,4'-DDD	72-54-8	NA	28	NA	NA	41	NA
4,4'-DDE	72-55-9	NA	11	NA	NA	47	NA
4,4'-DDT	50-29-3	NA	14	NA	NA	44	NA
Delta-BHC	319-86-8	NA	35	NA	NA	37	NA
Dieldrin	60-57-1	NA	27	NA	NA	33	NA
Endosulfan I	959-98-8	NA	9	NA	NA	37	NA
Endosulfan II	33213-65-9	NA	19	NA	NA	37	NA
Endosulfan sulfate	1031-07-8	NA	37	NA	NA	34	NA
Endrin	72-20-8	NA	12	NA	NA	34	NA
Endrin aldehyde	7421-93-4	NA	15	NA	NA	30	NA
Endrin Ketone	53494-70-5	NA	6	NA	NA	36	NA
Gamma-BHC (Lindane)	58-89-9	NA	27	NA	NA	29	NA
Gamma-chlordane	12789-03-6	NA	31	NA	NA	49	NA
Heptachlor	76-44-8	NA	28	NA	NA	25	NA
Heptachlor epoxide	1024-57-3	NA	27	NA	NA	52	NA
Methoxychlor	72-43-5	NA	28	NA	NA	39	NA
Toxaphene	8001-35-2	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
POLYCHLORINATED BIPHENYLS (SW-846 METHOD 8082)							
Aroclor-1016	12674-11-2	NA	20	NA	NA	16	NA
Aroclor-1221	11104-28-2	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Aroclor-1232	11141-16-5	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Aroclor-1242	53469-21-9	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Aroclor-1248	12672-29-6	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Aroclor-1254	11097-69-1	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Aroclor-1260	11096-82-5	NA	21	NA	NA	31	NA

TABLE 7-1

AQUEOUS AND SOLID RELATIVE PERCENT DIFFERENCE QUALITY CONTROL LIMITS FOR LABORATORY CONTOL SAMPLES, MATRIX SPIKES, AND LABORATORY DUPLICATES
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	AQUEOUS[1]			SOLID[1]		
		LCSD RPD	MSD RPD	LABDUP RPD	LCSD RPD	MSD RPD	LABDUP RPD
POLYNUCLEAR AROMATIC HYDROCARBONS SW-846 METHOD 8270C WITH SELECTIVE ION MONITORING							
2-Methylnaphthalene	91-57-6	NA	30	NA	NA	30	NA
Acenaphthene	83-32-9	NA	30	NA	NA	30	NA
Acenaphthylene	208-96-8	NA	30	NA	NA	30	NA
Anthracene	120-12-7	NA	41	NA	NA	30	NA
Benzo(a)anthracene	56-55-3	NA	30	NA	NA	50	NA
Benzo(a)pyrene	50-32-8	NA	50	NA	NA	30	NA
Benzo(b)fluoranthene	205-99-2	NA	30	NA	NA	30	NA
Benzo(g,h,i)perylene	191-24-2	NA	50	NA	NA	30	NA
Benzo(k)fluoranthene	207-08-9	NA	50	NA	NA	30	NA
Carbazole	86-74-8	NA	30	NA	NA	30	NA
Chrysene	218-01-9	NA	30	NA	NA	30	NA
Dibenzo(a,h)anthracene	53-70-3	NA	30	NA	NA	50	NA
Fluoranthene	206-44-0	NA	30	NA	NA	50	NA
Fluorene	86-73-7	NA	30	NA	NA	50	NA
Indeno(1,2,3-cd)pyrene	193-39-5	NA	50	NA	NA	30	NA
Naphthalene	91-20-3	NA	50	NA	NA	50	NA
Phenanthrene	85-01-8	NA	41	NA	NA	50	NA
Pyrene	129-00-0	NA	35	NA	NA	30	NA
SEMIVOLATILE ORGANIC COMPOUNDS (EXCEPT PAHs) SW-846 METHOD 8270C							
1,2,4,5-Tetrachlorobenzene	95-94-3	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
1,2,4-Trichlorobenzene	120-82-1	NA	30	NA	NA	30	NA
1,2-Dichlorobenzene	95-50-1	NA	30	NA	NA	30	NA
1,3-Dichlorobenzene	541-73-1	NA	30	NA	NA	30	NA
1,4-Dichlorobenzene	106-46-7	NA	30	NA	NA	30	NA

TABLE 7-1

AQUEOUS AND SOLID RELATIVE PERCENT DIFFERENCE QUALITY CONTROL LIMITS FOR LABORATORY CONTOL SAMPLES, MATRIX SPIKES, AND LABORATORY DUPLICATES
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	AQUEOUS[1]			SOLID[1]		
		LCSD RPD	MSD RPD	LABDUP RPD	LCSD RPD	MSD RPD	LABDUP RPD
1,4-Naphthoquinone	130-15-4	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
1,4-Phenylenediamine	106-50-3	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
1-Naphthylamine	134-32-7	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
2,3,4,6-Tetrachlorophenol	58-90-2	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
2,4,5-Trichlorophenol	95-95-4	NA	30	NA	NA	30	NA
2,4,6-Trichlorophenol	88-06-2	NA	30	NA	NA	30	NA
2,4-Dichlorophenol	120-83-2	NA	30	NA	NA	30	NA
2,4-Dimethylphenol	105-67-9	NA	30	NA	NA	30	NA
2,4-Dinitrophenol	51-28-5	NA	30	NA	NA	30	NA
2,6-Dichlorophenol	87-65-0	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
2-Acetylaminofluorene	53-96-3	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
2-Chloronaphthalene	91-58-7	NA	30	NA	NA	30	NA
2-Chlorophenol	95-57-8	NA	30	NA	NA	30	NA
2-Methylphenol	95-48-7	NA	30	NA	NA	30	NA
2-Naphthylamine	91-59-8	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
2-Nitroaniline	88-74-4	NA	30	NA	NA	30	NA
2-Nitrophenol	88-75-5	NA	30	NA	NA	30	NA
2-Picoline	109-06-8	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
3,3'-Dichlorobenzidine	91-94-1	NA	30	NA	NA	30	NA
3,3'-Dimethylbenzidine	119-93-7	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
3-Methylcholanthrene	56-49-5	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
3&4-Methylphenol[5]	1319-77-3	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
3-Nitroaniline	99-09-2	NA	30	NA	NA	30	NA
4,6-Dinitro-2-methylphenol	534-52-1	NA	30	NA	NA	30	NA
4-Aminobiphenyl	92-67-1	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
4-Bromophenyl phenyl ether	101-55-3	NA	30	NA	NA	30	NA

TABLE 7-1

AQUEOUS AND SOLID RELATIVE PERCENT DIFFERENCE QUALITY CONTROL LIMITS FOR LABORATORY CONTOL SAMPLES, MATRIX SPIKES, AND LABORATORY DUPLICATES
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	AQUEOUS[1]			SOLID[1]		
		LCSD RPD	MSD RPD	LABDUP RPD	LCSD RPD	MSD RPD	LABDUP RPD
4-Chloro-3-methylphenol	59-50-7	NA	30	NA	NA	30	NA
4-Chloroaniline	106-47-8	NA	30	NA	NA	30	NA
4-Chlorophenyl phenyl ether	7005-72-3	NA	30	NA	NA	30	NA
4-Nitroaniline	100-01-6	NA	30	NA	NA	30	NA
4-Nitrophenol	100-02-7	NA	30	NA	NA	30	NA
4-Nitroquinoline-1-oxide	56-57-5	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
5-Nitro-o-toluidine	99-55-8	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
7,12-Dimethylbenz(a)anthracene	57-97-6	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Acetophenone	98-86-2	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Aniline	62-53-3	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Aramite	140-57-8	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Benzyl alcohol	100-51-6	NA	30	NA	NA	30	NA
Bis(2-chloroethoxy)methane	111-91-1	NA	30	NA	NA	30	NA
Bis(2-chloroethyl)ether	111-44-4	NA	30	NA	NA	30	NA
Bis(2-chloroisopropyl)ether	108-60-1	NA	30	NA	NA	42	NA
Bis(2-ethylhexyl)phthalate	117-81-7	NA	30	NA	NA	30	NA
Butyl benzyl phthalate	85-68-7	NA	30	NA	NA	30	NA
Chlorobenzilate	510-15-6	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Diallate	2303-16-4	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Di-n-butyl phthalate	84-74-2	NA	30	NA	NA	30	NA
Di-n-octyl phthalate	117-84-0	NA	30	NA	NA	50	NA
Dibenzofuran	132-64-9	NA	30	NA	NA	30	NA
Diethyl phthalate	84-66-2	NA	30	NA	NA	30	NA
p-(Dimethylamino)azobenzene	60-11-7	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
a,a-Dimethylphenethylamine	122-09-8	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Dimethyl phthalate	131-11-3	NA	30	NA	NA	30	NA

TABLE 7-1

AQUEOUS AND SOLID RELATIVE PERCENT DIFFERENCE QUALITY CONTROL LIMITS FOR LABORATORY CONTOL SAMPLES, MATRIX SPIKES, AND LABORATORY DUPLICATES
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	AQUEOUS[1]			SOLID[1]		
		LCSD RPD	MSD RPD	LABDUP RPD	LCSD RPD	MSD RPD	LABDUP RPD
Diphenylamine [6]	122-39-4	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Ethyl methane sulfonate	62-50-0	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Hexachlorobenzene	118-74-1	NA	30	NA	NA	30	NA
Hexachlorobutadiene	87-68-3	NA	30	NA	NA	30	NA
Hexachlorocyclopentadiene	77-47-4	NA	50	NA	NA	30	NA
Hexachloroethane	67-72-1	NA	30	NA	NA	30	NA
Hexachloropropene	1888-71-7	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Isodrin	465-73-6	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Isophorone	78-59-1	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Isosafrole	120-58-1	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Kepone	143-50-0	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Methapyrilene	91-80-5	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Methyl methane sulfonate	66-27-3	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
n-Nitrosodi-n-butylamine	924-16-3	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
n-Nitrosodiethylamine	55-18-5	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
n-Nitrosodimethylamine	62-75-9	NA	30	NA	NA	50	NA
n-Nitrosodi-n-propylamine	621-64-7	NA	30	NA	NA	30	NA
n-Nitrosomethylethylamine	62-75-9	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
n-Nitrosomorpholine	59-89-2	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
n-Nitrosopiperidine	100-75-4	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
n-Nitrosopyrrolidine	930-55-2	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Pentachlorobenzene	608-93-5	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Pentachloroethane	76-01-7	NA	50	NA	NA	50	NA
Pentachloronitrobenzene	82-68-8	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Phenacetin	62-44-2	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Phenol	108-95-2	NA	30	NA	NA	30	NA

TABLE 7-1

AQUEOUS AND SOLID RELATIVE PERCENT DIFFERENCE QUALITY CONTROL LIMITS FOR LABORATORY CONTOL SAMPLES, MATRIX SPIKES, AND LABORATORY DUPLICATES
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	AQUEOUS[1]			SOLID[1]		
		LCSD RPD	MSD RPD	LABDUP RPD	LCSD RPD	MSD RPD	LABDUP RPD
Pronamide	23950-58-5	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Pyridine	110-86-1	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Safrole	94-59-7	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
o-Toluidine	95-53-4	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
O,O,O-Triethyl phosphorothioate	126-68-1	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
TAL METALS PLUS TIN SW-846 Method 6020							
Aluminum	7429-90-5	NA	NA	20	NA	NA	20
Antimony	7440-36-0	NA	NA	20	NA	NA	20
Arsenic	7440-38-2	NA	NA	20	NA	NA	20
Barium	7440-39-3	NA	NA	20	NA	NA	20
Beryllium	7440-41-7	NA	NA	20	NA	NA	20
Cadmium	7440-43-9	NA	NA	20	NA	NA	20
Calcium	7440-70-2	NA	NA	20	NA	NA	20
Chromium (total)	7440-47-3	NA	NA	20	NA	NA	20
Cobalt	7440-48-4	NA	NA	20	NA	NA	20
Copper	7440-50-8	NA	NA	20	NA	NA	20
Iron	7439-89-6	NA	NA	20	NA	NA	20
Lead	7439-92-1	NA	NA	20	NA	NA	20
Magnesium	7439-95-4	NA	NA	20	NA	NA	20
Manganese	7439-96-5	NA	NA	20	NA	NA	20
Nickel	7440-02-0	NA	NA	20	NA	NA	20
Potassium	7440-09-7	NA	NA	20	NA	NA	20
Selenium	7782-49-2	NA	NA	20	NA	NA	20
Silver	7440-22-4	NA	NA	20	NA	NA	20
Sodium	7440-23-5	NA	NA	20	NA	NA	20
Thallium	7440-28-0	NA	NA	20	NA	NA	20

TABLE 7-1

AQUEOUS AND SOLID RELATIVE PERCENT DIFFERENCE QUALITY CONTROL LIMITS FOR LABORATORY CONTOL SAMPLES, MATRIX SPIKES, AND LABORATORY DUPLICATES
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	AQUEOUS[1]			SOLID[1]		
		LCSD RPD	MSD RPD	LABDUP RPD	LCSD RPD	MSD RPD	LABDUP RPD
Tin	7440-31-5	NA	NA	20	NA	NA	20
Vanadium	7440-62-2	NA	NA	20	NA	NA	20
Zinc	7440-66-6	NA	NA	20	NA	NA	20
SW-846 7470A/7471A							
Mercury	7439-97-6	NA	20	NA	NA	20	NA
VOLATILE ORGANIC COMPOUNDS SW-846 METHOD 5035B/8260B							
1,1,1-Trichloroethane	71-55-6	NA	20	NA	NA	24	NA
1,1,1,2-Tetrachloroethane	630-20-6	NA	20	NA	NA	20	NA
1,1,2,2-Tetrachloroethane	79-34-5	NA	20	NA	NA	41	NA
1,1,2-Trichloroethane	79-00-5	NA	20	NA	NA	30	NA
1,2,3-Trichloropropane	96-18-4	NA	20	NA	NA	20	NA
1,1-Dichloroethane	75-34-3	NA	20	NA	NA	33	NA
1,1-Dichloroethene	75-35-4	NA	20	NA	NA	34	NA
1,2-Dibromo-3-chloropropane	96-12-8	NA	20	NA	NA	20	NA
1,2-Dibromoethane	106-93-4	NA	20	NA	NA	20	NA
1,2-Dichloroethane	107-06-2	NA	20	NA	NA	26	NA
1,2-Dichloropropane	78-87-5	NA	20	NA	NA	26	NA
2-Butanone	78-93-3	NA	20	NA	NA	50	NA
2-Chloro-1,3-butadiene (chloroprene)	126-99-8	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
2-Hexanone	591-78-6	NA	20	NA	NA	50	NA
4-Methyl-2-pentanone	108-10-1	NA	20	NA	NA	50	NA
Acetone	67-64-1	NA	20	NA	NA	50	NA
Acrolein	107-02-8	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Acrylonitrile	107-13-1	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Allyl chloride (3-chloro-1-propene)	107-05-1	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Benzene	71-43-2	NA	20	NA	NA	37	NA

TABLE 7-1

AQUEOUS AND SOLID RELATIVE PERCENT DIFFERENCE QUALITY CONTROL LIMITS FOR LABORATORY CONTOL SAMPLES, MATRIX SPIKES, AND LABORATORY DUPLICATES
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	AQUEOUS[1]			SOLID[1]		
		LCSD RPD	MSD RPD	LABDUP RPD	LCSD RPD	MSD RPD	LABDUP RPD
Bromodichloromethane	75-27-4	NA	20	NA	NA	30	NA
Bromoform	75-25-2	NA	20	NA	NA	47	NA
Bromomethane	74-83-9	NA	20	NA	NA	50	NA
Carbon disulfide	75-15-0	NA	20	NA	NA	50	NA
Carbon tetrachloride	56-23-5	NA	20	NA	NA	21	NA
Chlorobenzene	108-90-7	NA	20	NA	NA	45	NA
Chloroethane	75-00-3	NA	20	NA	NA	48	NA
Chloroform	67-66-3	NA	20	NA	NA	21	NA
Chloromethane	74-87-3	NA	20	NA	NA	50	NA
cis-1,2-Dichloroethene	156-59-2	NA	20	NA	NA	24	NA
cis-1,3-Dichloropropene	10061-01-5	NA	20	NA	NA	39	NA
Dibromochloromethane	124-48-1	NA	20	NA	NA	33	NA
Dibromomethane	74-95-3	NA	20	NA	NA	20	NA
Dichlorodifluoromethane	75-71-8	NA	20	NA	NA	20	NA
Ethylbenzene	100-41-4	NA	20	NA	NA	41	NA
Ethyl methacrylate	97-63-2	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Methacrylonitrile	126-98-7	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Methylene chloride	75-09-2	NA	20	NA	NA	50	NA
Methyl iodide	74-88-4	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Methyl methacrylate	80-62-6	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Methyl tert-Butyl Ether	1634-04-4	NA	20	NA	NA	20	NA
Styrene	100-42-5	NA	20	NA	NA	36	NA
Tetrachloroethene	127-18-4	NA	20	NA	NA	34	NA
Toluene	108-88-3	NA	20	NA	NA	37	NA
trans-1,2-Dichloroethene	156-60-5	NA	20	NA	NA	23	NA
trans-1,3-Dichloropropene	10061-02-6	NA	20	NA	NA	39	NA
trans-1,4-Dichloro-2-butene	110-57-6	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]

TABLE 7-1

AQUEOUS AND SOLID RELATIVE PERCENT DIFFERENCE QUALITY CONTROL LIMITS FOR LABORATORY CONTOL SAMPLES, MATRIX SPIKES, AND LABORATORY DUPLICATES
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	AQUEOUS[1]			SOLID[1]		
		LCSD RPD	MSD RPD	LABDUP RPD	LCSD RPD	MSD RPD	LABDUP RPD
Trichloroethene	79-01-6	NA	20	NA	NA	50	NA
Trichlorofluoromethane	75-69-4	NA	20	NA	NA	20	NA
Vinyl acetate	108-05-4	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Vinyl chloride	75-01-4	NA	20	NA	NA	50	NA
Total Xylenes	1330-20-7	NA	20	NA	NA	31	NA
SW-846 Method 5035B/8015B							
1,4-Dioxane	123-91-1	NA	26	NA	NA	37	NA
Acetonitrile	75-05-8	NA	20	NA	NA	46	NA
Ethylene Glycol	107-21-1	NA	40	NA	NA	40	NA
Isobutanol	78-83-1	NA	20	NA	NA	27	NA
Propionitrile	107-12-0	NA	20	NA	NA	45	NA
MISCELLANEOUS PARAMETERS							
CEC SW-846 Method 9081	---	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Perchlorate EPA Method 314.0	14797-73-0	NA	15	NA	NA	15	NA
pH SW-846 Method 9045C	---	--[2]	--[2]	--[2]	--[2]	--[2]	20
TOC SW-846 Method 9060/Lloyd Khan	---	NA	20	NA	NA	11	NA
Total Petroleum Hydrocarbons (TPH) SW-846 Method 9070/9071B		NA	15	NA	NA	26	NA

NA = Not applicable.
RPD = Relative percent difference.
MSD = Matrix spike duplicate.
LCSD = Laboratory control spike duplicate.
LABDUP = Laboratory duplicate.

1 Aqueous and solid percent recoveries were provided by Lauck's laboratory. Quality Control (QC) limits may change pror to SWMU investigations as laboratory QC data is updated.
2 Analyte is not included in the spiking solution.

TABLE 7-2

LABORATORY CONTROL SAMPLE AND MATRIX SPIKE RECOVERY QUALITY CONTROL LIMITS FOR AQUEOUS AND SOLID SAMPLES
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	AQUEOUS[1]		SOLID[1]	
		LCS	MS	LCS	MS
		%R	%R	%R	%R
EXPLOSIVES (NITROAROMATICS AND NITRAMINES) SW-846 METHOD 8330					
1,3,5-Trinitrobenzene	99-35-4	60 - 120	50 - 140	55 - 125	50 - 140
1,3-Dinitrobenzene	99-65-0	60 - 120	50 - 140	55 - 125	50 - 140
2,4,6-Trinitrotoluene (TNT)	118-96-7	60 - 120	50 - 140	55 - 125	50 - 140
2,4-Dinitrotoluene	121-14-2	60 - 120	50 - 140	55 - 125	50 - 140
2,6-Dinitrotoluene	606-20-2	60 - 120	50 - 140	55 - 125	50 - 140
2-Amino-4,6-dinitrotoluene	35572-78-2	60 - 120	50 - 140	55 - 125	50 - 140
2-Nitrotoluene	88-72-2	60 - 120	50 - 140	55 - 125	50 - 140
3-Nitrotoluene	99-08-1	60 - 120	50 - 140	55 - 125	50 - 140
4-Amino-2,6-dinitrotoluene	1946-51-0	60 - 120	50 - 140	55 - 125	50 - 140
4-Nitrotoluene	99-99-0	60 - 120	50 - 140	55 - 125	50 - 140
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4	60 - 120	50 - 140	55 - 125	50 - 140
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	479-45-8	60 - 120	50 - 140	55 - 125	50 - 140
Nitrobenzene	98-95-3	60 - 120	50 - 140	55 - 125	50 - 140
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0	60 - 120	50 - 140	55 - 125	50 - 140
APPENDIX IX HERBICIDES (SW-846 METHOD 8151A)					
2,4-D	94-75-7	30-130	21 - 165	20 - 160	10-119
2,4,5-T	93-76-5	10 - 178	18 - 167	20 - 160	22 - 155
2,4,5-TP (Silvex)	93-72-1	17 - 137	34 - 148	20 - 160	12 - 132
Dinoseb[11]	88-85-7	15-123	29 - 113	20 - 160	7 - 99
Pentachlorophenol	87-86-5	55-99	29 - 113	20 - 160	20 - 160
Hexachlorophene	70-30-4	20 - 160	18 - 60	20 - 160	20 - 160
ORGANOCHLORINE PESTICIDES (SW-846 METHOD 8081A)					
Aldrin	309-00-2	20 - 160	18 - 147	59 - 126	47 - 139
Alpha-BHC	319-84-6	57 - 149	45 - 150	53 - 136	46 - 141
Alpha-chlordane	5103-71-9	71 - 176	56 - 153	38 - 189	19 - 174

TABLE 7-2

LABORATORY CONTROL SAMPLE AND MATRIX SPIKE RECOVERY QUALITY CONTROL LIMITS FOR AQUEOUS AND SOLID SAMPLES
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	AQUEOUS[1]		SOLID[1]	
		LCS	MS	LCS	MS
		%R	%R	%R	%R
Beta-BHC	319-85-7	66 - 152	41 - 166	59 - 146	43 - 158
4,4'-DDD	72-54-8	41 - 151	53 - 147	29 - 160	49 - 170
4,4'-DDE	72-55-9	67 - 141	57 - 161	57 - 153	20 - 190
4,4'-DDT	50-29-3	40 - 151	51 - 149	41 - 133	38 - 156
Delta-BHC	319-86-8	60 - 168	54 - 175	66 - 156	48 - 162
Dieldrin	60-57-1	75 - 146	39 - 143	52 - 140	44 - 153
Endosulfan I	959-98-8	65 - 133	37 - 171	42 - 139	19 - 167
Endosulfan II	33213-65-9	73 - 161	61 - 151	39 - 162	6 - 179
Endosulfan sulfate	1031-07-8	68 - 139	48 - 153	41 - 150	41 - 155
Endrin	72-20-8	76 - 154	66 - 159	48 - 154	55 - 167
Endrin aldehyde	7421-93-4	39 - 142	36 - 141	45 - 119	28 - 114
Endrin Ketone	53494-70-5	86 - 129	93 - 138	49 - 154	40 - 165
Gamma-BHC (Lindane)	58-89-9	52 - 160	35 - 142	46 - 131	39 - 144
Gamma-chlordane	12789-03-6	67 - 131	40 - 149	53 - 132	26 - 150
Heptachlor	76-44-8	20 - 143	30 - 127	56 - 117	57 - 118
Heptachlor epoxide	1024-57-3	64 - 140	41 - 149	50 - 133	36 - 140
Methoxychlor	72-43-5	30 - 159	54 - 149	61 - 118	67 - 142
Toxaphene	8001-35-2	--[2]	--[2]	--[2]	--[2]
POLYCHLORINATED BIPHENYLS (SW-846 METHOD 8082)					
Aroclor-1016	12674-11-2	46 - 125	60 - 132	62 - 130	42 - 128
Aroclor-1221	11104-28-2	--[2]	--[2]	--[2]	--[2]
Aroclor-1232	11141-16-5	--[2]	--[2]	--[2]	--[2]
Aroclor-1242	53469-21-9	--[2]	--[2]	--[2]	--[2]
Aroclor-1248	12672-29-6	--[2]	--[2]	--[2]	--[2]
Aroclor-1254	11097-69-1	--[2]	--[2]	--[2]	--[2]
Aroclor-1260	11096-82-5	50 - 143	59 - 139	58 - 139	49 - 158

TABLE 7-2

LABORATORY CONTROL SAMPLE AND MATRIX SPIKE RECOVERY QUALITY CONTROL LIMITS FOR AQUEOUS AND SOLID SAMPLES
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	AQUEOUS[1]		SOLID[1]	
		LCS	MS	LCS	MS
		%R	%R	%R	%R
POLYNUCLEAR AROMATIC HYDROCARBONS SW-846 METHOD 8270C WITH SELECTIVE ION MONITORING					
2-Methylnaphthalene	91-57-6	45 - 105	45 - 105	63 - 114	51 - 125
Acenaphthene	83-32-9	45 - 110	45 - 110	67 - 110	53 - 125
Acenaphthylene	208-96-8	50 - 105	50 - 105	68 - 106	52 - 121
Anthracene	120-12-7	44 - 90	20 - 105	64 - 113	51 - 123
Benzo(a)anthracene	56-55-3	55 - 110	55 - 110	56 - 105	22 - 140
Benzo(a)pyrene	50-32-8	42 - 99	20 - 106	66 - 113	49 - 129
Benzo(b)fluoranthene	205-99-2	45 - 120	45 - 120	56 - 126	45 - 143
Benzo(g,h,i)perylene	191-24-2	39 - 118	20 - 112	48 - 120	26 - 130
Benzo(k)fluoranthene	207-08-9	53 - 115	20 - 137	65 - 126	51 - 153
Carbazole	86-74-8	50 - 115	50 - 115	71 - 116	57 - 135
Chrysene	218-01-9	55 - 110	55 - 110	67 - 133	51 - 149
Dibenzo(a,h)anthracene	53-70-3	40 - 125	40 - 125	42 - 109	10 - 142
Fluoranthene	206-44-0	55 - 115	55 - 115	47 - 117	12 - 158
Fluorene	86-73-7	50 - 110	50 - 110	49 - 104	28 - 124
Indeno(1,2,3-cd)pyrene	193-39-5	40 - 119	20 - 117	52 - 121	28 - 134
Naphthalene	91-20-3	23 - 105	20 - 92	43 - 99	19 - 98
Phenanthrene	85-01-8	56 - 107	39 - 99	48 - 107	20 - 141
Pyrene	129-00-0	49 - 128	20 - 113	58 - 117	24 - 158
SEMIVOLATILE ORGANIC COMPOUNDS (EXCEPT PAHs) SW-846 METHOD 8270C					
1,2,4,5-Tetrachlorobenzene	95-94-3	--[2]	--[2]	--[2]	--[2]
1,2,4-Trichlorobenzene	120-82-1	35 - 105	35 - 105	62 - 107	47 - 119
1,2-Dichlorobenzene	95-50-1	35 - 100	35 - 100	60 - 108	46 - 116
1,3-Dichlorobenzene	541-73-1	30 - 100	30 - 100	55 - 108	40 - 112
1,4-Dichlorobenzene	106-46-7	30 - 100	30 - 100	56 - 105	42 - 110

TABLE 7-2

LABORATORY CONTROL SAMPLE AND MATRIX SPIKE RECOVERY QUALITY CONTROL LIMITS FOR AQUEOUS AND SOLID SAMPLES
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	AQUEOUS[1]		SOLID[1]	
		LCS	MS	LCS	MS
		%R	%R	%R	%R
1,4-Naphthoquinone	130-15-4	--[2]	--[2]	--[2]	--[2]
1,4-Phenylenediamine	106-50-3	--[2]	--[2]	--[2]	--[2]
1-Naphthylamine	134-32-7	--[2]	--[2]	--[2]	--[2]
2,3,4,6-Tetrachlorophenol	58-90-2	--[2]	--[2]	--[2]	--[2]
2,4,5-Trichlorophenol	95-95-4	50 - 110	50 - 110	66 - 114	42 - 136
2,4,6-Trichlorophenol	88-06-2	50 - 115	50 - 115	61 - 112	47 - 129
2,4-Dichlorophenol	120-83-2	50 - 105	50 - 105	53 - 117	50 - 125
2,4-Dimethylphenol	105-67-9	30 - 110	30 - 110	51 - 99	10 - 135
2,4-Dinitrophenol	51-28-5	15 - 140	15 - 140	10 - 120	10 - 119
2,6-Dichlorophenol	87-65-0	--[2]	--[2]	--[2]	--[2]
2-Acetylaminofluorene	53-96-3	--[2]	--[2]	--[2]	--[2]
2-Chloronaphthalene	91-58-7	50 - 105	50 - 105	68 - 112	54 - 129
2-Chlorophenol	95-57-8	35 - 105	35 - 105	65 - 113	55 - 121
2-Methylphenol	95-48-7	40 - 110	40 - 110	62 - 106	44 - 120
2-Naphthylamine	91-59-8	--[2]	--[2]	--[2]	--[2]
2-Nitroaniline	88-74-4	50 - 115	50 - 115	58 - 121	49 - 139
2-Nitrophenol	88-75-5	40 - 115	40 - 115	66 - 112	45 - 127
2-Picoline	109-06-8	--[2]	--[2]	--[2]	--[2]
3,3'-Dichlorobenzidine	91-94-1	20 - 110	20 - 110	29 - 111	10 - 109
3,3'-Dimethylbenzidine	119-93-7	--[2]	--[2]	--[2]	--[2]
3-Methylcholanthrene	56-49-5	--[2]	--[2]	--[2]	--[2]
3&4-Methylphenol [5]	1319-77-3	--[2]	--[2]	--[2]	--[2]
3-Nitroaniline	99-09-2	20 - 125	20 - 125	57 - 98	10 - 122
4,6-Dinitro-2-methylphenol	534-52-1	40 - 130	40 - 130	49 - 114	10 - 130
4-Aminobiphenyl	92-67-1	--[2]	--[2]	--[2]	--[2]
4-Bromophenyl phenyl ether	101-55-3	50 - 115	50 - 115	61 - 114	52 - 130

TABLE 7-2

LABORATORY CONTROL SAMPLE AND MATRIX SPIKE RECOVERY QUALITY CONTROL LIMITS FOR AQUEOUS AND SOLID SAMPLES
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	AQUEOUS[1]		SOLID[1]	
		LCS	MS	LCS	MS
		%R	%R	%R	%R
4-Chloro-3-methylphenol	59-50-7	45 - 110	45 - 110	70 - 114	53 - 133
4-Chloroaniline	106-47-8	15 - 110	15 - 110	20 - 89	10 - 83
4-Chlorophenyl phenyl ether	7005-72-3	50 - 110	50 - 110	66 - 113	55 - 127
4-Nitroaniline	100-01-6	35 - 120	35 - 120	63 - 114	25 - 134
4-Nitrophenol	100-02-7	10 - 125	10 - 125	36 - 136	18 - 171
4-Nitroquinoline-1-oxide	56-57-5	--[2]	--[2]	--[2]	--[2]
5-Nitro-o-toluidine	99-55-8	--[2]	--[2]	--[2]	--[2]
7,12-Dimethylbenz(a)anthracene	57-97-6	--[2]	--[2]	--[2]	--[2]
Acetophenone	98-86-2	--[2]	--[2]	--[2]	--[2]
Aniline	62-53-3	--[2]	--[2]	--[2]	--[2]
Aramite	140-57-8	--[2]	--[2]	--[2]	--[2]
Benzyl alcohol	100-51-6	30 - 110	30 - 110	42 - 153	12 - 166
Bis(2-chloroethoxy)methane	111-91-1	45 - 105	45 - 105	63 - 111	50 - 122
Bis(2-chloroethyl)ether	111-44-4	35 - 110	35 - 110	61 - 115	50 - 123
Bis(2-chloroisopropyl)ether	108-60-1	35 - 110	35 - 110	46 - 134	45 - 141
Bis(2-ethylhexyl)phthalate	117-81-7	40 - 125	40 - 125	31 - 180	10 - 185
Butyl benzyl phthalate	85-68-7	45 - 115	45 - 115	63 - 120	47 - 155
Chlorobenzilate	510-15-6	--[2]	--[2]	--[2]	--[2]
Diallate	2303-16-4	--[2]	--[2]	--[2]	--[2]
Di-n-butyl phthalate	84-74-2	55 - 115	55 - 115	65 - 136	40 - 132
Di-n-octyl phthalate	117-84-0	35 - 135	35 - 135	62 - 127	10 - 160
Dibenzofuran	132-64-9	55 - 105	55 - 105	70 - 112	56 - 128
Diethyl phthalate	84-66-2	40 - 120	40 - 120	54 - 137	52 - 126
p-(Dimethylamino)azobenzene	60-11-7	--[2]	--[2]	--[2]	--[2]
a,a-Dimethylphenethylamine	122-09-8	--[2]	--[2]	--[2]	--[2]
Dimethyl phthalate	131-11-3	25 - 125	25 - 125	67 - 115	51 - 134

TABLE 7-2

LABORATORY CONTROL SAMPLE AND MATRIX SPIKE RECOVERY QUALITY CONTROL LIMITS FOR AQUEOUS AND SOLID SAMPLES
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	AQUEOUS[1]		SOLID[1]	
		LCS	MS	LCS	MS
		%R	%R	%R	%R
Diphenylamine [6]	122-39-4	--[2]	--[2]	--[2]	--[2]
Ethyl methane sulfonate	62-50-0	--[2]	--[2]	--[2]	--[2]
Hexachlorobenzene	118-74-1	50 - 110	50 - 110	58 - 116	47 - 134
Hexachlorobutadiene	87-68-3	25 - 105	25 - 105	56 - 110	42 - 120
Hexachlorocyclopentadiene	77-47-4	20 - 160	20 - 160	13 - 98	10 - 95
Hexachloroethane	67-72-1	30 - 95	30 - 95	54 - 114	37 - 116
Hexachloropropene	1888-71-7	--[2]	--[2]	--[2]	--[2]
Isodrin	465-73-6	--[2]	--[2]	--[2]	--[2]
Isophorone	78-59-1	--[2]	--[2]	--[2]	--[2]
Isosafrole	120-58-1	--[2]	--[2]	--[2]	--[2]
Kepone	143-50-0	--[2]	--[2]	--[2]	--[2]
Methapyrilene	91-80-5	--[2]	--[2]	--[2]	--[2]
Methyl methane sulfonate	66-27-3	--[2]	--[2]	--[2]	--[2]
n-Nitrosodi-n-butylamine	924-16-3	--[2]	--[2]	--[2]	--[2]
n-Nitrosodiethylamine	55-18-5	--[2]	--[2]	--[2]	--[2]
n-Nitrosodimethylamine	62-75-9	25 - 110	25 - 110	40 - 109	20 - 160
n-Nitrosodi-n-propylamine	621-64-7	35 - 130	35 - 130	61 - 126	52 - 136
n-Nitrosomethylethylamine	62-75-9	--[2]	--[2]	--[2]	--[2]
n-Nitrosomorpholine	59-89-2	--[2]	--[2]	--[2]	--[2]
n-Nitrosopiperidine	100-75-4	--[2]	--[2]	--[2]	--[2]
n-Nitrosopyrrolidine	930-55-2	--[2]	--[2]	--[2]	--[2]
Pentachlorobenzene	608-93-5	--[2]	--[2]	--[2]	--[2]
Pentachloroethane	76-01-7	20 - 160	20 - 160	20 - 160	20 - 160
Pentachloronitrobenzene	82-68-8	--[2]	--[2]	--[2]	--[2]
Phenacetin	62-44-2	--[2]	--[2]	--[2]	--[2]

TABLE 7-2

LABORATORY CONTROL SAMPLE AND MATRIX SPIKE RECOVERY QUALITY CONTROL LIMITS FOR AQUEOUS AND SOLID SAMPLES
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	AQUEOUS[1]		SOLID[1]	
		LCS	MS	LCS	MS
		%R	%R	%R	%R
Phenol	108-95-2	10 - 115	10 - 115	63 - 111	52 - 124
Pronamide	23950-58-5	--[2]	--[2]	--[2]	--[2]
Pyridine	110-86-1	--[2]	--[2]	--[2]	--[2]
Safrole	94-59-7	--[2]	--[2]	--[2]	--[2]
o-Toluidine	95-53-4	--[2]	--[2]	--[2]	--[2]
O,O,O-Triethyl phosphorothioate	126-68-1	--[2]	--[2]	--[2]	--[2]
TAL METALS PLUS TIN					
SW-846 Method 6020					
Aluminum	7429-90-5	80 - 120	75 - 125	80 - 120	75 - 125
Antimony	7440-36-0	80 - 120	75 - 125	80 - 120	75 - 125
Arsenic	7440-38-2	80 - 120	75 - 125	80 - 120	75 - 125
Barium	7440-39-3	80 - 120	75 - 125	80 - 120	75 - 125
Beryllium	7440-41-7	80 - 120	75 - 125	80 - 120	75 - 125
Cadmium	7440-43-9	80 - 120	75 - 125	80 - 120	75 - 125
Calcium	7440-70-2	80 - 120	75 - 125	80 - 120	75 - 125
Chromium (total)	7440-47-3	80 - 120	75 - 125	80 - 120	75 - 125
Cobalt	7440-48-4	80 - 120	75 - 125	80 - 120	75 - 125
Copper	7440-50-8	80 - 120	75 - 125	80 - 120	75 - 125
Iron	7439-89-6	80 - 120	75 - 125	80 - 120	75 - 125
Lead	7439-92-1	80 - 120	75 - 125	80 - 120	75 - 125
Magnesium	7439-95-4	80 - 120	75 - 125	80 - 120	75 - 125
Manganese	7439-96-5	80 - 120	75 - 125	80 - 120	75 - 125
Nickel	7440-02-0	80 - 120	75 - 125	80 - 120	75 - 125
Potassium	7440-09-7	80 - 120	75 - 125	80 - 120	75 - 125
Selenium	7782-49-2	80 - 120	75 - 125	80 - 120	75 - 125
Silver	7440-22-4	80 - 120	75 - 125	80 - 120	75 - 125
Sodium	7440-23-5	80 - 120	75 - 125	80 - 120	75 - 125

TABLE 7-2

LABORATORY CONTROL SAMPLE AND MATRIX SPIKE RECOVERY QUALITY CONTROL LIMITS FOR AQUEOUS AND SOLID SAMPLES
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	AQUEOUS[1]		SOLID[1]	
		LCS	MS	LCS	MS
		%R	%R	%R	%R
Thallium	7440-28-0	80 - 120	75 - 125	80 - 120	75 - 125
Tin	7440-31-5	80 - 120	75 - 125	80 - 120	75 - 125
Vanadium	7440-62-2	80 - 120	75 - 125	80 - 120	75 - 125
Zinc	7440-66-6	80 - 120	75 - 125	80 - 120	75 - 125
SW-846 7470A/7471A					
Mercury	7439-97-6	75 - 125	85 - 115	90 - 110	85 - 115
VOLATILE ORGANIC COMPOUNDS SW-846 METHOD 5035B/8260B					
1,1,1-Trichloroethane	71-55-6	66 - 128	62 - 142	60 - 140	54 - 104
1,1,1,2-Tetrachloroethane	630-20-6	76 - 123	60 - 140	60 - 140	60 - 140
1,1,2,2-Tetrachloroethane	79-34-5	54 - 153	52 - 155	60 - 140	22 - 113
1,1,2-Trichloroethane	79-00-5	80 - 124	80 - 123	60 - 140	44 - 103
1,2,3-Trichloropropane	96-18-4	54 - 154	60 - 140	60 - 140	60 - 140
1,1-Dichloroethane	75-34-3	77 - 122	61 - 149	60 - 140	45 - 126
1,1-Dichloroethene	75-35-4	67 - 135	68 - 155	65 - 129	26 - 136
1,2-Dibromo-3-chloropropane	96-12-8	42 - 156	60 - 140	60 - 140	60 - 140
1,2-Dibromoethane	106-93-4	77 - 118	60 - 140	60 - 140	60 - 140
1,2-Dichloroethane	107-06-2	66 - 135	65 - 130	60 - 140	51 - 115
1,2-Dichloropropane	78-87-5	80 - 129	80 - 114	60 - 140	45 - 123
2-Butanone	78-93-3	60 - 140	37 - 156	60 - 140	20 - 160
2-Chloro-1,3-butadiene (chloroprene)	126-99-8	--[2]	--[2]	--[2]	--[2]
2-Hexanone	591-78-6	60 - 140	47 - 161	60 - 140	20 - 160
4-Methyl-2-pentanone	108-10-1	60 - 140	39 - 181	60 - 140	20 - 160
Acetone	67-64-1	60 - 140	20 - 160	60 - 140	20 - 160
Acrolein	107-02-8	--[2]	--[2]	--[2]	--[2]
Acrylonitrile	107-13-1	--[2]	--[2]	--[2]	--[2]
Allyl chloride (3-chloro-1-propene)	107-05-1	--[2]	--[2]	--[2]	--[2]

TABLE 7-2

LABORATORY CONTROL SAMPLE AND MATRIX SPIKE RECOVERY QUALITY CONTROL LIMITS FOR AQUEOUS AND SOLID SAMPLES
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	AQUEOUS[1]		SOLID[1]	
		LCS	MS	LCS	MS
		%R	%R	%R	%R
Benzene	71-43-2	75 - 122	87 - 128	72 - 121	52 - 112
Bromodichloromethane	75-27-4	73 - 127	72 - 122	60 - 140	48 - 107
Bromoform	75-25-2	67 - 131	65 - 133	60 - 140	31 - 102
Bromomethane	74-83-9	43 - 146	33 - 166	60 - 140	20 - 146
Carbon disulfide	75-15-0	60 - 140	50 - 158	60 - 140	20 - 134
Carbon tetrachloride	56-23-5	61 - 138	47 - 149	60 - 140	48 - 110
Chlorobenzene	108-90-7	83 - 111	75 - 124	65 - 121	45 - 108
Chloroethane	75-00-3	61 - 139	73 - 147	60 - 140	38 - 140
Chloroform	67-66-3	73 - 123	70 - 125	60 - 140	59 - 101
Chloromethane	74-87-3	45 - 159	51 - 151	60 - 140	20 - 158
cis-1,2-Dichloroethene	156-59-2	77 - 123	76 - 132	60 - 140	55 - 93
cis-1,3-Dichloropropene	10061-01-5	73 - 122	64 - 129	60 - 140	33 - 108
Dibromochloromethane	124-48-1	79 - 123	78 - 125	60 - 140	36 - 108
Dibromomethane	74-95-3	74 - 125	60 - 140	60 - 140	60 - 140
Dichlorodifluoromethane	75-71-8	40 - 160	60 - 140	60 - 140	60 - 140
Ethylbenzene	100-41-4	60 - 140	78 - 129	72 - 127	40 - 118
Ethyl methacrylate	97-63-2	--[2]	--[2]	--[2]	--[2]
Methacrylonitrile	126-98-7	--[2]	--[2]	--[2]	--[2]
Methylene chloride	75-09-2	62 - 127	35 - 142	60 - 140	20 - 160
Methyl iodide	74-88-4	--[2]	--[2]	--[2]	--[2]
Methyl methacrylate	80-62-6	--[2]	--[2]	--[2]	--[2]
Methyl tert-Butyl Ether	1634-04-4	60 - 140	60 - 140	60 - 140	60 - 140
Styrene	100-42-5	80 - 121	60 - 144	60 - 140	29 - 114
Tetrachloroethene	127-18-4	80 - 116	74 - 134	60 - 140	32 - 94
Toluene	108-88-3	73 - 115	73 - 136	66 - 124	39 - 120
trans-1,2-Dichloroethene	156-60-5	71 - 125	60 - 143	60 - 140	42 - 97
trans-1,3-Dichloropropene	10061-02-6	60 - 140	53 - 136	60 - 140	34 - 109

TABLE 7-2

LABORATORY CONTROL SAMPLE AND MATRIX SPIKE RECOVERY QUALITY CONTROL LIMITS FOR AQUEOUS AND SOLID SAMPLES
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	AQUEOUS[1]		SOLID[1]	
		LCS	MS	LCS	MS
		%R	%R	%R	%R
trans-1,4-Dichloro-2-butene	110-57-6	--[2]	--[2]	--[2]	--[2]
Trichloroethene	79-01-6	73 - 118	69 - 119	61 - 124	36 - 124
Trichlorofluoromethane	75-69-4	60 - 140	60 - 140	60 - 140	60 - 140
Vinyl acetate	108-05-4	--[2]	--[2]	--[2]	--[2]
Vinyl chloride	75-01-4	60 - 140	66 - 153	60 - 140	29 - 138
Total Xylenes	1330-20-7	60 - 140	60 - 140	60 - 140	38 - 108
SW-846 Method 5035B/8015B					
1,4-Dioxane	123-91-1	41 - 145	65 - 138	20 - 142	62 - 99
Acetonitrile	75-05-8	71 - 109	66 - 112	71 - 111	49 - 103
Ethylene Glycol	107-21-1	40 - 140	20 - 160	40-140	20 - 160
Isobutanol	78-83-1	74 - 110	68 - 124	40 - 117	51 - 95
Propionitrile	107-12-0	82 - 110	67 - 129	73 - 105	44 - 105
MISCELLANEOUS PARAMETERS					
CEC SW-846 Method 9081	---	--[2]	--[2]	--[2]	--[2]
Perchlorate EPA Method 314.0	14797-73-0	85 - 115	80 - 120	80 - 120	80 - 120
pH SW-846 Method 9045C	---	NA	NA	NA	NA
TOC SW-846 Method 9060/Lloyd Khan	---	80-120	75-125	--[2]	70 - 119
Total Petroleum Hydrocarbons (TPH) SW-846 Method 9070/9071B		71 - 119	71 - 119	51 - 122	51 - 122

NA = not applicable.
LCS = Laboratory control sample.
MS = Matrix spike.

1 Aqueous and solid percent recoveries were provided by Lauck's laboratory. Quality Control (QC) limits may change prior to SWMU investigations as laboratory QC data is updated.
2 Analyte is not included in the spiking solution.

8.0 DATA REDUCTION, VALIDATION, ASSESSMENT, AND REPORTING

This section describes the procedures to be used for data reduction, validation, assessment, 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.

8.1 DATA REDUCTION

8.1.1 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 1-5.

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 will be brought to the immediate attention of the TOM.

8.1.2 Laboratory Data Reduction Procedures

Data reduction will be completed by the laboratory in accordance with method-specific laboratory SOPs. In addition, data are reviewed in accordance with the laboratory QA plan.

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.

8.2 DATA VALIDATION

Validation procedures for field measurements and laboratory analytical data are presented in this section.

8.2.1 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.

8.2.2 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 laboratory SOPs, 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, 1995a and 1995b) and the National Functional Guidelines for Inorganic and Organic Data Review (U.S. EPA, 1994a and 1994b) 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.

Compliance with quantitative QC objectives for laboratory accuracy and precision, as outlined in Tables 7-1 and 7-2, will be evaluated during data validation. In general, data validation requires that data be evaluated batch by batch based on the results of quality indicators for the respective batches.

8.3 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.

8.3.1 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.

After data validation, the data will be reconciled with DQOs to determine whether sufficient data of acceptable quality are available for decision making. In addition to the evaluations described in the following sections, a series of inspections and statistical analyses may 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, TVs, and IDLs (inspection).
- Identify unusable data (i.e., data qualified as "R") (inspection).
- Evaluate project assumptions such as ground water flow 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-percent 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 (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 any remaining data gaps (inspection/statistics).

For statistical comparisons and mathematical manipulations, analytes that are not detected at the applicable sample-specific MDL, IDL, or TV will be represented by a concentration equal to one-half of the sample-specific MDL, IDL, or TV.

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 COPCs are evaluated, 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-percent significance level. Statistical testing at other significance levels may also be warranted to provide perspective on the results of testing at 5-percent significance. If other significance levels are used, they will be supported with rationale for their use.

8.3.2 Precision Assessment

Laboratory duplicate samples (for inorganic analyses) and MSD samples (for organic analyses) will be prepared and analyzed at a minimum frequency of one per every 20 environmental samples per matrix. Field duplicate samples also will be collected at a minimum frequency of one per 20 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:

$$\text{RPD} = \frac{(\text{Amount in Sample 1} - \text{Amount in Sample 2})}{0.5\,(\text{Amount in Sample 1} + \text{Amount in Sample 2})} \text{ X } 100\ \%$$

If field duplicate precision is significantly different than laboratory duplicate precision, the underlying cause will be investigated to determine whether the observed difference could be an artifact of sampling and analysis. Because of the inherent and unknown heterogeneity of soil samples, the precision of soil field duplicates will not be used for QC but will be used to gain a perspective on the natural heterogeneity of the soil.

8.3.3 Accuracy Assessment

Sample collection accuracy cannot be evaluated because there is no standard by which to judge such accuracy. Instead of a qualitative evaluation of sample collection accuracy, compliance with field SOPs 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 one 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 using the following formula:

$$\%R = \frac{\text{Amount in Spiked Sample} - \text{Amount in Sample}}{\text{Known Amount Added}} \times 100\%$$

LCSs and surrogate spikes are also analyzed to assess accuracy. The %R calculation for LCSs and surrogate spikes is as follows:

$$\%R = \frac{\text{Experimental Concentration}}{\text{Certified or Known Concentration}} \times 100\%$$

Accuracy measurements will be used to detect biases resulting from the sample handling and analysis process.

8.3.4 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 matrix type and analyte will be counted and compared to the completeness objectives in Sections 7.3.2 and 7.3.3.

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.

8.3.5 Representativeness

Representativeness of field data will be evaluated by ensuring that the SAP has been followed and that proper sampling techniques were used. Representativeness of laboratory data will be evaluated by ensuring that proper analytical procedures were followed and sample holding times were met and by evaluating field duplicates relative to laboratory duplicates.

8.3.6 Comparability

Comparability will be evaluated by ensuring that standardized sampling and analysis methods and data reporting formats are used and that reporting limits and threshold values are sufficiently low to satisfy project detection and quantitation criteria.

8.4 DATA REPORTING

8.4.1 Field Data Reporting

Field data will be transcribed from the site logbooks 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 (noting the date, person, and 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 4.3.

8.4.2 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 the laboratory for all analytical fractions will be in a CLP-like reporting format. Hard-copy data deliverables will 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.

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 then 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.

8.4.3 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 each SWMU. When no more data collection is necessary, a Phase III RFI report will be issued that summarizes the findings of the investigation. If contaminants are 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 as a summary of the measured soil concentrations relative to background soil concentrations and RBTLs. Discussions with IDEM 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 U.S. EPA Region 5, IDEM, Navy NAVFAC EFD SOUTH, and NSWC Crane.

8.5 DATA ACQUISITION REQUIREMENTS AND DATA MANAGEMENT

Data are managed in a way that ensures adherence to database requirements for content, format, and integrity. 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 E. 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. Data will then be transmitted from the laboratory in both hard-copy and electronic formats according to laboratory SOPs. The data deliverable requirements are specified in TtNUS's basic ordering agreement

with the analytical laboratory. This agreement requires the analytical laboratory to provide data in both hard-copy and electronic format. Upon receipt by TtNUS, the data will be validated, analyzed, assessed, and ultimately archived. A copy of the data deliverable requirements will be provided to the NSWC Crane Lab prior to the commencement of field activities.

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 TVs, IDLs, and RLs will be reported for non-detected analytes. Units will be clearly summarized in the database and will conform to those identified in Section 7.0. 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.

9.0 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 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, frequencies, and procedures are provided in the remainder of this section. Field performance and system audits are addressed in Section 9.1. Laboratory performance and system audits are addressed in Section 9.2.

9.1 FIELD PERFORMANCE AND SYSTEM AUDITS

This section presents the responsibilities, frequencies, and procedures associated with internal and external field performance and system audits.

9.1.1 Internal Field Audits

9.1.1.1 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.

9.1.1.2 Internal Field Audit Frequency

As explained in Section 9.1.1.1, 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.

9.1.1.3 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.
- Upon arrival at the audit location, the auditor will 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

9.1.2 External Field Audits

9.1.2.1 External Field Audit Responsibilities

IDEM, U.S. EPA Region 5, or both may conduct external field audits.

9.1.2.2 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.

9.1.2.3 Overview of the External Field Audit Process

External audit procedures are at the discretion of IDEM and U.S. EPA Region 5.

9.2 LABORATORY PERFORMANCE AND SYSTEMS AUDITS

This section presents the responsibilities, frequencies, and procedures associated with internal and external laboratory performance and system audits.

9.2.1 Internal Laboratory Audits

9.2.1.1 Internal Laboratory Audit Responsibilities

The QAM or appropriate designee of the subcontracted laboratory performs routine internal audits of the laboratory. The Navy, through the NFESC, also conducts internal laboratory audits. TtNUS has 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.

9.2.1.2 Internal Laboratory Audit Frequency

Internal audits are performed approximately annually at the laboratory. In addition, each laboratory department analyzes blind performance evaluation (PE) samples as described in their applicable SOPs and QA plans.

The United States Navy completes internal laboratory performance and system audits for each contracted laboratory on an 18-month schedule.

9.2.1.3 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 and Triangle Laboratories are presented in applicable laboratory SOPs or the QA Plan.

Internal United States 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.

9.2.2 External Laboratory Audits

9.2.2.1 External Laboratory Audit Responsibilities

IDEM and U.S. EPA Region 5 may perform external audits at their discretion.

The laboratory 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.

9.2.2.2 External Laboratory Audit Frequency

IDEM or U.S. EPA Region 5 may conduct an external laboratory audit prior to or during sampling and analysis activities.

9.2.2.3 Overview of the External Laboratory Audit Process

External audit procedures are at the discretion of IDEM and U.S. EPA Region 5. 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.

10.0 PREVENTIVE MAINTENANCE PROCEDURES

Equipment used to collect samples will be maintained in accordance with the manufacturer's operation and maintenance manuals. Equipment and instruments will be calibrated in accordance with the procedures and at the frequencies presented in Section 5.0 (Calibration Procedures and Frequency). Preventive maintenance for field and laboratory equipment is addressed in the remainder of this section.

10.1 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. Maintenance procedures for electronic field instruments are detailed in SOP CTO331-14. Any problems encountered while operating an instrument will be recorded in the field logbook, including a description of the symptoms and corrective actions taken. If problems with equipment are detected and service is required, the equipment will be logged, tagged, and segregated from equipment in proper working order. Use of the malfunctioning equipment will not resume until the problem is corrected.

10.2 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.

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 inductively coupled plasma (ICP) instruments will be of sufficient quality to minimize fouling of the instrument. The routine use of other supporting supplies from reputable manufacturers will help prevent unnecessary periods of instrument downtime. An inventory of critical spare parts will also be maintained by the laboratory to minimize instrument downtime.

10.3 INSPECTION/ACCEPTANCE REQUIREMENTS FOR SUPPLIES AND CONSUMABLES

All field equipment will 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 will be sufficient to ensure that the equipment is suitable for use. This visual inspection will occur during mobilization and during each use by the equipment user.

Laboratory inspection and acceptance requirements are provided in the laboratory QA Plan. The plan presents 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.

11.0 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 that are performed. A brief summary of corrective actions for some specific field samples and laboratory QC check samples is presented in Section 3.0, Table 3-11.

11.1 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 United States Navy (in conjunction with IDEM). The FOL is responsible for initiating FTMRs. A FTMR will be prepared for all deviations from the project plan documents, as applicable. Copies of all FTMRs will be maintained with the on-site project planning documents and will be placed in the final evidence file.

11.2 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 greater than 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 12.0 of this QAPP.

11.3 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 8.0. When conducting data assessment for project decision making, 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 8.0.

12.0 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 12-1.

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, PM, 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 events. These reports will explain accomplishments, deviations from the QAPP, and upcoming activities, and will provide a QA summary. The TOM provides a monthly progress report to the Navy that addresses the project budget, schedule, accomplishments, planned activities, and QA/QC issues and intended corrective actions.

The analytical laboratory will provide QA reports to TtNUS if QC limits are updated or if other significant plan deviations result from unanticipated circumstances. Because MDLs will be included in the analytical data packages for the NSWC Crane Laboratory samples, it is not necessary for the laboratories to include updated MDLs in their QA reports unless the updates result in MDLs that exceed RBTLs.

TABLE 12-1

SUMMARY OF REPORTS
SWMUs 8, 15, 18, 19, AND 20 AND THE OGTSL
NSWC CRANE, CRANE, INDIANA

Report	Content	Preparer	Frequency of Submittal	Recipient(s)
Data Validation Report	All major and minor laboratory non-compliances, 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 non-compliances, 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, PM, 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.	Laboratories TBD.	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/TVs/IDLs cause them to exceed RBTLs or if QAPP deviations impact DQOs.

DQO = Data quality objective.
FOL = Field Operations Leader.
IDL = Instrument detection limit.
QA/QC = Quality Assurance/Quality Control.
QAM = Quality assurance manager.
QAPP = Quality Assurance Project Plan.
RL = Reporting limit.
SAP = Sampling and Analysis Plan.
SDG = Sample delivery group.
TBD = To be determined.
TOM = Task Order Manager.
TV = Threshold value.

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APPENDIX A

HISTORICAL DATA

APPENDIX A.1

BUILDING 106 POND HISTORICAL DATA

TABLE A-1

1972 SUMMARY OF EFFLUENT ANAYTICAL RESULTS
BUILDING 106 POND[1]
NSWC CRANE
CRANE, INDIANA
PAGE 1 OF 2

Analyte	Count	Minimum Concentration[2] (ppm)		Maximum Concentration[2] (ppm)		Average Concentration[2] (ppm)	
Temperature	47	7.00	°C	27.20	°C	18.291	°C
Dissolved Oxygen	47	4.00		10.20		7.647	
pHF	46	9.20	SU	11.80	SU	11.028	SU
pHL	47	7.00	SU	11.70	SU	10.311	SU
L Turbidity	47	1.30	JTU	89.00	JTU	25.845	JTU
Dissolved Oxygen (Lab)	46	4.40		10.20		7.659	
BOD	27	0.00		29.00		12.296	
COD	42	8.00		7,820.00		988.786	
Settleable Solids	2	0.00		2.00		1.00	
TSS	37	1.00		118.00		28.186	
TDS	40	64.00		7,382.00		1,010.50	
N-Ammonia	35	0.10		2.25		0.667	
N-Nitrate	33	0.04		2.77		0.905	
N-Nitrite	41	0.05		8.10		1.098	
Total Nitrogen	18	0.50		6.63		2.245	
Flowrate	36	0.021		0.339		0.051	
Total Phosphorus	30	0.00		1.15		0.306	
Chloride	33	2.00		317.00		43.778	
O&G	21	1.00		141.00		47.571	
Phenols	2	0.00		0.03		0.015	
Copper	34	0.00		0.70		0.159	
Zinc	40	0.02		20.00		3.464	
Magnesium	35	0.40		4.10		2.237	
Potassium	34	0.80	ppb	2.35	ppb	1.519	ppb
Mercury	8	0.00		1.00		0.125	
Chromium	33	0.00	MPN	3.50	MPN	0.70	MPN
Total Coliform	8	0.00	MPN	9,300.00	MPN	1,278.75	MPN
Fecal Coliform	8	0.00		1,500.00		187.50	
TOC	2	0.00		0.00		0.00	
Calcium	32	11.00		28.50		19.75	
Iron	43	0.00		100.00		19.04	
Silver	3	0.00		0.00		0.00	
Cadmium	34	0.00		0.20		0.009	
Manganese	33	0.00		0.00		0.141	
Sodium	32	4.80		1,500.00		298.181	
Lead	33	0.00		20.00		2.322	

TABLE A-1

1972 SUMMARY OF EFFLUENT ANAYTICAL RESULTS
BUILDING 106 POND[1]
NSWC CRANE
CRANE, INDIANA

Analyte	Count	Minimum Concentration[2] (ppm)	Maximum Concentration[2] (ppm)	Average Concentration[2] (ppm)
TNT	7	0.00	0.00	0.00
Cyanide	3	0.00	0.00	0.00
RDX	5	0.00	0.00	0.00
HMX	6	0.00	0.00	0.00

1 — This data has been directly incorporated form the "Final RCRA Facility Investigation Phase I Environmental Monitoring Reports, Solid Waste Management Units #19/00, #08/17, #12/14, #13/14 Naval Surface Warfare Center, Crane Division, Crane, Indiana" developed by Halliburton NUS Environmental Corporation in August 1992.

2 — concentrations are parts per billion (ppb) unless otherwise noted.

Terminology
°C — degrees Celsius.
BOD — biological oxygen demand.
COD — chemical oxygen demand.
HMX — octahydro 1,3,5,7 tetranitro 1,2,5,7-tetrazocine (which is cyclotetramethylene tetranitramine)
JTU — Jackson Turgidity Unit.
LAB — laboratory.
L Turbidity — turbidity as measured in the laboratory.
MPN — most probable number.
O&G — oil and grease.
pHF — pH as measured in the field.
pHL — pH as measured in the laboratory.
ppb — parts per billion.
ppm — parts per million.
RDX — hexahydro 1,3,5 trinitro 1,3,5 triazine (which is cyclo-trimethyl-trinitramine or "cyclonite").
SU — standard units.
TDS — total dissolved solids.
TNT — 2,4,6-trinitrotoluene.
TOC — total organic carbon.
TSS — total suspended solids.

APPENDIX A.2

OLD GUN TUB STORAGE LOT HISTORICAL DATA

SHERRY Laboratories
Testing Today – Protecting Tomorrow
2203 S. Madison Street
Muncie Indiana 47302
800-874-3563

Anita Netherland
SAIC
RR 6 Box 28
Bloomfield, IN 47424
TEL: (812) 384-3587
FAX (812) 384-3744

July 26, 2002
Order No.: M02070406

RE: NSWC Crane OGTSL

Dear Anita Netherland:

Sherry Laboratories received 14 samples on 7/12/02 for the analyses presented in the following report.

In accordance with your instructions, Sherry Laboratories conducted the analysis shown on the following pages on samples submitted by your company. The results relate only to the items tested. Unless otherwise noted, all analysis was conducted using approved methodologies from EPA, FDA, USDA, AOAC, SM, or other client-specified methods. All relevant sampling information is on the attached chain-of-custody form. The initials SUB as the analyst designate any testing sub-contracted by SL.

Certifications/Accreditation: A2LA# 0174-03 IN# C-18-02
IN# M-18-5 PERPLab No. 7107
LELAP No. 02016

A scope of Certified/Accredited parameters is available upon request.

If you have any questions regarding these test results, please feel free to call.

Sincerely,

Stan West

Approved By: Wendy Conn

SHERRYLaboratories

Testing Today – Protecting Tomorrow

2203 S. Madison Street
Muncie Indiana 47302
800-874-3563

CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-01
Date Received: 12-Jul-02

Client Sample ID: Rinsate
Tag Number:
Collection Date: 7/10/02 11:06:00 AM
Matrix: WATER
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
SEMI-VOLATILES IN WATER	**SW8270A**				**GB**
1,2,4-Trichlorobenzene	ND	10	µg/L	7/18/02 12:01:00 P	
1,2-Dichlorobenzene	ND	10	µg/L	7/18/02 12:01:00 P	
1,2-Diphenylhydrazine	ND	10	µg/L	7/18/02 12:01:00 P	
1,3-Dichlorobenzene	ND	10	µg/L	7/18/02 12:01:00 P	
1,3-Dinitrobenzene	ND	20	µg/L	7/18/02 12:01:00 P	
1,4-Dichlorobenzene	ND	10	µg/L	7/18/02 12:01:00 P	
2,4,5-Trichlorophenol	ND	10	µg/L	7/18/02 12:01:00 P	
2,4,6-Trichlorophenol	ND	10	µg/L	7/18/02 12:01:00 P	
2,4-Dichlorophenol	ND	10	µg/L	7/18/02 12:01:00 P	
2,4-Dimethylphenol	ND	10	µg/L	7/18/02 12:01:00 P	
2,4-Dinitrophenol	ND	50	µg/L	7/18/02 12:01:00 P	
2,4-Dinitrotoluene	ND	10	µg/L	7/18/02 12:01:00 P	
2,6-Dinitrotoluene	ND	10	µg/L	7/18/02 12:01:00 P	
2-Chloronaphthalene	ND	10	µg/L	7/18/02 12:01:00 P	
2-Chlorophenol	ND	10	µg/L	7/18/02 12:01:00 P	
2-Methylnaphthalene	ND	10	µg/L	7/18/02 12:01:00 P	
2-Methylphenol	ND	10	µg/L	7/18/02 12:01:00 P	
2-Nitroaniline	ND	50	µg/L	7/18/02 12:01:00 P	
2-Nitrophenol	ND	10	µg/L	7/18/02 12:01:00 P	
2-Picoline	ND	50	µg/L	7/18/02 12:01:00 P	
3,3'-Dichlorobenzidine	ND	20	µg/L	7/18/02 12:01:00 P	
3-Nitroaniline	ND	50	µg/L	7/18/02 12:01:00 P	
4,6-Dinitro-2-methylphenol	ND	50	µg/L	7/18/02 12:01:00 P	
4-Bromophenyl phenyl ether	ND	10	µg/L	7/18/02 12:01:00 P	
4-Chloro-3-methylphenol	ND	20	µg/L	7/18/02 12:01:00 P	
4-Chloroaniline	ND	20	µg/L	7/18/02 12:01:00 P	
4-Chlorophenyl phenyl ether	ND	10	µg/L	7/18/02 12:01:00 P	
4-Methylphenol	ND	10	µg/L	7/18/02 12:01:00 P	
4-Nitroaniline	ND	20	µg/L	7/18/02 12:01:00 P	
4-Nitrophenol	ND	50	µg/L	7/18/02 12:01:00 P	
Acenaphthene	ND	10	µg/L	7/18/02 12:01:00 P	
Acenaphthylene	ND	10	µg/L	7/18/02 12:01:00 P	
Aniline	ND	20	µg/L	7/18/02 12:01:00 P	

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Muncie Indiana 47302
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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-01
Date Received: 12-Jul-02

Client Sample ID: Rinsate
Tag Number:
Collection Date: 7/10/02 11:06:00 AM
Matrix: WATER
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Anthracene	ND	10	µg/L	7/18/02 12:01:00	P
Benz(a)anthracene	ND	10	µg/L	7/18/02 12:01:00	P
Benzidine	ND	50	µg/L	7/18/02 12:01:00	P
Benzo(a)pyrene	ND	10	µg/L	7/18/02 12:01:00	P
Benzo(b)fluoranthene	ND	10	µg/L	7/18/02 12:01:00	P
Benzo(g,h,i)perylene	ND	10	µg/L	7/18/02 12:01:00	P
Benzo(k)fluoranthene	ND	10	µg/L	7/18/02 12:01:00	P
Benzoic acid	ND	50	µg/L	7/18/02 12:01:00	P
Benzyl alcohol	ND	20	µg/L	7/18/02 12:01:00	P
Bis(2-chloroethoxy)methane	ND	10	µg/L	7/18/02 12:01:00	P
Bis(2-chloroethyl)ether	ND	10	µg/L	7/18/02 12:01:00	P
Bis(2-chloroisopropyl)ether	ND	10	µg/L	7/18/02 12:01:00	P
Bis(2-ethylhexyl)phthalate	ND	10	µg/L	7/18/02 12:01:00	P
Butyl benzyl phthalate	ND	10	µg/L	7/18/02 12:01:00	P
Carbazole	ND	10	µg/L	7/18/02 12:01:00	P
Chrysene	ND	10	µg/L	7/18/02 12:01:00	P
Di-n-butyl phthalate	ND	10	µg/L	7/18/02 12:01:00	P
Di-n-octyl phthalate	ND	10	µg/L	7/18/02 12:01:00	P
Dibenz(a,h)anthracene	ND	10	µg/L	7/18/02 12:01:00	P
Dibenzofuran	ND	10	µg/L	7/18/02 12:01:00	P
Diethyl phthalate	ND	10	µg/L	7/18/02 12:01:00	P
Dimethyl phthalate	ND	10	µg/L	7/18/02 12:01:00	P
Fluoranthene	ND	10	µg/L	7/18/02 12:01:00	P
Fluorene	ND	10	µg/L	7/18/02 12:01:00	P
Hexachlorobenzene	ND	10	µg/L	7/18/02 12:01:00	P
Hexachlorobutadiene	ND	10	µg/L	7/18/02 12:01:00	P
Hexachlorocyclopentadiene	ND	10	µg/L	7/18/02 12:01:00	P
Hexachloroethane	ND	10	µg/L	7/18/02 12:01:00	P
Indeno(1,2,3-cd)pyrene	ND	10	µg/L	7/18/02 12:01:00	P
Isophorone	ND	10	µg/L	7/18/02 12:01:00	P
N-Nitrosodi-n-propylamine	ND	10	µg/L	7/18/02 12:01:00	P
N-Nitrosodimethylamine	ND	10	µg/L	7/18/02 12:01:00	P
N-Nitrosodiphenylamine	ND	20	µg/L	7/18/02 12:01:00	P
Naphthalene	ND	10	µg/L	7/18/02 12:01:00	P
Nitrobenzene	ND	10	µg/L	7/18/02 12:01:00	P

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-01
Date Received: 12-Jul-02

Client Sample ID: Rinsate
Tag Number:
Collection Date: 7/10/02 11:06:00 AM
Matrix: WATER
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
o-Toluidine	ND	20	µg/L	7/18/02 12:01:00 P	
Pentachlorophenol	ND	50	µg/L	7/18/02 12:01:00 P	
Phenanthrene	ND	10	µg/L	7/18/02 12:01:00 P	
Phenol	ND	10	µg/L	7/18/02 12:01:00 P	
Pyrene	ND	10	µg/L	7/18/02 12:01:00 P	
Pyridine	ND	50	µg/L	7/18/02 12:01:00 P	
Surr: 2,4,6-Tribromophenol	85.1	10-123	%REC	7/18/02 12:01:00 P	
Surr: 2-Fluorobiphenyl	82.2	43-116	%REC	7/18/02 12:01:00 P	
Surr: 2-Fluorophenol	54.3	21-110	%REC	7/18/02 12:01:00 P	
Surr: 4-Terphenyl-d14	93.9	33-141	%REC	7/18/02 12:01:00 P	
Surr: Nitrobenzene-d5	78.3	35-114	%REC	7/18/02 12:01:00 P	
Surr: Phenol-d5	37.9	10-110	%REC	7/18/02 12:01:00 P	
METALS BY ICP FOR WW, TOTALS		**E200.7**			**FJR**
Cadmium	ND	0.002	ppm	7/15/02 5:41:44 P	
Chromium	ND	0.005	ppm	7/15/02 5:41:44 P	
Lead	ND	0.004	ppm	7/15/02 5:41:44 P	
PCBS IN WATER		**SW8082**			**SDW**
Aroclor 1016	ND	2.0	ppb	7/23/02	
Aroclor 1221	ND	2.0	ppb	7/23/02	
Aroclor 1232	ND	2.0	ppb	7/23/02	
Aroclor 1242	ND	2.0	ppb	7/23/02	
Aroclor 1248	ND	2.0	ppb	7/23/02	
Aroclor 1254	ND	2.0	ppb	7/23/02	
Aroclor 1260	ND	2.0	ppb	7/23/02	
Surr: Decachlorobiphenyl	82.0	70-130	%REC	7/23/02	

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-02
Date Received: 12-Jul-02

Client Sample ID: 34SB06071002
Tag Number:
Collection Date: 7/10/02 9:36:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
SEMI-VOLATILES IN SOIL	**SW8270A**				**GB**
1,2,4,5-Tetrachlorobenzene	ND	0.33	ppm	7/22/02 1:06:00 A	
1,2,4-Trichlorobenzene	ND	0.33	ppm	7/22/02 1:06:00 A	
1,2-Dichlorobenzene	ND	0.33	ppm	7/22/02 1:06:00 A	
1,2-Diphenylhydrazine	ND	0.33	ppm	7/22/02 1:06:00 A	
1,3-Dichlorobenzene	ND	0.33	ppm	7/22/02 1:06:00 A	
1,3-Dinitrobenzene	ND	0.33	ppm	7/22/02 1:06:00 A	
1,4-Dichlorobenzene	ND	0.33	ppm	7/22/02 1:06:00 A	
2,3,4,6-Tetrachlorophenol	ND	0.33	ppm	7/22/02 1:06:00 A	
2,4,5-Trichlorophenol	ND	0.33	ppm	7/22/02 1:06:00 A	
2,4,6-Trichlorophenol	ND	0.33	ppm	7/22/02 1:06:00 A	
2,4-Dichlorophenol	ND	0.33	ppm	7/22/02 1:06:00 A	
2,4-Dimethylphenol	ND	0.33	ppm	7/22/02 1:06:00 A	
2,4-Dinitrophenol	ND	1.6	ppm	7/22/02 1:06:00 A	
2,4-Dinitrotoluene	ND	0.33	ppm	7/22/02 1:06:00 A	
2,6-Dinitrotoluene	ND	0.33	ppm	7/22/02 1:06:00 A	
2-Chloronaphthalene	ND	0.33	ppm	7/22/02 1:06:00 A	
2-Chlorophenol	ND	0.33	ppm	7/22/02 1:06:00 A	
2-Methylnaphthalene	ND	0.33	ppm	7/22/02 1:06:00 A	
2-Methylphenol	ND	0.33	ppm	7/22/02 1:06:00 A	
2-Nitroaniline	ND	0.33	ppm	7/22/02 1:06:00 A	
2-Nitrophenol	ND	0.33	ppm	7/22/02 1:06:00 A	
2-Picoline	ND	0.33	ppm	7/22/02 1:06:00 A	
3,3'-Dichlorobenzidine	ND	0.66	ppm	7/22/02 1:06:00 A	
3-Nitroaniline	ND	0.33	ppm	7/22/02 1:06:00 A	
4,6-Dinitro-2-methylphenol	ND	1.6	ppm	7/22/02 1:06:00 A	
4-Bromophenyl phenyl ether	ND	0.33	ppm	7/22/02 1:06:00 A	
4-Chloro-3-methylphenol	ND	0.66	ppm	7/22/02 1:06:00 A	
4-Chloroaniline	ND	0.33	ppm	7/22/02 1:06:00 A	
4-Chlorophenyl phenyl ether	ND	0.33	ppm	7/22/02 1:06:00 A	
4-Methylphenol	ND	0.33	ppm	7/22/02 1:06:00 A	
4-Nitroaniline	ND	0.33	ppm	7/22/02 1:06:00 A	
4-Nitrophenol	ND	1.6	ppm	7/22/02 1:06:00 A	
Acenaphthene	ND	0.33	ppm	7/22/02 1:06:00 A	

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-02
Date Received: 12-Jul-02

Client Sample ID: 34SB06071002
Tag Number:
Collection Date: 7/10/02 9:36:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Acenaphthylene	ND	0.33	ppm	7/22/02 1:06:00	A
Aniline	ND	0.66	ppm	7/22/02 1:06:00	A
Anthracene	ND	0.33	ppm	7/22/02 1:06:00	A
Benz(a)anthracene	ND	0.33	ppm	7/22/02 1:06:00	A
Benzidine	ND	1.6	ppm	7/22/02 1:06:00	A
Benzo(a)pyrene	ND	0.33	ppm	7/22/02 1:06:00	A
Benzo(b)fluoranthene	ND	0.33	ppm	7/22/02 1:06:00	A
Benzo(g,h,i)perylene	ND	0.33	ppm	7/22/02 1:06:00	A
Benzo(k)fluoranthene	ND	0.33	ppm	7/22/02 1:06:00	A
Benzoic acid	ND	1.6	ppm	7/22/02 1:06:00	A
Benzyl alcohol	ND	0.66	ppm	7/22/02 1:06:00	A
Bis(2-chloroethoxy)methane	ND	0.33	ppm	7/22/02 1:06:00	A
Bis(2-chloroethyl)ether	ND	0.33	ppm	7/22/02 1:06:00	A
Bis(2-chloroisopropyl)ether	ND	0.33	ppm	7/22/02 1:06:00	A
Bis(2-ethylhexyl)phthalate	ND	0.33	ppm	7/22/02 1:06:00	A
Butyl benzyl phthalate	ND	0.33	ppm	7/22/02 1:06:00	A
Carbazole	ND	0.33	ppm	7/22/02 1:06:00	A
Chrysene	ND	0.33	ppm	7/22/02 1:06:00	A
Di-n-butyl phthalate	ND	0.33	ppm	7/22/02 1:06:00	A
Di-n-octyl phthalate	ND	0.33	ppm	7/22/02 1:06:00	A
Dibenz(a,h)anthracene	ND	0.33	ppm	7/22/02 1:06:00	A
Dibenzofuran	ND	0.33	ppm	7/22/02 1:06:00	A
Diethyl phthalate	ND	0.33	ppm	7/22/02 1:06:00	A
Dimethyl phthalate	ND	0.33	ppm	7/22/02 1:06:00	A
Fluoranthene	ND	0.33	ppm	7/22/02 1:06:00	A
Fluorene	ND	0.33	ppm	7/22/02 1:06:00	A
Hexachlorobenzene	ND	0.33	ppm	7/22/02 1:06:00	A
Hexachlorobutadiene	ND	0.33	ppm	7/22/02 1:06:00	A
Hexachlorocyclopentadiene	ND	0.33	ppm	7/22/02 1:06:00	A
Hexachloroethane	ND	0.33	ppm	7/22/02 1:06:00	A
Indeno(1,2,3-cd)pyrene	ND	0.33	ppm	7/22/02 1:06:00	A
Isophorone	ND	0.33	ppm	7/22/02 1:06:00	A
N-Nitrosodi-n-propylamine	ND	0.33	ppm	7/22/02 1:06:00	A
N-Nitrosodimethylamine	ND	0.33	ppm	7/22/02 1:06:00	A
N-Nitrosodiphenylamine	ND	0.66	ppm	7/22/02 1:06:00	A

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CLIENT:	SAIC	**Client Sample ID:**	34SB06071002
Lab Order:	M02070406	**Tag Number:**	
Project:	NSWC Crane OGTSL	**Collection Date:**	7/10/02 9:36:00 AM
Lab ID:	M02070406-02	**Matrix:**	SOIL
Date Received:	12-Jul-02	**Date Reported:**	26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Naphthalene	ND	0.33	ppm	7/22/02 1:06:00 A	
Nitrobenzene	ND	0.33	ppm	7/22/02 1:06:00 A	
o-Toluidine	ND	0.66	ppm	7/22/02 1:06:00 A	
Pentachlorophenol	ND	1.6	ppm	7/22/02 1:06:00 A	
Phenanthrene	ND	0.33	ppm	7/22/02 1:06:00 A	
Phenol	ND	0.33	ppm	7/22/02 1:06:00 A	
Pyrene	ND	0.33	ppm	7/22/02 1:06:00 A	
Pyridine	ND	1.6	ppm	7/22/02 1:06:00 A	
Surr: 2,4,6-Tribromophenol	74.1	19-122	%REC	7/22/02 1:06:00 A	
Surr: 2-Fluorobiphenyl	73.6	30-115	%REC	7/22/02 1:06:00 A	
Surr: 2-Fluorophenol	73.1	25-121	%REC	7/22/02 1:06:00 A	
Surr: 4-Terphenyl-d14	78.0	18-137	%REC	7/22/02 1:06:00 A	
Surr: Nitrobenzene-d5	63.8	23-120	%REC	7/22/02 1:06:00 A	
Surr: Phenol-d5	71.7	24-113	%REC	7/22/02 1:06:00 A	
METALS IN SOIL OR SLUDGE BY ICP		**SW6010A**			**FJR**
Cadmium	0.91	0.030	ppm	7/16/02 11:30:47 A	
Chromium	6.2	0.10	ppm	7/16/02 11:30:47 A	
Lead	6.5	0.25	ppm	7/16/02 11:30:47 A	
PCBS IN SOIL OR SOLID WASTE		**SW8082**			**SDW**
Aroclor 1016	ND	2.00	ppm	7/23/02	
Aroclor 1221	ND	2.00	ppm	7/23/02	
Aroclor 1232	ND	2.00	ppm	7/23/02	
Aroclor 1242	ND	2.00	ppm	7/23/02	
Aroclor 1248	ND	2.00	ppm	7/23/02	
Aroclor 1254	ND	2.00	ppm	7/23/02	
Aroclor 1260	ND	2.00	ppm	7/23/02	
Surr: Decachlorobiphenyl	Diluted Out	70-130	%REC	7/23/02	

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-03
Date Received: 12-Jul-02

Client Sample ID: 34SS10071002
Tag Number:
Collection Date: 7/10/02 10:46:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
SEMI-VOLATILES IN SOIL	**SW8270A**				**GB**
1,2,4,5-Tetrachlorobenzene	ND	0.33	ppm	7/22/02 3:16:00 A	
1,2,4-Trichlorobenzene	ND	0.33	ppm	7/22/02 3:16:00 A	
1,2-Dichlorobenzene	ND	0.33	ppm	7/22/02 3:16:00 A	
1,2-Diphenylhydrazine	ND	0.33	ppm	7/22/02 3:16:00 A	
1,3-Dichlorobenzene	ND	0.33	ppm	7/22/02 3:16:00 A	
1,3-Dinitrobenzene	ND	0.33	ppm	7/22/02 3:16:00 A	
1,4-Dichlorobenzene	ND	0.33	ppm	7/22/02 3:16:00 A	
2,3,4,6-Tetrachlorophenol	ND	0.33	ppm	7/22/02 3:16:00 A	
2,4,5-Trichlorophenol	ND	0.33	ppm	7/22/02 3:16:00 A	
2,4,6-Trichlorophenol	ND	0.33	ppm	7/22/02 3:16:00 A	
2,4-Dichlorophenol	ND	0.33	ppm	7/22/02 3:16:00 A	
2,4-Dimethylphenol	ND	0.33	ppm	7/22/02 3:16:00 A	
2,4-Dinitrophenol	ND	1.6	ppm	7/22/02 3:16:00 A	
2,4-Dinitrotoluene	ND	0.33	ppm	7/22/02 3:16:00 A	
2,6-Dinitrotoluene	ND	0.33	ppm	7/22/02 3:16:00 A	
2-Chloronaphthalene	ND	0.33	ppm	7/22/02 3:16:00 A	
2-Chlorophenol	ND	0.33	ppm	7/22/02 3:16:00 A	
2-Methylnaphthalene	ND	0.33	ppm	7/22/02 3:16:00 A	
2-Methylphenol	ND	0.33	ppm	7/22/02 3:16:00 A	
2-Nitroaniline	ND	0.33	ppm	7/22/02 3:16:00 A	
2-Nitrophenol	ND	0.33	ppm	7/22/02 3:16:00 A	
2-Picoline	ND	0.33	ppm	7/22/02 3:16:00 A	
3,3'-Dichlorobenzidine	ND	0.66	ppm	7/22/02 3:16:00 A	
3-Nitroaniline	ND	0.33	ppm	7/22/02 3:16:00 A	
4,6-Dinitro-2-methylphenol	ND	1.6	ppm	7/22/02 3:16:00 A	
4-Bromophenyl phenyl ether	ND	0.33	ppm	7/22/02 3:16:00 A	
4-Chloro-3-methylphenol	ND	0.66	ppm	7/22/02 3:16:00 A	
4-Chloroaniline	ND	0.33	ppm	7/22/02 3:16:00 A	
4-Chlorophenyl phenyl ether	ND	0.33	ppm	7/22/02 3:16:00 A	
4-Methylphenol	ND	0.33	ppm	7/22/02 3:16:00 A	
4-Nitroaniline	ND	0.33	ppm	7/22/02 3:16:00 A	
4-Nitrophenol	ND	1.6	ppm	7/22/02 3:16:00 A	
Acenaphthene	ND	0.33	ppm	7/22/02 3:16:00 A	

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-03
Date Received: 12-Jul-02

Client Sample ID: 34SS10071002
Tag Number:
Collection Date: 7/10/02 10:46:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Acenaphthylene	ND	0.33	ppm	7/22/02 3:16:00	A
Aniline	ND	0.66	ppm	7/22/02 3:16:00	A
Anthracene	ND	0.33	ppm	7/22/02 3:16:00	A
Benz(a)anthracene	ND	0.33	ppm	7/22/02 3:16:00	A
Benzidine	ND	1.6	ppm	7/22/02 3:16:00	A
Benzo(a)pyrene	ND	0.33	ppm	7/22/02 3:16:00	A
Benzo(b)fluoranthene	ND	0.33	ppm	7/22/02 3:16:00	A
Benzo(g,h,i)perylene	ND	0.33	ppm	7/22/02 3:16:00	A
Benzo(k)fluoranthene	ND	0.33	ppm	7/22/02 3:16:00	A
Benzoic acid	ND	1.6	ppm	7/22/02 3:16:00	A
Benzyl alcohol	ND	0.66	ppm	7/22/02 3:16:00	A
Bis(2-chloroethoxy)methane	ND	0.33	ppm	7/22/02 3:16:00	A
Bis(2-chloroethyl)ether	ND	0.33	ppm	7/22/02 3:16:00	A
Bis(2-chloroisopropyl)ether	ND	0.33	ppm	7/22/02 3:16:00	A
Bis(2-ethylhexyl)phthalate	ND	0.33	ppm	7/22/02 3:16:00	A
Butyl benzyl phthalate	ND	0.33	ppm	7/22/02 3:16:00	A
Carbazole	ND	0.33	ppm	7/22/02 3:16:00	A
Chrysene	ND	0.33	ppm	7/22/02 3:16:00	A
Di-n-butyl phthalate	ND	0.33	ppm	7/22/02 3:16:00	A
Di-n-octyl phthalate	ND	0.33	ppm	7/22/02 3:16:00	A
Dibenz(a,h)anthracene	ND	0.33	ppm	7/22/02 3:16:00	A
Dibenzofuran	ND	0.33	ppm	7/22/02 3:16:00	A
Diethyl phthalate	ND	0.33	ppm	7/22/02 3:16:00	A
Dimethyl phthalate	ND	0.33	ppm	7/22/02 3:16:00	A
Fluoranthene	0.36	0.33	ppm	7/22/02 3:16:00	A
Fluorene	ND	0.33	ppm	7/22/02 3:16:00	A
Hexachlorobenzene	ND	0.33	ppm	7/22/02 3:16:00	A
Hexachlorobutadiene	ND	0.33	ppm	7/22/02 3:16:00	A
Hexachlorocyclopentadiene	ND	0.33	ppm	7/22/02 3:16:00	A
Hexachloroethane	ND	0.33	ppm	7/22/02 3:16:00	A
Indeno(1,2,3-cd)pyrene	ND	0.33	ppm	7/22/02 3:16:00	A
Isophorone	ND	0.33	ppm	7/22/02 3:16:00	A
N-Nitrosodi-n-propylamine	ND	0.33	ppm	7/22/02 3:16:00	A
N-Nitrosodimethylamine	ND	0.33	ppm	7/22/02 3:16:00	A
N-Nitrosodiphenylamine	ND	0.66	ppm	7/22/02 3:16:00	A

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-03
Date Received: 12-Jul-02

Client Sample ID: 34SS10071002
Tag Number:
Collection Date: 7/10/02 10:46:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Naphthalene	ND	0.33	ppm	7/22/02 3:16:00	A
Nitrobenzene	ND	0.33	ppm	7/22/02 3:16:00	A
o-Toluidine	ND	0.66	ppm	7/22/02 3:16:00	A
Pentachlorophenol	ND	1.6	ppm	7/22/02 3:16:00	A
Phenanthrene	ND	0.33	ppm	7/22/02 3:16:00	A
Phenol	ND	0.33	ppm	7/22/02 3:16:00	A
Pyrene	ND	0.33	ppm	7/22/02 3:16:00	A
Pyridine	ND	1.6	ppm	7/22/02 3:16:00	A
Surr: 2,4,6-Tribromophenol	73.8	19-122	%REC	7/22/02 3:16:00	A
Surr: 2-Fluorobiphenyl	70.9	30-115	%REC	7/22/02 3:16:00	A
Surr: 2-Fluorophenol	66.8	25-121	%REC	7/22/02 3:16:00	A
Surr: 4-Terphenyl-d14	74.7	18-137	%REC	7/22/02 3:16:00	A
Surr: Nitrobenzene-d5	59.4	23-120	%REC	7/22/02 3:16:00	A
Surr: Phenol-d5	66.5	24-113	%REC	7/22/02 3:16:00	A
METALS IN SOIL OR SLUDGE BY ICP		**SW6010A**			**FJR**
Cadmium	1.6	0.030	ppm	7/16/02 11:33:39	A
Chromium	7.5	0.10	ppm	7/16/02 11:33:39	A
Lead	16	0.25	ppm	7/16/02 11:33:39	A
PCBS IN SOIL OR SOLID WASTE		**SW8082**			**SDW**
Aroclor 1016	ND	2.00	ppm	7/23/02	
Aroclor 1221	ND	2.00	ppm	7/23/02	
Aroclor 1232	ND	2.00	ppm	7/23/02	
Aroclor 1242	ND	2.00	ppm	7/23/02	
Aroclor 1248	ND	2.00	ppm	7/23/02	
Aroclor 1254	ND	2.00	ppm	7/23/02	
Aroclor 1260	ND	2.00	ppm	7/23/02	
Surr: Decachlorobiphenyl	Diluted Out	70-130	%REC	7/23/02	

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Testing Today – Protecting Tomorrow
2203 S. Madison Street
Muncie Indiana 47302
800-874-3563

CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-04
Date Received: 12-Jul-02

Client Sample ID: 34SS09071002
Tag Number:
Collection Date: 7/10/02 10:30:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
SEMI-VOLATILES IN SOIL	**SW8270A**				**GB**
1,2,4,5-Tetrachlorobenzene	ND	0.33	ppm	7/22/02 3:49:00 A	
1,2,4-Trichlorobenzene	ND	0.33	ppm	7/22/02 3:49:00 A	
1,2-Dichlorobenzene	ND	0.33	ppm	7/22/02 3:49:00 A	
1,2-Diphenylhydrazine	ND	0.33	ppm	7/22/02 3:49:00 A	
1,3-Dichlorobenzene	ND	0.33	ppm	7/22/02 3:49:00 A	
1,3-Dinitrobenzene	ND	0.33	ppm	7/22/02 3:49:00 A	
1,4-Dichlorobenzene	ND	0.33	ppm	7/22/02 3:49:00 A	
2,3,4,6-Tetrachlorophenol	ND	0.33	ppm	7/22/02 3:49:00 A	
2,4,5-Trichlorophenol	ND	0.33	ppm	7/22/02 3:49:00 A	
2,4,6-Trichlorophenol	ND	0.33	ppm	7/22/02 3:49:00 A	
2,4-Dichlorophenol	ND	0.33	ppm	7/22/02 3:49:00 A	
2,4-Dimethylphenol	ND	0.33	ppm	7/22/02 3:49:00 A	
2,4-Dinitrophenol	ND	1.6	ppm	7/22/02 3:49:00 A	
2,4-Dinitrotoluene	ND	0.33	ppm	7/22/02 3:49:00 A	
2,6-Dinitrotoluene	ND	0.33	ppm	7/22/02 3:49:00 A	
2-Chloronaphthalene	ND	0.33	ppm	7/22/02 3:49:00 A	
2-Chlorophenol	ND	0.33	ppm	7/22/02 3:49:00 A	
2-Methylnaphthalene	ND	0.33	ppm	7/22/02 3:49:00 A	
2-Methylphenol	ND	0.33	ppm	7/22/02 3:49:00 A	
2-Nitroaniline	ND	0.33	ppm	7/22/02 3:49:00 A	
2-Nitrophenol	ND	0.33	ppm	7/22/02 3:49:00 A	
2-Picoline	ND	0.33	ppm	7/22/02 3:49:00 A	
3,3'-Dichlorobenzidine	ND	0.66	ppm	7/22/02 3:49:00 A	
3-Nitroaniline	ND	0.33	ppm	7/22/02 3:49:00 A	
4,6-Dinitro-2-methylphenol	ND	1.6	ppm	7/22/02 3:49:00 A	
4-Bromophenyl phenyl ether	ND	0.33	ppm	7/22/02 3:49:00 A	
4-Chloro-3-methylphenol	ND	0.66	ppm	7/22/02 3:49:00 A	
4-Chloroaniline	ND	0.33	ppm	7/22/02 3:49:00 A	
4-Chlorophenyl phenyl ether	ND	0.33	ppm	7/22/02 3:49:00 A	
4-Methylphenol	ND	0.33	ppm	7/22/02 3:49:00 A	
4-Nitroaniline	ND	0.33	ppm	7/22/02 3:49:00 A	
4-Nitrophenol	ND	1.6	ppm	7/22/02 3:49:00 A	
Acenaphthene	ND	0.33	ppm	7/22/02 3:49:00 A	

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-04
Date Received: 12-Jul-02

Client Sample ID: 34SS09071002
Tag Number:
Collection Date: 7/10/02 10:30:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Acenaphthylene	ND	0.33	ppm	7/22/02 3:49:00	A
Aniline	ND	0.66	ppm	7/22/02 3:49:00	A
Anthracene	ND	0.33	ppm	7/22/02 3:49:00	A
Benz(a)anthracene	ND	0.33	ppm	7/22/02 3:49:00	A
Benzidine	ND	1.6	ppm	7/22/02 3:49:00	A
Benzo(a)pyrene	ND	0.33	ppm	7/22/02 3:49:00	A
Benzo(b)fluoranthene	ND	0.33	ppm	7/22/02 3:49:00	A
Benzo(g,h,i)perylene	ND	0.33	ppm	7/22/02 3:49:00	A
Benzo(k)fluoranthene	ND	0.33	ppm	7/22/02 3:49:00	A
Benzoic acid	ND	1.6	ppm	7/22/02 3:49:00	A
Benzyl alcohol	ND	0.66	ppm	7/22/02 3:49:00	A
Bis(2-chloroethoxy)methane	ND	0.33	ppm	7/22/02 3:49:00	A
Bis(2-chloroethyl)ether	ND	0.33	ppm	7/22/02 3:49:00	A
Bis(2-chloroisopropyl)ether	ND	0.33	ppm	7/22/02 3:49:00	A
Bis(2-ethylhexyl)phthalate	3.6	0.33	ppm	7/22/02 3:49:00	A
Butyl benzyl phthalate	ND	0.33	ppm	7/22/02 3:49:00	A
Carbazole	ND	0.33	ppm	7/22/02 3:49:00	A
Chrysene	ND	0.33	ppm	7/22/02 3:49:00	A
Di-n-butyl phthalate	ND	0.33	ppm	7/22/02 3:49:00	A
Di-n-octyl phthalate	ND	0.33	ppm	7/22/02 3:49:00	A
Dibenz(a,h)anthracene	ND	0.33	ppm	7/22/02 3:49:00	A
Dibenzofuran	ND	0.33	ppm	7/22/02 3:49:00	A
Diethyl phthalate	ND	0.33	ppm	7/22/02 3:49:00	A
Dimethyl phthalate	ND	0.33	ppm	7/22/02 3:49:00	A
Fluoranthene	ND	0.33	ppm	7/22/02 3:49:00	A
Fluorene	ND	0.33	ppm	7/22/02 3:49:00	A
Hexachlorobenzene	ND	0.33	ppm	7/22/02 3:49:00	A
Hexachlorobutadiene	ND	0.33	ppm	7/22/02 3:49:00	A
Hexachlorocyclopentadiene	ND	0.33	ppm	7/22/02 3:49:00	A
Hexachloroethane	ND	0.33	ppm	7/22/02 3:49:00	A
Indeno(1,2,3-cd)pyrene	ND	0.33	ppm	7/22/02 3:49:00	A
Isophorone	ND	0.33	ppm	7/22/02 3:49:00	A
N-Nitrosodi-n-propylamine	ND	0.33	ppm	7/22/02 3:49:00	A
N-Nitrosodimethylamine	ND	0.33	ppm	7/22/02 3:49:00	A
N-Nitrosodiphenylamine	ND	0.66	ppm	7/22/02 3:49:00	A

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-04
Date Received: 12-Jul-02

Client Sample ID: 34SS09071002
Tag Number:
Collection Date: 7/10/02 10:30:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Naphthalene	ND	0.33	ppm	7/22/02 3:49:00	A
Nitrobenzene	ND	0.33	ppm	7/22/02 3:49:00	A
o-Toluidine	ND	0.66	ppm	7/22/02 3:49:00	A
Pentachlorophenol	ND	1.6	ppm	7/22/02 3:49:00	A
Phenanthrene	ND	0.33	ppm	7/22/02 3:49:00	A
Phenol	ND	0.33	ppm	7/22/02 3:49:00	A
Pyrene	ND	0.33	ppm	7/22/02 3:49:00	A
Pyridine	ND	1.6	ppm	7/22/02 3:49:00	A
Surr: 2,4,6-Tribromophenol	60.1	19-122	%REC	7/22/02 3:49:00	A
Surr: 2-Fluorobiphenyl	57.8	30-115	%REC	7/22/02 3:49:00	A
Surr: 2-Fluorophenol	43.3	25-121	%REC	7/22/02 3:49:00	A
Surr: 4-Terphenyl-d14	65.6	18-137	%REC	7/22/02 3:49:00	A
Surr: Nitrobenzene-d5	45.3	23-120	%REC	7/22/02 3:49:00	A
Surr: Phenol-d5	48.3	24-113	%REC	7/22/02 3:49:00	A
METALS IN SOIL OR SLUDGE BY ICP		**SW6010A**			**FJR**
Cadmium	1.7	0.030	ppm	7/16/02 11:36:38	A
Chromium	ND	0.10	ppm	7/16/02 11:36:38	A
Lead	9.6	0.25	ppm	7/16/02 11:36:38	A
PCBS IN SOIL OR SOLID WASTE		**SW8082**			**SDW**
Aroclor 1016	ND	2.00	ppm	7/23/02	
Aroclor 1221	ND	2.00	ppm	7/23/02	
Aroclor 1232	ND	2.00	ppm	7/23/02	
Aroclor 1242	ND	2.00	ppm	7/23/02	
Aroclor 1248	ND	2.00	ppm	7/23/02	
Aroclor 1254	ND	2.00	ppm	7/23/02	
Aroclor 1260	ND	2.00	ppm	7/23/02	
Surr: Decachlorobiphenyl	Diluted Out	70-130	%REC	7/23/02	

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-05
Date Received: 12-Jul-02

Client Sample ID: 34SB07071002
Tag Number:
Collection Date: 7/10/02 10:00:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
SEMI-VOLATILES IN SOIL	**SW8270A**				**GB**
1,2,4,5-Tetrachlorobenzene	ND	0.33	ppm	7/22/02 1:39:00 A	
1,2,4-Trichlorobenzene	ND	0.33	ppm	7/22/02 1:39:00 A	
1,2-Dichlorobenzene	ND	0.33	ppm	7/22/02 1:39:00 A	
1,2-Diphenylhydrazine	ND	0.33	ppm	7/22/02 1:39:00 A	
1,3-Dichlorobenzene	ND	0.33	ppm	7/22/02 1:39:00 A	
1,3-Dinitrobenzene	ND	0.33	ppm	7/22/02 1:39:00 A	
1,4-Dichlorobenzene	ND	0.33	ppm	7/22/02 1:39:00 A	
2,3,4,6-Tetrachlorophenol	ND	0.33	ppm	7/22/02 1:39:00 A	
2,4,5-Trichlorophenol	ND	0.33	ppm	7/22/02 1:39:00 A	
2,4,6-Trichlorophenol	ND	0.33	ppm	7/22/02 1:39:00 A	
2,4-Dichlorophenol	ND	0.33	ppm	7/22/02 1:39:00 A	
2,4-Dimethylphenol	ND	0.33	ppm	7/22/02 1:39:00 A	
2,4-Dinitrophenol	ND	1.6	ppm	7/22/02 1:39:00 A	
2,4-Dinitrotoluene	ND	0.33	ppm	7/22/02 1:39:00 A	
2,6-Dinitrotoluene	ND	0.33	ppm	7/22/02 1:39:00 A	
2-Chloronaphthalene	ND	0.33	ppm	7/22/02 1:39:00 A	
2-Chlorophenol	ND	0.33	ppm	7/22/02 1:39:00 A	
2-Methylnaphthalene	ND	0.33	ppm	7/22/02 1:39:00 A	
2-Methylphenol	ND	0.33	ppm	7/22/02 1:39:00 A	
2-Nitroaniline	ND	0.33	ppm	7/22/02 1:39:00 A	
2-Nitrophenol	ND	0.33	ppm	7/22/02 1:39:00 A	
2-Picoline	ND	0.33	ppm	7/22/02 1:39:00 A	
3,3'-Dichlorobenzidine	ND	0.66	ppm	7/22/02 1:39:00 A	
3-Nitroaniline	ND	0.33	ppm	7/22/02 1:39:00 A	
4,6-Dinitro-2-methylphenol	ND	1.6	ppm	7/22/02 1:39:00 A	
4-Bromophenyl phenyl ether	ND	0.33	ppm	7/22/02 1:39:00 A	
4-Chloro-3-methylphenol	ND	0.66	ppm	7/22/02 1:39:00 A	
4-Chloroaniline	ND	0.33	ppm	7/22/02 1:39:00 A	
4-Chlorophenyl phenyl ether	ND	0.33	ppm	7/22/02 1:39:00 A	
4-Methylphenol	ND	0.33	ppm	7/22/02 1:39:00 A	
4-Nitroaniline	ND	0.33	ppm	7/22/02 1:39:00 A	
4-Nitrophenol	ND	1.6	ppm	7/22/02 1:39:00 A	
Acenaphthene	ND	0.33	ppm	7/22/02 1:39:00 A	

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-05
Date Received: 12-Jul-02

Client Sample ID: 34SB07071002
Tag Number:
Collection Date: 7/10/02 10:00:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Acenaphthylene	ND	0.33	ppm	7/22/02 1:39:00	A
Aniline	ND	0.66	ppm	7/22/02 1:39:00	A
Anthracene	ND	0.33	ppm	7/22/02 1:39:00	A
Benz(a)anthracene	ND	0.33	ppm	7/22/02 1:39:00	A
Benzidine	ND	1.6	ppm	7/22/02 1:39:00	A
Benzo(a)pyrene	ND	0.33	ppm	7/22/02 1:39:00	A
Benzo(b)fluoranthene	ND	0.33	ppm	7/22/02 1:39:00	A
Benzo(g,h,i)perylene	ND	0.33	ppm	7/22/02 1:39:00	A
Benzo(k)fluoranthene	ND	0.33	ppm	7/22/02 1:39:00	A
Benzoic acid	ND	1.6	ppm	7/22/02 1:39:00	A
Benzyl alcohol	ND	0.66	ppm	7/22/02 1:39:00	A
Bis(2-chloroethoxy)methane	ND	0.33	ppm	7/22/02 1:39:00	A
Bis(2-chloroethyl)ether	ND	0.33	ppm	7/22/02 1:39:00	A
Bis(2-chloroisopropyl)ether	ND	0.33	ppm	7/22/02 1:39:00	A
Bis(2-ethylhexyl)phthalate	ND	0.33	ppm	7/22/02 1:39:00	A
Butyl benzyl phthalate	ND	0.33	ppm	7/22/02 1:39:00	A
Carbazole	ND	0.33	ppm	7/22/02 1:39:00	A
Chrysene	ND	0.33	ppm	7/22/02 1:39:00	A
Di-n-butyl phthalate	ND	0.33	ppm	7/22/02 1:39:00	A
Di-n-octyl phthalate	ND	0.33	ppm	7/22/02 1:39:00	A
Dibenz(a,h)anthracene	ND	0.33	ppm	7/22/02 1:39:00	A
Dibenzofuran	ND	0.33	ppm	7/22/02 1:39:00	A
Diethyl phthalate	ND	0.33	ppm	7/22/02 1:39:00	A
Dimethyl phthalate	ND	0.33	ppm	7/22/02 1:39:00	A
Fluoranthene	ND	0.33	ppm	7/22/02 1:39:00	A
Fluorene	ND	0.33	ppm	7/22/02 1:39:00	A
Hexachlorobenzene	ND	0.33	ppm	7/22/02 1:39:00	A
Hexachlorobutadiene	ND	0.33	ppm	7/22/02 1:39:00	A
Hexachlorocyclopentadiene	ND	0.33	ppm	7/22/02 1:39:00	A
Hexachloroethane	ND	0.33	ppm	7/22/02 1:39:00	A
Indeno(1,2,3-cd)pyrene	ND	0.33	ppm	7/22/02 1:39:00	A
Isophorone	ND	0.33	ppm	7/22/02 1:39:00	A
N-Nitrosodi-n-propylamine	ND	0.33	ppm	7/22/02 1:39:00	A
N-Nitrosodimethylamine	ND	0.33	ppm	7/22/02 1:39:00	A
N-Nitrosodiphenylamine	ND	0.66	ppm	7/22/02 1:39:00	A

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-05
Date Received: 12-Jul-02

Client Sample ID: 34SB07071002
Tag Number:
Collection Date: 7/10/02 10:00:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Naphthalene	ND	0.33	ppm	7/22/02 1:39:00	A
Nitrobenzene	ND	0.33	ppm	7/22/02 1:39:00	A
o-Toluidine	ND	0.66	ppm	7/22/02 1:39:00	A
Pentachlorophenol	ND	1.6	ppm	7/22/02 1:39:00	A
Phenanthrene	ND	0.33	ppm	7/22/02 1:39:00	A
Phenol	ND	0.33	ppm	7/22/02 1:39:00	A
Pyrene	ND	0.33	ppm	7/22/02 1:39:00	A
Pyridine	ND	1.6	ppm	7/22/02 1:39:00	A
Surr: 2,4,6-Tribromophenol	69.8	19-122	%REC	7/22/02 1:39:00	A
Surr: 2-Fluorobiphenyl	63.7	30-115	%REC	7/22/02 1:39:00	A
Surr: 2-Fluorophenol	72.8	25-121	%REC	7/22/02 1:39:00	A
Surr: 4-Terphenyl-d14	72.4	18-137	%REC	7/22/02 1:39:00	A
Surr: Nitrobenzene-d5	62.3	23-120	%REC	7/22/02 1:39:00	A
Surr: Phenol-d5	73.6	24-113	%REC	7/22/02 1:39:00	A
METALS IN SOIL OR SLUDGE BY ICP	**SW6010A**				**FJR**
Cadmium	0.99	0.030	ppm	7/16/02 11:39:27	A
Chromium	6.8	0.10	ppm	7/16/02 11:39:27	A
Lead	6.7	0.25	ppm	7/16/02 11:39:27	A
PCBS IN SOIL OR SOLID WASTE	**SW8082**				**SDW**
Aroclor 1016	ND	2.00	ppm	7/23/02	
Aroclor 1221	ND	2.00	ppm	7/23/02	
Aroclor 1232	ND	2.00	ppm	7/23/02	
Aroclor 1242	ND	2.00	ppm	7/23/02	
Aroclor 1248	ND	2.00	ppm	7/23/02	
Aroclor 1254	ND	2.00	ppm	7/23/02	
Aroclor 1260	ND	2.00	ppm	7/23/02	
Surr: Decachlorobiphenyl	Diluted Out	70-130	%REC	7/23/02	

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-06
Date Received: 12-Jul-02

Client Sample ID: 34SS11071002
Tag Number:
Collection Date: 7/10/02 10:56:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
SEMI-VOLATILES IN SOIL	**SW8270A**				**GB**
1,2,4,5-Tetrachlorobenzene	ND	0.33	ppm	7/22/02 4:23:00 A	
1,2,4-Trichlorobenzene	ND	0.33	ppm	7/22/02 4:23:00 A	
1,2-Dichlorobenzene	ND	0.33	ppm	7/22/02 4:23:00 A	
1,2-Diphenylhydrazine	ND	0.33	ppm	7/22/02 4:23:00 A	
1,3-Dichlorobenzene	ND	0.33	ppm	7/22/02 4:23:00 A	
1,3-Dinitrobenzene	ND	0.33	ppm	7/22/02 4:23:00 A	
1,4-Dichlorobenzene	ND	0.33	ppm	7/22/02 4:23:00 A	
2,3,4,6-Tetrachlorophenol	ND	0.33	ppm	7/22/02 4:23:00 A	
2,4,5-Trichlorophenol	ND	0.33	ppm	7/22/02 4:23:00 A	
2,4,6-Trichlorophenol	ND	0.33	ppm	7/22/02 4:23:00 A	
2,4-Dichlorophenol	ND	0.33	ppm	7/22/02 4:23:00 A	
2,4-Dimethylphenol	ND	0.33	ppm	7/22/02 4:23:00 A	
2,4-Dinitrophenol	ND	1.6	ppm	7/22/02 4:23:00 A	
2,4-Dinitrotoluene	ND	0.33	ppm	7/22/02 4:23:00 A	
2,6-Dinitrotoluene	ND	0.33	ppm	7/22/02 4:23:00 A	
2-Chloronaphthalene	ND	0.33	ppm	7/22/02 4:23:00 A	
2-Chlorophenol	ND	0.33	ppm	7/22/02 4:23:00 A	
2-Methylnaphthalene	ND	0.33	ppm	7/22/02 4:23:00 A	
2-Methylphenol	ND	0.33	ppm	7/22/02 4:23:00 A	
2-Nitroaniline	ND	0.33	ppm	7/22/02 4:23:00 A	
2-Nitrophenol	ND	0.33	ppm	7/22/02 4:23:00 A	
2-Picoline	ND	0.33	ppm	7/22/02 4:23:00 A	
3,3'-Dichlorobenzidine	ND	0.66	ppm	7/22/02 4:23:00 A	
3-Nitroaniline	ND	0.33	ppm	7/22/02 4:23:00 A	
4,6-Dinitro-2-methylphenol	ND	1.6	ppm	7/22/02 4:23:00 A	
4-Bromophenyl phenyl ether	ND	0.33	ppm	7/22/02 4:23:00 A	
4-Chloro-3-methylphenol	ND	0.66	ppm	7/22/02 4:23:00 A	
4-Chloroaniline	ND	0.33	ppm	7/22/02 4:23:00 A	
4-Chlorophenyl phenyl ether	ND	0.33	ppm	7/22/02 4:23:00 A	
4-Methylphenol	ND	0.33	ppm	7/22/02 4:23:00 A	
4-Nitroaniline	ND	0.33	ppm	7/22/02 4:23:00 A	
4-Nitrophenol	ND	1.6	ppm	7/22/02 4:23:00 A	
Acenaphthene	ND	0.33	ppm	7/22/02 4:23:00 A	

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Testing Today - Protecting Tomorrow ..
2203 S. Madison Street
Muncie Indiana 47302
800-874-3563

CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-06
Date Received: 12-Jul-02

Client Sample ID: 34SS11071002
Tag Number:
Collection Date: 7/10/02 10:56:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Acenaphthylene	ND	0.33	ppm	7/22/02 4:23:00	A
Aniline	ND	0.66	ppm	7/22/02 4:23:00	A
Anthracene	ND	0.33	ppm	7/22/02 4:23:00	A
Benz(a)anthracene	ND	0.33	ppm	7/22/02 4:23:00	A
Benzidine	ND	1.6	ppm	7/22/02 4:23:00	A
Benzo(a)pyrene	ND	0.33	ppm	7/22/02 4:23:00	A
Benzo(b)fluoranthene	ND	0.33	ppm	7/22/02 4:23:00	A
Benzo(g,h,i)perylene	ND	0.33	ppm	7/22/02 4:23:00	A
Benzo(k)fluoranthene	ND	0.33	ppm	7/22/02 4:23:00	A
Benzoic acid	ND	1.6	ppm	7/22/02 4:23:00	A
Benzyl alcohol	ND	0.66	ppm	7/22/02 4:23:00	A
Bis(2-chloroethoxy)methane	ND	0.33	ppm	7/22/02 4:23:00	A
Bis(2-chloroethyl)ether	ND	0.33	ppm	7/22/02 4:23:00	A
Bis(2-chloroisopropyl)ether	ND	0.33	ppm	7/22/02 4:23:00	A
Bis(2-ethylhexyl)phthalate	1.3	0.33	ppm	7/22/02 4:23:00	A
Butyl benzyl phthalate	ND	0.33	ppm	7/22/02 4:23:00	A
Carbazole	ND	0.33	ppm	7/22/02 4:23:00	A
Chrysene	ND	0.33	ppm	7/22/02 4:23:00	A
Di-n-butyl phthalate	ND	0.33	ppm	7/22/02 4:23:00	A
Di-n-octyl phthalate	ND	0.33	ppm	7/22/02 4:23:00	A
Dibenz(a,h)anthracene	ND	0.33	ppm	7/22/02 4:23:00	A
Dibenzofuran	ND	0.33	ppm	7/22/02 4:23:00	A
Diethyl phthalate	ND	0.33	ppm	7/22/02 4:23:00	A
Dimethyl phthalate	ND	0.33	ppm	7/22/02 4:23:00	A
Fluoranthene	0.39	0.33	ppm	7/22/02 4:23:00	A
Fluorene	ND	0.33	ppm	7/22/02 4:23:00	A
Hexachlorobenzene	ND	0.33	ppm	7/22/02 4:23:00	A
Hexachlorobutadiene	ND	0.33	ppm	7/22/02 4:23:00	A
Hexachlorocyclopentadiene	ND	0.33	ppm	7/22/02 4:23:00	A
Hexachloroethane	ND	0.33	ppm	7/22/02 4:23:00	A
Indeno(1,2,3-cd)pyrene	ND	0.33	ppm	7/22/02 4:23:00	A
Isophorone	ND	0.33	ppm	7/22/02 4:23:00	A
N-Nitrosodi-n-propylamine	ND	0.33	ppm	7/22/02 4:23:00	A
N-Nitrosodimethylamine	ND	0.33	ppm	7/22/02 4:23:00	A
N-Nitrosodiphenylamine	ND	0.66	ppm	7/22/02 4:23:00	A

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-06
Date Received: 12-Jul-02

Client Sample ID: 34SS11071002
Tag Number:
Collection Date: 7/10/02 10:56:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Naphthalene	ND	0.33	ppm	7/22/02 4:23:00	A
Nitrobenzene	ND	0.33	ppm	7/22/02 4:23:00	A
o-Toluidine	ND	0.66	ppm	7/22/02 4:23:00	A
Pentachlorophenol	ND	1.6	ppm	7/22/02 4:23:00	A
Phenanthrene	ND	0.33	ppm	7/22/02 4:23:00	A
Phenol	ND	0.33	ppm	7/22/02 4:23:00	A
Pyrene	ND	0.33	ppm	7/22/02 4:23:00	A
Pyridine	ND	1.6	ppm	7/22/02 4:23:00	A
Surr: 2,4,6-Tribromophenol	83.4	19-122	%REC	7/22/02 4:23:00	A
Surr: 2-Fluorobiphenyl	67.5	30-115	%REC	7/22/02 4:23:00	A
Surr: 2-Fluorophenol	63.6	25-121	%REC	7/22/02 4:23:00	A
Surr: 4-Terphenyl-d14	81.5	18-137	%REC	7/22/02 4:23:00	A
Surr: Nitrobenzene-d5	56.9	23-120	%REC	7/22/02 4:23:00	A
Surr: Phenol-d5	63.8	24-113	%REC	7/22/02 4:23:00	A
METALS IN SOIL OR SLUDGE BY ICP		**SW6010A**			**FJR**
Cadmium	2.3	0.030	ppm	7/16/02 11:42:26	A
Chromium	20	0.10	ppm	7/16/02 11:42:26	A
Lead	170	0.25	ppm	7/16/02 11:42:26	A
PCBS IN SOIL OR SOLID WASTE		**SW8082**			**SDW**
Aroclor 1016	ND	2.00	ppm	7/23/02	
Aroclor 1221	ND	2.00	ppm	7/23/02	
Aroclor 1232	ND	2.00	ppm	7/23/02	
Aroclor 1242	ND	2.00	ppm	7/23/02	
Aroclor 1248	ND	2.00	ppm	7/23/02	
Aroclor 1254	ND	2.00	ppm	7/23/02	
Aroclor 1260	ND	2.00	ppm	7/23/02	
Surr: Decachlorobiphenyl	Diluted Out	70-130	%REC	7/23/02	

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-07
Date Received: 12-Jul-02

Client Sample ID: 34SS08071002
Tag Number:
Collection Date: 7/10/02 10:18:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
SEMI-VOLATILES IN SOIL	**SW8270A**				**GB**
1,2,4,5-Tetrachlorobenzene	ND	0.33	ppm	7/22/02 4:55:00 A	
1,2,4-Trichlorobenzene	ND	0.33	ppm	7/22/02 4:55:00 A	
1,2-Dichlorobenzene	ND	0.33	ppm	7/22/02 4:55:00 A	
1,2-Diphenylhydrazine	ND	0.33	ppm	7/22/02 4:55:00 A	
1,3-Dichlorobenzene	ND	0.33	ppm	7/22/02 4:55:00 A	
1,3-Dinitrobenzene	ND	0.33	ppm	7/22/02 4:55:00 A	
1,4-Dichlorobenzene	ND	0.33	ppm	7/22/02 4:55:00 A	
2,3,4,6-Tetrachlorophenol	ND	0.33	ppm	7/22/02 4:55:00 A	
2,4,5-Trichlorophenol	ND	0.33	ppm	7/22/02 4:55:00 A	
2,4,6-Trichlorophenol	ND	0.33	ppm	7/22/02 4:55:00 A	
2,4-Dichlorophenol	ND	0.33	ppm	7/22/02 4:55:00 A	
2,4-Dimethylphenol	ND	0.33	ppm	7/22/02 4:55:00 A	
2,4-Dinitrophenol	ND	1.6	ppm	7/22/02 4:55:00 A	
2,4-Dinitrotoluene	ND	0.33	ppm	7/22/02 4:55:00 A	
2,6-Dinitrotoluene	ND	0.33	ppm	7/22/02 4:55:00 A	
2-Chloronaphthalene	ND	0.33	ppm	7/22/02 4:55:00 A	
2-Chlorophenol	ND	0.33	ppm	7/22/02 4:55:00 A	
2-Methylnaphthalene	ND	0.33	ppm	7/22/02 4:55:00 A	
2-Methylphenol	ND	0.33	ppm	7/22/02 4:55:00 A	
2-Nitroaniline	ND	0.33	ppm	7/22/02 4:55:00 A	
2-Nitrophenol	ND	0.33	ppm	7/22/02 4:55:00 A	
2-Picoline	ND	0.33	ppm	7/22/02 4:55:00 A	
3,3'-Dichlorobenzidine	ND	0.66	ppm	7/22/02 4:55:00 A	
3-Nitroaniline	ND	0.33	ppm	7/22/02 4:55:00 A	
4,6-Dinitro-2-methylphenol	ND	1.6	ppm	7/22/02 4:55:00 A	
4-Bromophenyl phenyl ether	ND	0.33	ppm	7/22/02 4:55:00 A	
4-Chloro-3-methylphenol	ND	0.66	ppm	7/22/02 4:55:00 A	
4-Chloroaniline	ND	0.33	ppm	7/22/02 4:55:00 A	
4-Chlorophenyl phenyl ether	ND	0.33	ppm	7/22/02 4:55:00 A	
4-Methylphenol	ND	0.33	ppm	7/22/02 4:55:00 A	
4-Nitroaniline	ND	0.33	ppm	7/22/02 4:55:00 A	
4-Nitrophenol	ND	1.6	ppm	7/22/02 4:55:00 A	
Acenaphthene	ND	0.33	ppm	7/22/02 4:55:00 A	

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-07
Date Received: 12-Jul-02

Client Sample ID: 34SS08071002
Tag Number:
Collection Date: 7/10/02 10:18:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Acenaphthylene	ND	0.33	ppm	7/22/02 4:55:00	A
Aniline	ND	0.66	ppm	7/22/02 4:55:00	A
Anthracene	ND	0.33	ppm	7/22/02 4:55:00	A
Benz(a)anthracene	ND	0.33	ppm	7/22/02 4:55:00	A
Benzidine	ND	1.6	ppm	7/22/02 4:55:00	A
Benzo(a)pyrene	ND	0.33	ppm	7/22/02 4:55:00	A
Benzo(b)fluoranthene	ND	0.33	ppm	7/22/02 4:55:00	A
Benzo(g,h,i)perylene	ND	0.33	ppm	7/22/02 4:55:00	A
Benzo(k)fluoranthene	ND	0.33	ppm	7/22/02 4:55:00	A
Benzoic acid	ND	1.6	ppm	7/22/02 4:55:00	A
Benzyl alcohol	ND	0.66	ppm	7/22/02 4:55:00	A
Bis(2-chloroethoxy)methane	ND	0.33	ppm	7/22/02 4:55:00	A
Bis(2-chloroethyl)ether	ND	0.33	ppm	7/22/02 4:55:00	A
Bis(2-chloroisopropyl)ether	ND	0.33	ppm	7/22/02 4:55:00	A
Bis(2-ethylhexyl)phthalate	1.6	0.33	ppm	7/22/02 4:55:00	A
Butyl benzyl phthalate	ND	0.33	ppm	7/22/02 4:55:00	A
Carbazole	ND	0.33	ppm	7/22/02 4:55:00	A
Chrysene	ND	0.33	ppm	7/22/02 4:55:00	A
Di-n-butyl phthalate	ND	0.33	ppm	7/22/02 4:55:00	A
Di-n-octyl phthalate	ND	0.33	ppm	7/22/02 4:55:00	A
Dibenz(a,h)anthracene	ND	0.33	ppm	7/22/02 4:55:00	A
Dibenzofuran	ND	0.33	ppm	7/22/02 4:55:00	A
Diethyl phthalate	ND	0.33	ppm	7/22/02 4:55:00	A
Dimethyl phthalate	ND	0.33	ppm	7/22/02 4:55:00	A
Fluoranthene	ND	0.33	ppm	7/22/02 4:55:00	A
Fluorene	ND	0.33	ppm	7/22/02 4:55:00	A
Hexachlorobenzene	ND	0.33	ppm	7/22/02 4:55:00	A
Hexachlorobutadiene	ND	0.33	ppm	7/22/02 4:55:00	A
Hexachlorocyclopentadiene	ND	0.33	ppm	7/22/02 4:55:00	A
Hexachloroethane	ND	0.33	ppm	7/22/02 4:55:00	A
Indeno(1,2,3-cd)pyrene	ND	0.33	ppm	7/22/02 4:55:00	A
Isophorone	ND	0.33	ppm	7/22/02 4:55:00	A
N-Nitrosodi-n-propylamine	ND	0.33	ppm	7/22/02 4:55:00	A
N-Nitrosodimethylamine	ND	0.33	ppm	7/22/02 4:55:00	A
N-Nitrosodiphenylamine	ND	0.66	ppm	7/22/02 4:55:00	A

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-07
Date Received: 12-Jul-02

Client Sample ID: 34SS08071002
Tag Number:
Collection Date: 7/10/02 10:18:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Naphthalene	ND	0.33	ppm	7/22/02 4:55:00	A
Nitrobenzene	ND	0.33	ppm	7/22/02 4:55:00	A
o-Toluidine	ND	0.66	ppm	7/22/02 4:55:00	A
Pentachlorophenol	ND	1.6	ppm	7/22/02 4:55:00	A
Phenanthrene	ND	0.33	ppm	7/22/02 4:55:00	A
Phenol	ND	0.33	ppm	7/22/02 4:55:00	A
Pyrene	ND	0.33	ppm	7/22/02 4:55:00	A
Pyridine	ND	1.6	ppm	7/22/02 4:55:00	A
Surr: 2,4,6-Tribromophenol	79.9	19-122	%REC	7/22/02 4:55:00	A
Surr: 2-Fluorobiphenyl	72.3	30-115	%REC	7/22/02 4:55:00	A
Surr: 2-Fluorophenol	60.2	25-121	%REC	7/22/02 4:55:00	A
Surr: 4-Terphenyl-d14	82.7	18-137	%REC	7/22/02 4:55:00	A
Surr: Nitrobenzene-d5	60.4	23-120	%REC	7/22/02 4:55:00	A
Surr: Phenol-d5	65.9	24-113	%REC	7/22/02 4:55:00	A
METALS IN SOIL OR SLUDGE BY ICP	**SW6010A**				**FJR**
Cadmium	4.5	0.030	ppm	7/16/02 11:45:27	A
Chromium	10	0.10	ppm	7/16/02 11:45:27	A
Lead	39	0.25	ppm	7/16/02 11:45:27	A
PCBS IN SOIL OR SOLID WASTE	**SW8082**				**SDW**
Aroclor 1016	ND	2.00	ppm	7/23/02	
Aroclor 1221	ND	2.00	ppm	7/23/02	
Aroclor 1232	ND	2.00	ppm	7/23/02	
Aroclor 1242	ND	2.00	ppm	7/23/02	
Aroclor 1248	ND	2.00	ppm	7/23/02	
Aroclor 1254	ND	2.00	ppm	7/23/02	
Aroclor 1260	ND	2.00	ppm	7/23/02	
Surr: Decachlorobiphenyl	Diluted Out	70-130	%REC	7/23/02	

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-08
Date Received: 12-Jul-02

Client Sample ID: 34SS05071002
Tag Number:
Collection Date: 7/10/02 9:11:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
SEMI-VOLATILES IN SOIL	**SW8270A**				**GB**
1,2,4,5-Tetrachlorobenzene	ND	0.33	ppm	7/22/02 5:28:00 A	
1,2,4-Trichlorobenzene	ND	0.33	ppm	7/22/02 5:28:00 A	
1,2-Dichlorobenzene	ND	0.33	ppm	7/22/02 5:28:00 A	
1,2-Diphenylhydrazine	ND	0.33	ppm	7/22/02 5:28:00 A	
1,3-Dichlorobenzene	ND	0.33	ppm	7/22/02 5:28:00 A	
1,3-Dinitrobenzene	ND	0.33	ppm	7/22/02 5:28:00 A	
1,4-Dichlorobenzene	ND	0.33	ppm	7/22/02 5:28:00 A	
2,3,4,6-Tetrachlorophenol	ND	0.33	ppm	7/22/02 5:28:00 A	
2,4,5-Trichlorophenol	ND	0.33	ppm	7/22/02 5:28:00 A	
2,4,6-Trichlorophenol	ND	0.33	ppm	7/22/02 5:28:00 A	
2,4-Dichlorophenol	ND	0.33	ppm	7/22/02 5:28:00 A	
2,4-Dimethylphenol	ND	0.33	ppm	7/22/02 5:28:00 A	
2,4-Dinitrophenol	ND	1.6	ppm	7/22/02 5:28:00 A	
2,4-Dinitrotoluene	ND	0.33	ppm	7/22/02 5:28:00 A	
2,6-Dinitrotoluene	ND	0.33	ppm	7/22/02 5:28:00 A	
2-Chloronaphthalene	ND	0.33	ppm	7/22/02 5:28:00 A	
2-Chlorophenol	ND	0.33	ppm	7/22/02 5:28:00 A	
2-Methylnaphthalene	ND	0.33	ppm	7/22/02 5:28:00 A	
2-Methylphenol	ND	0.33	ppm	7/22/02 5:28:00 A	
2-Nitroaniline	ND	0.33	ppm	7/22/02 5:28:00 A	
2-Nitrophenol	ND	0.33	ppm	7/22/02 5:28:00 A	
2-Picoline	ND	0.33	ppm	7/22/02 5:28:00 A	
3,3'-Dichlorobenzidine	ND	0.66	ppm	7/22/02 5:28:00 A	
3-Nitroaniline	ND	0.33	ppm	7/22/02 5:28:00 A	
4,6-Dinitro-2-methylphenol	ND	1.6	ppm	7/22/02 5:28:00 A	
4-Bromophenyl phenyl ether	ND	0.33	ppm	7/22/02 5:28:00 A	
4-Chloro-3-methylphenol	ND	0.66	ppm	7/22/02 5:28:00 A	
4-Chloroaniline	ND	0.33	ppm	7/22/02 5:28:00 A	
4-Chlorophenyl phenyl ether	ND	0.33	ppm	7/22/02 5:28:00 A	
4-Methylphenol	ND	0.33	ppm	7/22/02 5:28:00 A	
4-Nitroaniline	ND	0.33	ppm	7/22/02 5:28:00 A	
4-Nitrophenol	ND	1.6	ppm	7/22/02 5:28:00 A	
Acenaphthene	ND	0.33	ppm	7/22/02 5:28:00 A	

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-08
Date Received: 12-Jul-02

Client Sample ID: 34SS05071002
Tag Number:
Collection Date: 7/10/02 9:11:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Acenaphthylene	ND	0.33	ppm	7/22/02 5:28:00	A
Aniline	ND	0.66	ppm	7/22/02 5:28:00	A
Anthracene	ND	0.33	ppm	7/22/02 5:28:00	A
Benz(a)anthracene	ND	0.33	ppm	7/22/02 5:28:00	A
Benzidine	ND	1.6	ppm	7/22/02 5:28:00	A
Benzo(a)pyrene	ND	0.33	ppm	7/22/02 5:28:00	A
Benzo(b)fluoranthene	ND	0.33	ppm	7/22/02 5:28:00	A
Benzo(g,h,i)perylene	ND	0.33	ppm	7/22/02 5:28:00	A
Benzo(k)fluoranthene	ND	0.33	ppm	7/22/02 5:28:00	A
Benzoic acid	ND	1.6	ppm	7/22/02 5:28:00	A
Benzyl alcohol	ND	0.66	ppm	7/22/02 5:28:00	A
Bis(2-chloroethoxy)methane	ND	0.33	ppm	7/22/02 5:28:00	A
Bis(2-chloroethyl)ether	ND	0.33	ppm	7/22/02 5:28:00	A
Bis(2-chloroisopropyl)ether	ND	0.33	ppm	7/22/02 5:28:00	A
Bis(2-ethylhexyl)phthalate	ND	0.33	ppm	7/22/02 5:28:00	A
Butyl benzyl phthalate	ND	0.33	ppm	7/22/02 5:28:00	A
Carbazole	ND	0.33	ppm	7/22/02 5:28:00	A
Chrysene	ND	0.33	ppm	7/22/02 5:28:00	A
Di-n-butyl phthalate	ND	0.33	ppm	7/22/02 5:28:00	A
Di-n-octyl phthalate	ND	0.33	ppm	7/22/02 5:28:00	A
Dibenz(a,h)anthracene	ND	0.33	ppm	7/22/02 5:28:00	A
Dibenzofuran	ND	0.33	ppm	7/22/02 5:28:00	A
Diethyl phthalate	ND	0.33	ppm	7/22/02 5:28:00	A
Dimethyl phthalate	ND	0.33	ppm	7/22/02 5:28:00	A
Fluoranthene	ND	0.33	ppm	7/22/02 5:28:00	A
Fluorene	ND	0.33	ppm	7/22/02 5:28:00	A
Hexachlorobenzene	ND	0.33	ppm	7/22/02 5:28:00	A
Hexachlorobutadiene	ND	0.33	ppm	7/22/02 5:28:00	A
Hexachlorocyclopentadiene	ND	0.33	ppm	7/22/02 5:28:00	A
Hexachloroethane	ND	0.33	ppm	7/22/02 5:28:00	A
Indeno(1,2,3-cd)pyrene	ND	0.33	ppm	7/22/02 5:28:00	A
Isophorone	ND	0.33	ppm	7/22/02 5:28:00	A
N-Nitrosodi-n-propylamine	ND	0.33	ppm	7/22/02 5:28:00	A
N-Nitrosodimethylamine	ND	0.33	ppm	7/22/02 5:28:00	A
N-Nitrosodiphenylamine	ND	0.66	ppm	7/22/02 5:28:00	A

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SHERRY Laboratories
Testing Today – Protecting Tomorrow
2203 S. Madison Street
Muncie Indiana 47302
800-874-3563

CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-08
Date Received: 12-Jul-02

Client Sample ID: 34SS05071002
Tag Number:
Collection Date: 7/10/02 9:11:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Naphthalene	ND	0.33	ppm	7/22/02 5:28:00	A
Nitrobenzene	ND	0.33	ppm	7/22/02 5:28:00	A
o-Toluidine	ND	0.66	ppm	7/22/02 5:28:00	A
Pentachlorophenol	ND	1.6	ppm	7/22/02 5:28:00	A
Phenanthrene	ND	0.33	ppm	7/22/02 5:28:00	A
Phenol	ND	0.33	ppm	7/22/02 5:28:00	A
Pyrene	ND	0.33	ppm	7/22/02 5:28:00	A
Pyridine	ND	1.6	ppm	7/22/02 5:28:00	A
Surr: 2,4,6-Tribromophenol	94.5	19-122	%REC	7/22/02 5:28:00	A
Surr: 2-Fluorobiphenyl	77.0	30-115	%REC	7/22/02 5:28:00	A
Surr: 2-Fluorophenol	71.1	25-121	%REC	7/22/02 5:28:00	A
Surr: 4-Terphenyl-d14	87.0	18-137	%REC	7/22/02 5:28:00	A
Surr: Nitrobenzene-d5	63.6	23-120	%REC	7/22/02 5:28:00	A
Surr: Phenol-d5	71.6	24-113	%REC	7/22/02 5:28:00	A
METALS IN SOIL OR SLUDGE BY ICP	**SW6010A**				**FJR**
Cadmium	7.7	0.030	ppm	7/16/02 11:48:41	A
Chromium	4.7	0.10	ppm	7/16/02 11:48:41	A
Lead	24	0.25	ppm	7/16/02 11:48:41	A
PCBS IN SOIL OR SOLID WASTE	**SW8082**				**SDW**
Aroclor 1016	ND	2.00	ppm	7/23/02	
Aroclor 1221	ND	2.00	ppm	7/23/02	
Aroclor 1232	ND	2.00	ppm	7/23/02	
Aroclor 1242	ND	2.00	ppm	7/23/02	
Aroclor 1248	ND	2.00	ppm	7/23/02	
Aroclor 1254	ND	2.00	ppm	7/23/02	
Aroclor 1260	ND	2.00	ppm	7/23/02	
Surr: Decachlorobiphenyl	Diluted Out	70-130	%REC	7/23/02	

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-09
Date Received: 12-Jul-02

Client Sample ID: 34SS07071002
Tag Number:
Collection Date: 7/10/02 9:54:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
SEMI-VOLATILES IN SOIL	**SW8270A**				**GB**
1,2,4,5-Tetrachlorobenzene	ND	0.33	ppm	7/22/02 6:00:00 A	
1,2,4-Trichlorobenzene	ND	0.33	ppm	7/22/02 6:00:00 A	
1,2-Dichlorobenzene	ND	0.33	ppm	7/22/02 6:00:00 A	
1,2-Diphenylhydrazine	ND	0.33	ppm	7/22/02 6:00:00 A	
1,3-Dichlorobenzene	ND	0.33	ppm	7/22/02 6:00:00 A	
1,3-Dinitrobenzene	ND	0.33	ppm	7/22/02 6:00:00 A	
1,4-Dichlorobenzene	ND	0.33	ppm	7/22/02 6:00:00 A	
2,3,4,6-Tetrachlorophenol	ND	0.33	ppm	7/22/02 6:00:00 A	
2,4,5-Trichlorophenol	ND	0.33	ppm	7/22/02 6:00:00 A	
2,4,6-Trichlorophenol	ND	0.33	ppm	7/22/02 6:00:00 A	
2,4-Dichlorophenol	ND	0.33	ppm	7/22/02 6:00:00 A	
2,4-Dimethylphenol	ND	0.33	ppm	7/22/02 6:00:00 A	
2,4-Dinitrophenol	ND	1.6	ppm	7/22/02 6:00:00 A	
2,4-Dinitrotoluene	ND	0.33	ppm	7/22/02 6:00:00 A	
2,6-Dinitrotoluene	ND	0.33	ppm	7/22/02 6:00:00 A	
2-Chloronaphthalene	ND	0.33	ppm	7/22/02 6:00:00 A	
2-Chlorophenol	ND	0.33	ppm	7/22/02 6:00:00 A	
2-Methylnaphthalene	ND	0.33	ppm	7/22/02 6:00:00 A	
2-Methylphenol	ND	0.33	ppm	7/22/02 6:00:00 A	
2-Nitroaniline	ND	0.33	ppm	7/22/02 6:00:00 A	
2-Nitrophenol	ND	0.33	ppm	7/22/02 6:00:00 A	
2-Picoline	ND	0.33	ppm	7/22/02 6:00:00 A	
3,3'-Dichlorobenzidine	ND	0.66	ppm	7/22/02 6:00:00 A	
3-Nitroaniline	ND	0.33	ppm	7/22/02 6:00:00 A	
4,6-Dinitro-2-methylphenol	ND	1.6	ppm	7/22/02 6:00:00 A	
4-Bromophenyl phenyl ether	ND	0.33	ppm	7/22/02 6:00:00 A	
4-Chloro-3-methylphenol	ND	0.66	ppm	7/22/02 6:00:00 A	
4-Chloroaniline	ND	0.33	ppm	7/22/02 6:00:00 A	
4-Chlorophenyl phenyl ether	ND	0.33	ppm	7/22/02 6:00:00 A	
4-Methylphenol	ND	0.33	ppm	7/22/02 6:00:00 A	
4-Nitroaniline	ND	0.33	ppm	7/22/02 6:00:00 A	
4-Nitrophenol	ND	1.6	ppm	7/22/02 6:00:00 A	
Acenaphthene	ND	0.33	ppm	7/22/02 6:00:00 A	

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-09
Date Received: 12-Jul-02

Client Sample ID: 34SS07071002
Tag Number:
Collection Date: 7/10/02 9:54:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Acenaphthylene	ND	0.33	ppm	7/22/02 6:00:00	A
Aniline	ND	0.66	ppm	7/22/02 6:00:00	A
Anthracene	ND	0.33	ppm	7/22/02 6:00:00	A
Benz(a)anthracene	ND	0.33	ppm	7/22/02 6:00:00	A
Benzidine	ND	1.6	ppm	7/22/02 6:00:00	A
Benzo(a)pyrene	ND	0.33	ppm	7/22/02 6:00:00	A
Benzo(b)fluoranthene	ND	0.33	ppm	7/22/02 6:00:00	A
Benzo(g,h,i)perylene	ND	0.33	ppm	7/22/02 6:00:00	A
Benzo(k)fluoranthene	ND	0.33	ppm	7/22/02 6:00:00	A
Benzoic acid	ND	1.6	ppm	7/22/02 6:00:00	A
Benzyl alcohol	ND	0.66	ppm	7/22/02 6:00:00	A
Bis(2-chloroethoxy)methane	ND	0.33	ppm	7/22/02 6:00:00	A
Bis(2-chloroethyl)ether	ND	0.33	ppm	7/22/02 6:00:00	A
Bis(2-chloroisopropyl)ether	ND	0.33	ppm	7/22/02 6:00:00	A
Bis(2-ethylhexyl)phthalate	0.41	0.33	ppm	7/22/02 6:00:00	A
Butyl benzyl phthalate	ND	0.33	ppm	7/22/02 6:00:00	A
Carbazole	ND	0.33	ppm	7/22/02 6:00:00	A
Chrysene	ND	0.33	ppm	7/22/02 6:00:00	A
Di-n-butyl phthalate	ND	0.33	ppm	7/22/02 6:00:00	A
Di-n-octyl phthalate	ND	0.33	ppm	7/22/02 6:00:00	A
Dibenz(a,h)anthracene	ND	0.33	ppm	7/22/02 6:00:00	A
Dibenzofuran	ND	0.33	ppm	7/22/02 6:00:00	A
Diethyl phthalate	ND	0.33	ppm	7/22/02 6:00:00	A
Dimethyl phthalate	ND	0.33	ppm	7/22/02 6:00:00	A
Fluoranthene	ND	0.33	ppm	7/22/02 6:00:00	A
Fluorene	ND	0.33	ppm	7/22/02 6:00:00	A
Hexachlorobenzene	ND	0.33	ppm	7/22/02 6:00:00	A
Hexachlorobutadiene	ND	0.33	ppm	7/22/02 6:00:00	A
Hexachlorocyclopentadiene	ND	0.33	ppm	7/22/02 6:00:00	A
Hexachloroethane	ND	0.33	ppm	7/22/02 6:00:00	A
Indeno(1,2,3-cd)pyrene	ND	0.33	ppm	7/22/02 6:00:00	A
Isophorone	ND	0.33	ppm	7/22/02 6:00:00	A
N-Nitrosodi-n-propylamine	ND	0.33	ppm	7/22/02 6:00:00	A
N-Nitrosodimethylamine	ND	0.33	ppm	7/22/02 6:00:00	A
N-Nitrosodiphenylamine	ND	0.66	ppm	7/22/02 6:00:00	A

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-09
Date Received: 12-Jul-02

Client Sample ID: 34SS07071002
Tag Number:
Collection Date: 7/10/02 9:54:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Naphthalene	ND	0.33	ppm	7/22/02 6:00:00	A
Nitrobenzene	ND	0.33	ppm	7/22/02 6:00:00	A
o-Toluidine	ND	0.66	ppm	7/22/02 6:00:00	A
Pentachlorophenol	ND	1.6	ppm	7/22/02 6:00:00	A
Phenanthrene	ND	0.33	ppm	7/22/02 6:00:00	A
Phenol	ND	0.33	ppm	7/22/02 6:00:00	A
Pyrene	ND	0.33	ppm	7/22/02 6:00:00	A
Pyridine	ND	1.6	ppm	7/22/02 6:00:00	A
Surr: 2,4,6-Tribromophenol	98.3	19-122	%REC	7/22/02 6:00:00	A
Surr: 2-Fluorobiphenyl	82.4	30-115	%REC	7/22/02 6:00:00	A
Surr: 2-Fluorophenol	72.1	25-121	%REC	7/22/02 6:00:00	A
Surr: 4-Terphenyl-d14	88.8	18-137	%REC	7/22/02 6:00:00	A
Surr: Nitrobenzene-d5	63.3	23-120	%REC	7/22/02 6:00:00	A
Surr: Phenol-d5	72.7	24-113	%REC	7/22/02 6:00:00	A
METALS IN SOIL OR SLUDGE BY ICP		**SW6010A**			**FJR**
Cadmium	4.9	0.030	ppm	7/16/02 11:51:58	A
Chromium	9.1	0.10	ppm	7/16/02 11:51:58	A
Lead	27	0.25	ppm	7/16/02 11:51:58	A
PCBS IN SOIL OR SOLID WASTE		**SW8082**			**SDW**
Aroclor 1016	ND	2.00	ppm	7/23/02	
Aroclor 1221	ND	2.00	ppm	7/23/02	
Aroclor 1232	ND	2.00	ppm	7/23/02	
Aroclor 1242	ND	2.00	ppm	7/23/02	
Aroclor 1248	ND	2.00	ppm	7/23/02	
Aroclor 1254	ND	2.00	ppm	7/23/02	
Aroclor 1260	4.09	2.00	ppm	7/23/02	
Surr: Decachlorobiphenyl	Diluted Out	70-130	%REC	7/23/02	

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CLIENT:	SAIC	**Client Sample ID:**	34SS06071002
Lab Order:	M02070406	**Tag Number:**	
Project:	NSWC Crane OGTSL	**Collection Date:**	7/10/02 9:30:00 AM
Lab ID:	M02070406-10	**Matrix:**	SOIL
Date Received:	12-Jul-02	**Date Reported:**	26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
SEMI-VOLATILES IN SOIL	**SW8270A**				**GB**
1,2,4,5-Tetrachlorobenzene	ND	1.6	ppm	7/22/02 8:10:00 A	
1,2,4-Trichlorobenzene	ND	1.6	ppm	7/22/02 8:10:00 A	
1,2-Dichlorobenzene	ND	1.6	ppm	7/22/02 8:10:00 A	
1,2-Diphenylhydrazine	ND	1.6	ppm	7/22/02 8:10:00 A	
1,3-Dichlorobenzene	ND	1.6	ppm	7/22/02 8:10:00 A	
1,3-Dinitrobenzene	ND	1.6	ppm	7/22/02 8:10:00 A	
1,4-Dichlorobenzene	ND	1.6	ppm	7/22/02 8:10:00 A	
2,3,4,6-Tetrachlorophenol	ND	1.6	ppm	7/22/02 8:10:00 A	
2,4,5-Trichlorophenol	ND	1.6	ppm	7/22/02 8:10:00 A	
2,4,6-Trichlorophenol	ND	1.6	ppm	7/22/02 8:10:00 A	
2,4-Dichlorophenol	ND	1.6	ppm	7/22/02 8:10:00 A	
2,4-Dimethylphenol	ND	1.6	ppm	7/22/02 8:10:00 A	
2,4-Dinitrophenol	ND	8.2	ppm	7/22/02 8:10:00 A	
2,4-Dinitrotoluene	ND	1.6	ppm	7/22/02 8:10:00 A	
2,6-Dinitrotoluene	ND	1.6	ppm	7/22/02 8:10:00 A	
2-Chloronaphthalene	ND	1.6	ppm	7/22/02 8:10:00 A	
2-Chlorophenol	ND	1.6	ppm	7/22/02 8:10:00 A	
2-Methylnaphthalene	ND	1.6	ppm	7/22/02 8:10:00 A	
2-Methylphenol	ND	1.6	ppm	7/22/02 8:10:00 A	
2-Nitroaniline	ND	1.6	ppm	7/22/02 8:10:00 A	
2-Nitrophenol	ND	1.6	ppm	7/22/02 8:10:00 A	
2-Picoline	ND	1.6	ppm	7/22/02 8:10:00 A	
3,3'-Dichlorobenzidine	ND	3.3	ppm	7/22/02 8:10:00 A	
3-Nitroaniline	ND	1.6	ppm	7/22/02 8:10:00 A	
4,6-Dinitro-2-methylphenol	ND	8.2	ppm	7/22/02 8:10:00 A	
4-Bromophenyl phenyl ether	ND	1.6	ppm	7/22/02 8:10:00 A	
4-Chloro-3-methylphenol	ND	3.3	ppm	7/22/02 8:10:00 A	
4-Chloroaniline	ND	1.6	ppm	7/22/02 8:10:00 A	
4-Chlorophenyl phenyl ether	ND	1.6	ppm	7/22/02 8:10:00 A	
4-Methylphenol	ND	1.6	ppm	7/22/02 8:10:00 A	
4-Nitroaniline	ND	1.6	ppm	7/22/02 8:10:00 A	
4-Nitrophenol	ND	8.2	ppm	7/22/02 8:10:00 A	
Acenaphthene	ND	1.6	ppm	7/22/02 8:10:00 A	

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-10
Date Received: 12-Jul-02

Client Sample ID: 34SS06071002
Tag Number:
Collection Date: 7/10/02 9:30:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Acenaphthylene	ND	1.6	ppm	7/22/02 8:10:00	A
Aniline	ND	3.3	ppm	7/22/02 8:10:00	A
Anthracene	ND	1.6	ppm	7/22/02 8:10:00	A
Benz(a)anthracene	ND	1.6	ppm	7/22/02 8:10:00	A
Benzidine	ND	8.2	ppm	7/22/02 8:10:00	A
Benzo(a)pyrene	ND	1.6	ppm	7/22/02 8:10:00	A
Benzo(b)fluoranthene	ND	1.6	ppm	7/22/02 8:10:00	A
Benzo(g,h,i)perylene	ND	1.6	ppm	7/22/02 8:10:00	A
Benzo(k)fluoranthene	ND	1.6	ppm	7/22/02 8:10:00	A
Benzoic acid	ND	8.2	ppm	7/22/02 8:10:00	A
Benzyl alcohol	ND	3.3	ppm	7/22/02 8:10:00	A
Bis(2-chloroethoxy)methane	ND	1.6	ppm	7/22/02 8:10:00	A
Bis(2-chloroethyl)ether	ND	1.6	ppm	7/22/02 8:10:00	A
Bis(2-chloroisopropyl)ether	ND	1.6	ppm	7/22/02 8:10:00	A
Bis(2-ethylhexyl)phthalate	ND	1.6	ppm	7/22/02 8:10:00	A
Butyl benzyl phthalate	ND	1.6	ppm	7/22/02 8:10:00	A
Carbazole	ND	1.6	ppm	7/22/02 8:10:00	A
Chrysene	ND	1.6	ppm	7/22/02 8:10:00	A
Di-n-butyl phthalate	ND	1.6	ppm	7/22/02 8:10:00	A
Di-n-octyl phthalate	ND	1.6	ppm	7/22/02 8:10:00	A
Dibenz(a,h)anthracene	ND	1.6	ppm	7/22/02 8:10:00	A
Dibenzofuran	ND	1.6	ppm	7/22/02 8:10:00	A
Diethyl phthalate	ND	1.6	ppm	7/22/02 8:10:00	A
Dimethyl phthalate	ND	1.6	ppm	7/22/02 8:10:00	A
Fluoranthene	ND	1.6	ppm	7/22/02 8:10:00	A
Fluorene	ND	1.6	ppm	7/22/02 8:10:00	A
Hexachlorobenzene	ND	1.6	ppm	7/22/02 8:10:00	A
Hexachlorobutadiene	ND	1.6	ppm	7/22/02 8:10:00	A
Hexachlorocyclopentadiene	ND	1.6	ppm	7/22/02 8:10:00	A
Hexachloroethane	ND	1.6	ppm	7/22/02 8:10:00	A
Indeno(1,2,3-cd)pyrene	ND	1.6	ppm	7/22/02 8:10:00	A
Isophorone	ND	1.6	ppm	7/22/02 8:10:00	A
N-Nitrosodi-n-propylamine	ND	1.6	ppm	7/22/02 8:10:00	A
N-Nitrosodimethylamine	ND	1.6	ppm	7/22/02 8:10:00	A
N-Nitrosodiphenylamine	ND	3.3	ppm	7/22/02 8:10:00	A

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-10
Date Received: 12-Jul-02

Client Sample ID: 34SS06071002
Tag Number:
Collection Date: 7/10/02 9:30:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Naphthalene	ND	1.6	ppm	7/22/02 8:10:00	A
Nitrobenzene	ND	1.6	ppm	7/22/02 8:10:00	A
o-Toluidine	ND	3.3	ppm	7/22/02 8:10:00	A
Pentachlorophenol	ND	8.2	ppm	7/22/02 8:10:00	A
Phenanthrene	ND	1.6	ppm	7/22/02 8:10:00	A
Phenol	ND	1.6	ppm	7/22/02 8:10:00	A
Pyrene	ND	1.6	ppm	7/22/02 8:10:00	A
Pyridine	ND	8.2	ppm	7/22/02 8:10:00	A
Surr: 2,4,6-Tribromophenol	96.6	19-122	%REC	7/22/02 8:10:00	A
Surr: 2-Fluorobiphenyl	83.3	30-115	%REC	7/22/02 8:10:00	A
Surr: 2-Fluorophenol	73.7	25-121	%REC	7/22/02 8:10:00	A
Surr: 4-Terphenyl-d14	96.9	18-137	%REC	7/22/02 8:10:00	A
Surr: Nitrobenzene-d5	58.6	23-120	%REC	7/22/02 8:10:00	A
Surr: Phenol-d5	69.2	24-113	%REC	7/22/02 8:10:00	A
METALS IN SOIL OR SLUDGE BY ICP		**SW6010A**			**FJR**
Cadmium	1.2	0.030	ppm	7/16/02 11:57:49	A
Chromium	2.5	0.10	ppm	7/16/02 11:57:49	A
Lead	35	0.25	ppm	7/16/02 11:57:49	A
PCBS IN SOIL OR SOLID WASTE		**SW8082**			**SDW**
Aroclor 1016	ND	2.00	ppm	7/23/02	
Aroclor 1221	ND	2.00	ppm	7/23/02	
Aroclor 1232	ND	2.00	ppm	7/23/02	
Aroclor 1242	ND	2.00	ppm	7/23/02	
Aroclor 1248	ND	2.00	ppm	7/23/02	
Aroclor 1254	ND	2.00	ppm	7/23/02	
Aroclor 1260	ND	2.00	ppm	7/23/02	
Surr: Decachlorobiphenyl	Diluted Out	70-130	%REC	7/23/02	

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Testing Today – Protecting Tomorrow
2203 S. Madison Street
Muncie Indiana 47302
800-874-3563

CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-11
Date Received: 12-Jul-02

Client Sample ID: 34SS04071002
Tag Number:
Collection Date: 7/10/02 8:56:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
SEMI-VOLATILES IN SOIL	**SW8270A**				**GB**
1,2,4,5-Tetrachlorobenzene	ND	0.33	ppm	7/22/02 6:33:00 A	
1,2,4-Trichlorobenzene	ND	0.33	ppm	7/22/02 6:33:00 A	
1,2-Dichlorobenzene	ND	0.33	ppm	7/22/02 6:33:00 A	
1,2-Diphenylhydrazine	ND	0.33	ppm	7/22/02 6:33:00 A	
1,3-Dichlorobenzene	ND	0.33	ppm	7/22/02 6:33:00 A	
1,3-Dinitrobenzene	ND	0.33	ppm	7/22/02 6:33:00 A	
1,4-Dichlorobenzene	ND	0.33	ppm	7/22/02 6:33:00 A	
2,3,4,6-Tetrachlorophenol	ND	0.33	ppm	7/22/02 6:33:00 A	
2,4,5-Trichlorophenol	ND	0.33	ppm	7/22/02 6:33:00 A	
2,4,6-Trichlorophenol	ND	0.33	ppm	7/22/02 6:33:00 A	
2,4-Dichlorophenol	ND	0.33	ppm	7/22/02 6:33:00 A	
2,4-Dimethylphenol	ND	0.33	ppm	7/22/02 6:33:00 A	
2,4-Dinitrophenol	ND	1.6	ppm	7/22/02 6:33:00 A	
2,4-Dinitrotoluene	ND	0.33	ppm	7/22/02 6:33:00 A	
2,6-Dinitrotoluene	ND	0.33	ppm	7/22/02 6:33:00 A	
2-Chloronaphthalene	ND	0.33	ppm	7/22/02 6:33:00 A	
2-Chlorophenol	ND	0.33	ppm	7/22/02 6:33:00 A	
2-Methylnaphthalene	ND	0.33	ppm	7/22/02 6:33:00 A	
2-Methylphenol	ND	0.33	ppm	7/22/02 6:33:00 A	
2-Nitroaniline	ND	0.33	ppm	7/22/02 6:33:00 A	
2-Nitrophenol	ND	0.33	ppm	7/22/02 6:33:00 A	
2-Picoline	ND	0.33	ppm	7/22/02 6:33:00 A	
3,3'-Dichlorobenzidine	ND	0.66	ppm	7/22/02 6:33:00 A	
3-Nitroaniline	ND	0.33	ppm	7/22/02 6:33:00 A	
4,6-Dinitro-2-methylphenol	ND	1.6	ppm	7/22/02 6:33:00 A	
4-Bromophenyl phenyl ether	ND	0.33	ppm	7/22/02 6:33:00 A	
4-Chloro-3-methylphenol	ND	0.66	ppm	7/22/02 6:33:00 A	
4-Chloroaniline	ND	0.33	ppm	7/22/02 6:33:00 A	
4-Chlorophenyl phenyl ether	ND	0.33	ppm	7/22/02 6:33:00 A	
4-Methylphenol	ND	0.33	ppm	7/22/02 6:33:00 A	
4-Nitroaniline	ND	0.33	ppm	7/22/02 6:33:00 A	
4-Nitrophenol	ND	1.6	ppm	7/22/02 6:33:00 A	
Acenaphthene	ND	0.33	ppm	7/22/02 6:33:00 A	

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CLIENT:	SAIC	**Client Sample ID:**	34SS04071002
Lab Order:	M02070406	**Tag Number:**	
Project:	NSWC Crane OGTSL	**Collection Date:**	7/10/02 8:56:00 AM
Lab ID:	M02070406-11	**Matrix:**	SOIL
Date Received:	12-Jul-02	**Date Reported:**	26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Acenaphthylene	ND	0.33	ppm	7/22/02 6:33:00	A
Aniline	ND	0.66	ppm	7/22/02 6:33:00	A
Anthracene	ND	0.33	ppm	7/22/02 6:33:00	A
Benz(a)anthracene	ND	0.33	ppm	7/22/02 6:33:00	A
Benzidine	ND	1.6	ppm	7/22/02 6:33:00	A
Benzo(a)pyrene	ND	0.33	ppm	7/22/02 6:33:00	A
Benzo(b)fluoranthene	ND	0.33	ppm	7/22/02 6:33:00	A
Benzo(g,h,i)perylene	ND	0.33	ppm	7/22/02 6:33:00	A
Benzo(k)fluoranthene	ND	0.33	ppm	7/22/02 6:33:00	A
Benzoic acid	ND	1.6	ppm	7/22/02 6:33:00	A
Benzyl alcohol	ND	0.66	ppm	7/22/02 6:33:00	A
Bis(2-chloroethoxy)methane	ND	0.33	ppm	7/22/02 6:33:00	A
Bis(2-chloroethyl)ether	ND	0.33	ppm	7/22/02 6:33:00	A
Bis(2-chloroisopropyl)ether	ND	0.33	ppm	7/22/02 6:33:00	A
Bis(2-ethylhexyl)phthalate	7.5	0.33	ppm	7/22/02 6:33:00	A
Butyl benzyl phthalate	ND	0.33	ppm	7/22/02 6:33:00	A
Carbazole	ND	0.33	ppm	7/22/02 6:33:00	A
Chrysene	ND	0.33	ppm	7/22/02 6:33:00	A
Di-n-butyl phthalate	ND	0.33	ppm	7/22/02 6:33:00	A
Di-n-octyl phthalate	ND	0.33	ppm	7/22/02 6:33:00	A
Dibenz(a,h)anthracene	ND	0.33	ppm	7/22/02 6:33:00	A
Dibenzofuran	ND	0.33	ppm	7/22/02 6:33:00	A
Diethyl phthalate	ND	0.33	ppm	7/22/02 6:33:00	A
Dimethyl phthalate	ND	0.33	ppm	7/22/02 6:33:00	A
Fluoranthene	ND	0.33	ppm	7/22/02 6:33:00	A
Fluorene	ND	0.33	ppm	7/22/02 6:33:00	A
Hexachlorobenzene	ND	0.33	ppm	7/22/02 6:33:00	A
Hexachlorobutadiene	ND	0.33	ppm	7/22/02 6:33:00	A
Hexachlorocyclopentadiene	ND	0.33	ppm	7/22/02 6:33:00	A
Hexachloroethane	ND	0.33	ppm	7/22/02 6:33:00	A
Indeno(1,2,3-cd)pyrene	ND	0.33	ppm	7/22/02 6:33:00	A
Isophorone	ND	0.33	ppm	7/22/02 6:33:00	A
N-Nitrosodi-n-propylamine	ND	0.33	ppm	7/22/02 6:33:00	A
N-Nitrosodimethylamine	ND	0.33	ppm	7/22/02 6:33:00	A
N-Nitrosodiphenylamine	ND	0.66	ppm	7/22/02 6:33:00	A

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-11
Date Received: 12-Jul-02

Client Sample ID: 34SS04071002
Tag Number:
Collection Date: 7/10/02 8:56:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Naphthalene	ND	0.33	ppm	7/22/02 6:33:00	A
Nitrobenzene	ND	0.33	ppm	7/22/02 6:33:00	A
o-Toluidine	ND	0.66	ppm	7/22/02 6:33:00	A
Pentachlorophenol	ND	1.6	ppm	7/22/02 6:33:00	A
Phenanthrene	ND	0.33	ppm	7/22/02 6:33:00	A
Phenol	ND	0.33	ppm	7/22/02 6:33:00	A
Pyrene	ND	0.33	ppm	7/22/02 6:33:00	A
Pyridine	ND	1.6	ppm	7/22/02 6:33:00	A
Surr: 2,4,6-Tribromophenol	73.2	19-122	%REC	7/22/02 6:33:00	A
Surr: 2-Fluorobiphenyl	60.9	30-115	%REC	7/22/02 6:33:00	A
Surr: 2-Fluorophenol	50.8	25-121	%REC	7/22/02 6:33:00	A
Surr: 4-Terphenyl-d14	67.2	18-137	%REC	7/22/02 6:33:00	A
Surr: Nitrobenzene-d5	47.3	23-120	%REC	7/22/02 6:33:00	A
Surr: Phenol-d5	52.4	24-113	%REC	7/22/02 6:33:00	A
METALS IN SOIL OR SLUDGE BY ICP		**SW6010A**			**FJR**
Cadmium	2.9	0.030	ppm	7/16/02 12:01:02	P
Chromium	3.5	0.10	ppm	7/16/02 12:01:02	P
Lead	23	0.25	ppm	7/16/02 12:01:02	P
PCBS IN SOIL OR SOLID WASTE		**SW8082**			**SDW**
Aroclor 1016	ND	2.00	ppm	7/23/02	
Aroclor 1221	ND	2.00	ppm	7/23/02	
Aroclor 1232	ND	2.00	ppm	7/23/02	
Aroclor 1242	ND	2.00	ppm	7/23/02	
Aroclor 1248	ND	2.00	ppm	7/23/02	
Aroclor 1254	ND	2.00	ppm	7/23/02	
Aroclor 1260	ND	2.00	ppm	7/23/02	
Surr: Decachlorobiphenyl	Diluted Out	70-130	%REC	7/23/02	

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CLIENT:	SAIC	**Client Sample ID:**	34SS02071002
Lab Order:	M02070406	**Tag Number:**	
Project:	NSWC Crane OGTSL	**Collection Date:**	7/10/02 8:20:00 AM
Lab ID:	M02070406-12	**Matrix:**	SOIL
Date Received:	12-Jul-02	**Date Reported:**	26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
SEMI-VOLATILES IN SOIL	**SW8270A**				**GB**
1,2,4,5-Tetrachlorobenzene	ND	1.6	ppm	7/22/02 8:43:00 A	
1,2,4-Trichlorobenzene	ND	1.6	ppm	7/22/02 8:43:00 A	
1,2-Dichlorobenzene	ND	1.6	ppm	7/22/02 8:43:00 A	
1,2-Diphenylhydrazine	ND	1.6	ppm	7/22/02 8:43:00 A	
1,3-Dichlorobenzene	ND	1.6	ppm	7/22/02 8:43:00 A	
1,3-Dinitrobenzene	ND	1.6	ppm	7/22/02 8:43:00 A	
1,4-Dichlorobenzene	ND	1.6	ppm	7/22/02 8:43:00 A	
2,3,4,6-Tetrachlorophenol	ND	1.6	ppm	7/22/02 8:43:00 A	
2,4,5-Trichlorophenol	ND	1.6	ppm	7/22/02 8:43:00 A	
2,4,6-Trichlorophenol	ND	1.6	ppm	7/22/02 8:43:00 A	
2,4-Dichlorophenol	ND	1.6	ppm	7/22/02 8:43:00 A	
2,4-Dimethylphenol	ND	1.6	ppm	7/22/02 8:43:00 A	
2,4-Dinitrophenol	ND	8.2	ppm	7/22/02 8:43:00 A	
2,4-Dinitrotoluene	ND	1.6	ppm	7/22/02 8:43:00 A	
2,6-Dinitrotoluene	ND	1.6	ppm	7/22/02 8:43:00 A	
2-Chloronaphthalene	ND	1.6	ppm	7/22/02 8:43:00 A	
2-Chlorophenol	ND	1.6	ppm	7/22/02 8:43:00 A	
2-Methylnaphthalene	ND	1.6	ppm	7/22/02 8:43:00 A	
2-Methylphenol	ND	1.6	ppm	7/22/02 8:43:00 A	
2-Nitroaniline	ND	1.6	ppm	7/22/02 8:43:00 A	
2-Nitrophenol	ND	1.6	ppm	7/22/02 8:43:00 A	
2-Picoline	ND	1.6	ppm	7/22/02 8:43:00 A	
3,3'-Dichlorobenzidine	ND	3.3	ppm	7/22/02 8:43:00 A	
3-Nitroaniline	ND	1.6	ppm	7/22/02 8:43:00 A	
4,6-Dinitro-2-methylphenol	ND	8.2	ppm	7/22/02 8:43:00 A	
4-Bromophenyl phenyl ether	ND	1.6	ppm	7/22/02 8:43:00 A	
4-Chloro-3-methylphenol	ND	3.3	ppm	7/22/02 8:43:00 A	
4-Chloroaniline	ND	1.6	ppm	7/22/02 8:43:00 A	
4-Chlorophenyl phenyl ether	ND	1.6	ppm	7/22/02 8:43:00 A	
4-Methylphenol	ND	1.6	ppm	7/22/02 8:43:00 A	
4-Nitroaniline	ND	1.6	ppm	7/22/02 8:43:00 A	
4-Nitrophenol	ND	8.2	ppm	7/22/02 8:43:00 A	
Acenaphthene	ND	1.6	ppm	7/22/02 8:43:00 A	

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-12
Date Received: 12-Jul-02

Client Sample ID: 34SS02071002
Tag Number:
Collection Date: 7/10/02 8:20:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Acenaphthylene	ND	1.6	ppm	7/22/02 8:43:00	A
Aniline	ND	3.3	ppm	7/22/02 8:43:00	A
Anthracene	ND	1.6	ppm	7/22/02 8:43:00	A
Benz(a)anthracene	ND	1.6	ppm	7/22/02 8:43:00	A
Benzidine	ND	8.2	ppm	7/22/02 8:43:00	A
Benzo(a)pyrene	ND	1.6	ppm	7/22/02 8:43:00	A
Benzo(b)fluoranthene	ND	1.6	ppm	7/22/02 8:43:00	A
Benzo(g,h,i)perylene	ND	1.6	ppm	7/22/02 8:43:00	A
Benzo(k)fluoranthene	ND	1.6	ppm	7/22/02 8:43:00	A
Benzoic acid	ND	8.2	ppm	7/22/02 8:43:00	A
Benzyl alcohol	ND	3.3	ppm	7/22/02 8:43:00	A
Bis(2-chloroethoxy)methane	ND	1.6	ppm	7/22/02 8:43:00	A
Bis(2-chloroethyl)ether	ND	1.6	ppm	7/22/02 8:43:00	A
Bis(2-chloroisopropyl)ether	ND	1.6	ppm	7/22/02 8:43:00	A
Bis(2-ethylhexyl)phthalate	ND	1.6	ppm	7/22/02 8:43:00	A
Butyl benzyl phthalate	ND	1.6	ppm	7/22/02 8:43:00	A
Carbazole	ND	1.6	ppm	7/22/02 8:43:00	A
Chrysene	ND	1.6	ppm	7/22/02 8:43:00	A
Di-n-butyl phthalate	ND	1.6	ppm	7/22/02 8:43:00	A
Di-n-octyl phthalate	ND	1.6	ppm	7/22/02 8:43:00	A
Dibenz(a,h)anthracene	ND	1.6	ppm	7/22/02 8:43:00	A
Dibenzofuran	ND	1.6	ppm	7/22/02 8:43:00	A
Diethyl phthalate	ND	1.6	ppm	7/22/02 8:43:00	A
Dimethyl phthalate	ND	1.6	ppm	7/22/02 8:43:00	A
Fluoranthene	ND	1.6	ppm	7/22/02 8:43:00	A
Fluorene	ND	1.6	ppm	7/22/02 8:43:00	A
Hexachlorobenzene	ND	1.6	ppm	7/22/02 8:43:00	A
Hexachlorobutadiene	ND	1.6	ppm	7/22/02 8:43:00	A
Hexachlorocyclopentadiene	ND	1.6	ppm	7/22/02 8:43:00	A
Hexachloroethane	ND	1.6	ppm	7/22/02 8:43:00	A
Indeno(1,2,3-cd)pyrene	ND	1.6	ppm	7/22/02 8:43:00	A
Isophorone	ND	1.6	ppm	7/22/02 8:43:00	A
N-Nitrosodi-n-propylamine	ND	1.6	ppm	7/22/02 8:43:00	A
N-Nitrosodimethylamine	ND	1.6	ppm	7/22/02 8:43:00	A
N-Nitrosodiphenylamine	ND	3.3	ppm	7/22/02 8:43:00	A

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-12
Date Received: 12-Jul-02

Client Sample ID: 34SS02071002
Tag Number:
Collection Date: 7/10/02 8:20:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Naphthalene	ND	1.6	ppm	7/22/02 8:43:00	A
Nitrobenzene	ND	1.6	ppm	7/22/02 8:43:00	A
o-Toluidine	ND	3.3	ppm	7/22/02 8:43:00	A
Pentachlorophenol	ND	8.2	ppm	7/22/02 8:43:00	A
Phenanthrene	ND	1.6	ppm	7/22/02 8:43:00	A
Phenol	ND	1.6	ppm	7/22/02 8:43:00	A
Pyrene	ND	1.6	ppm	7/22/02 8:43:00	A
Pyridine	ND	8.2	ppm	7/22/02 8:43:00	A
Surr: 2,4,6-Tribromophenol	70.4	19-122	%REC	7/22/02 8:43:00	A
Surr: 2-Fluorobiphenyl	54.6	30-115	%REC	7/22/02 8:43:00	A
Surr: 2-Fluorophenol	39.5	25-121	%REC	7/22/02 8:43:00	A
Surr: 4-Terphenyl-d14	64.5	18-137	%REC	7/22/02 8:43:00	A
Surr: Nitrobenzene-d5	34.0	23-120	%REC	7/22/02 8:43:00	A
Surr: Phenol-d5	45.6	24-113	%REC	7/22/02 8:43:00	A
METALS IN SOIL OR SLUDGE BY ICP		**SW6010A**			**FJR**
Cadmium	1.9	0.030	ppm	7/16/02 12:15:59	P
Chromium	ND	0.10	ppm	7/16/02 12:15:59	P
Lead	32	0.25	ppm	7/16/02 12:15:59	P
PCBS IN SOIL OR SOLID WASTE		**SW8082**			**SDW**
Aroclor 1016	ND	2.00	ppm	7/23/02	
Aroclor 1221	ND	2.00	ppm	7/23/02	
Aroclor 1232	ND	2.00	ppm	7/23/02	
Aroclor 1242	ND	2.00	ppm	7/23/02	
Aroclor 1248	ND	2.00	ppm	7/23/02	
Aroclor 1254	ND	2.00	ppm	7/23/02	
Aroclor 1260	ND	2.00	ppm	7/23/02	
Surr: Decachlorobiphenyl	Diluted Out	70-130	%REC	7/23/02	

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CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-13
Date Received: 12-Jul-02

Client Sample ID: 34SS03071002
Tag Number:
Collection Date: 7/10/02 8:40:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
SEMI-VOLATILES IN SOIL	**SW8270A**				**GB**
1,2,4,5-Tetrachlorobenzene	ND	0.33	ppm	7/22/02 7:06:00 A	
1,2,4-Trichlorobenzene	ND	0.33	ppm	7/22/02 7:06:00 A	
1,2-Dichlorobenzene	ND	0.33	ppm	7/22/02 7:06:00 A	
1,2-Diphenylhydrazine	ND	0.33	ppm	7/22/02 7:06:00 A	
1,3-Dichlorobenzene	ND	0.33	ppm	7/22/02 7:06:00 A	
1,3-Dinitrobenzene	ND	0.33	ppm	7/22/02 7:06:00 A	
1,4-Dichlorobenzene	ND	0.33	ppm	7/22/02 7:06:00 A	
2,3,4,6-Tetrachlorophenol	ND	0.33	ppm	7/22/02 7:06:00 A	
2,4,5-Trichlorophenol	ND	0.33	ppm	7/22/02 7:06:00 A	
2,4,6-Trichlorophenol	ND	0.33	ppm	7/22/02 7:06:00 A	
2,4-Dichlorophenol	ND	0.33	ppm	7/22/02 7:06:00 A	
2,4-Dimethylphenol	ND	0.33	ppm	7/22/02 7:06:00 A	
2,4-Dinitrophenol	ND	1.6	ppm	7/22/02 7:06:00 A	
2,4-Dinitrotoluene	ND	0.33	ppm	7/22/02 7:06:00 A	
2,6-Dinitrotoluene	ND	0.33	ppm	7/22/02 7:06:00 A	
2-Chloronaphthalene	ND	0.33	ppm	7/22/02 7:06:00 A	
2-Chlorophenol	ND	0.33	ppm	7/22/02 7:06:00 A	
2-Methylnaphthalene	ND	0.33	ppm	7/22/02 7:06:00 A	
2-Methylphenol	ND	0.33	ppm	7/22/02 7:06:00 A	
2-Nitroaniline	ND	0.33	ppm	7/22/02 7:06:00 A	
2-Nitrophenol	ND	0.33	ppm	7/22/02 7:06:00 A	
2-Picoline	ND	0.33	ppm	7/22/02 7:06:00 A	
3,3'-Dichlorobenzidine	ND	0.66	ppm	7/22/02 7:06:00 A	
3-Nitroaniline	ND	0.33	ppm	7/22/02 7:06:00 A	
4,6-Dinitro-2-methylphenol	ND	1.6	ppm	7/22/02 7:06:00 A	
4-Bromophenyl phenyl ether	ND	0.33	ppm	7/22/02 7:06:00 A	
4-Chloro-3-methylphenol	ND	0.66	ppm	7/22/02 7:06:00 A	
4-Chloroaniline	ND	0.33	ppm	7/22/02 7:06:00 A	
4-Chlorophenyl phenyl ether	ND	0.33	ppm	7/22/02 7:06:00 A	
4-Methylphenol	ND	0.33	ppm	7/22/02 7:06:00 A	
4-Nitroaniline	ND	0.33	ppm	7/22/02 7:06:00 A	
4-Nitrophenol	ND	1.6	ppm	7/22/02 7:06:00 A	
Acenaphthene	ND	0.33	ppm	7/22/02 7:06:00 A	

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Testing Today – Protecting Tomorrow.
2203 S. Madison Street
Muncie Indiana 47302
800-874-3563

CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-13
Date Received: 12-Jul-02

Client Sample ID: 34SS03071002
Tag Number:
Collection Date: 7/10/02 8:40:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Acenaphthylene	ND	0.33	ppm	7/22/02 7:06:00	A
Aniline	ND	0.66	ppm	7/22/02 7:06:00	A
Anthracene	ND	0.33	ppm	7/22/02 7:06:00	A
Benz(a)anthracene	ND	0.33	ppm	7/22/02 7:06:00	A
Benzidine	ND	1.6	ppm	7/22/02 7:06:00	A
Benzo(a)pyrene	ND	0.33	ppm	7/22/02 7:06:00	A
Benzo(b)fluoranthene	ND	0.33	ppm	7/22/02 7:06:00	A
Benzo(g,h,i)perylene	ND	0.33	ppm	7/22/02 7:06:00	A
Benzo(k)fluoranthene	ND	0.33	ppm	7/22/02 7:06:00	A
Benzoic acid	ND	1.6	ppm	7/22/02 7:06:00	A
Benzyl alcohol	ND	0.66	ppm	7/22/02 7:06:00	A
Bis(2-chloroethoxy)methane	ND	0.33	ppm	7/22/02 7:06:00	A
Bis(2-chloroethyl)ether	ND	0.33	ppm	7/22/02 7:06:00	A
Bis(2-chloroisopropyl)ether	ND	0.33	ppm	7/22/02 7:06:00	A
Bis(2-ethylhexyl)phthalate	0.83	0.33	ppm	7/22/02 7:06:00	A
Butyl benzyl phthalate	ND	0.33	ppm	7/22/02 7:06:00	A
Carbazole	ND	0.33	ppm	7/22/02 7:06:00	A
Chrysene	ND	0.33	ppm	7/22/02 7:06:00	A
Di-n-butyl phthalate	ND	0.33	ppm	7/22/02 7:06:00	A
Di-n-octyl phthalate	ND	0.33	ppm	7/22/02 7:06:00	A
Dibenz(a,h)anthracene	ND	0.33	ppm	7/22/02 7:06:00	A
Dibenzofuran	ND	0.33	ppm	7/22/02 7:06:00	A
Diethyl phthalate	ND	0.33	ppm	7/22/02 7:06:00	A
Dimethyl phthalate	ND	0.33	ppm	7/22/02 7:06:00	A
Fluoranthene	ND	0.33	ppm	7/22/02 7:06:00	A
Fluorene	ND	0.33	ppm	7/22/02 7:06:00	A
Hexachlorobenzene	ND	0.33	ppm	7/22/02 7:06:00	A
Hexachlorobutadiene	ND	0.33	ppm	7/22/02 7:06:00	A
Hexachlorocyclopentadiene	ND	0.33	ppm	7/22/02 7:06:00	A
Hexachloroethane	ND	0.33	ppm	7/22/02 7:06:00	A
Indeno(1,2,3-cd)pyrene	ND	0.33	ppm	7/22/02 7:06:00	A
Isophorone	ND	0.33	ppm	7/22/02 7:06:00	A
N-Nitrosodi-n-propylamine	ND	0.33	ppm	7/22/02 7:06:00	A
N-Nitrosodimethylamine	ND	0.33	ppm	7/22/02 7:06:00	A
N-Nitrosodiphenylamine	ND	0.66	ppm	7/22/02 7:06:00	A

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2203 S. Madison Street
Muncie Indiana 47302
800-874-3563

CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-13
Date Received: 12-Jul-02

Client Sample ID: 34SS03071002
Tag Number:
Collection Date: 7/10/02 8:40:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Naphthalene	ND	0.33	ppm	7/22/02 7:06:00	A
Nitrobenzene	ND	0.33	ppm	7/22/02 7:06:00	A
o-Toluidine	ND	0.66	ppm	7/22/02 7:06:00	A
Pentachlorophenol	ND	1.6	ppm	7/22/02 7:06:00	A
Phenanthrene	ND	0.33	ppm	7/22/02 7:06:00	A
Phenol	ND	0.33	ppm	7/22/02 7:06:00	A
Pyrene	ND	0.33	ppm	7/22/02 7:06:00	A
Pyridine	ND	1.6	ppm	7/22/02 7:06:00	A
Surr: 2,4,6-Tribromophenol	93.5	19-122	%REC	7/22/02 7:06:00	A
Surr: 2-Fluorobiphenyl	72.4	30-115	%REC	7/22/02 7:06:00	A
Surr: 2-Fluorophenol	58.6	25-121	%REC	7/22/02 7:06:00	A
Surr: 4-Terphenyl-d14	82.4	18-137	%REC	7/22/02 7:06:00	A
Surr: Nitrobenzene-d5	54.5	23-120	%REC	7/22/02 7:06:00	A
Surr: Phenol-d5	62.3	24-113	%REC	7/22/02 7:06:00	A
METALS IN SOIL OR SLUDGE BY ICP		**SW6010A**			**FJR**
Cadmium	1.3	0.030	ppm	7/16/02 12:18:49	P
Chromium	ND	0.10	ppm	7/16/02 12:18:49	P
Lead	21	0.25	ppm	7/16/02 12:18:49	P
PCBS IN SOIL OR SOLID WASTE		**SW8082**			**SDW**
Aroclor 1016	ND	2.00	ppm	7/23/02	
Aroclor 1221	ND	2.00	ppm	7/23/02	
Aroclor 1232	ND	2.00	ppm	7/23/02	
Aroclor 1242	ND	2.00	ppm	7/23/02	
Aroclor 1248	ND	2.00	ppm	7/23/02	
Aroclor 1254	ND	2.00	ppm	7/23/02	
Aroclor 1260	ND	2.00	ppm	7/23/02	
Surr: Decachlorobiphenyl	Diluted Out	70-130	%REC	7/23/02	

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Muncie Indiana 47302
800-874-3563

CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-14
Date Received: 12-Jul-02

Client Sample ID: 34SS01071002
Tag Number:
Collection Date: 7/10/02 8:06:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
SEMI-VOLATILES IN SOIL	**SW8270A**				**GB**
1,2,4,5-Tetrachlorobenzene	ND	0.33	ppm	7/22/02 7:38:00 A	
1,2,4-Trichlorobenzene	ND	0.33	ppm	7/22/02 7:38:00 A	
1,2-Dichlorobenzene	ND	0.33	ppm	7/22/02 7:38:00 A	
1,2-Diphenylhydrazine	ND	0.33	ppm	7/22/02 7:38:00 A	
1,3-Dichlorobenzene	ND	0.33	ppm	7/22/02 7:38:00 A	
1,3-Dinitrobenzene	ND	0.33	ppm	7/22/02 7:38:00 A	
1,4-Dichlorobenzene	ND	0.33	ppm	7/22/02 7:38:00 A	
2,3,4,6-Tetrachlorophenol	ND	0.33	ppm	7/22/02 7:38:00 A	
2,4,5-Trichlorophenol	ND	0.33	ppm	7/22/02 7:38:00 A	
2,4,6-Trichlorophenol	ND	0.33	ppm	7/22/02 7:38:00 A	
2,4-Dichlorophenol	ND	0.33	ppm	7/22/02 7:38:00 A	
2,4-Dimethylphenol	ND	0.33	ppm	7/22/02 7:38:00 A	
2,4-Dinitrophenol	ND	1.6	ppm	7/22/02 7:38:00 A	
2,4-Dinitrotoluene	ND	0.33	ppm	7/22/02 7:38:00 A	
2,6-Dinitrotoluene	ND	0.33	ppm	7/22/02 7:38:00 A	
2-Chloronaphthalene	ND	0.33	ppm	7/22/02 7:38:00 A	
2-Chlorophenol	ND	0.33	ppm	7/22/02 7:38:00 A	
2-Methylnaphthalene	ND	0.33	ppm	7/22/02 7:38:00 A	
2-Methylphenol	ND	0.33	ppm	7/22/02 7:38:00 A	
2-Nitroaniline	ND	0.33	ppm	7/22/02 7:38:00 A	
2-Nitrophenol	ND	0.33	ppm	7/22/02 7:38:00 A	
2-Picoline	ND	0.33	ppm	7/22/02 7:38:00 A	
3,3'-Dichlorobenzidine	ND	0.66	ppm	7/22/02 7:38:00 A	
3-Nitroaniline	ND	0.33	ppm	7/22/02 7:38:00 A	
4,6-Dinitro-2-methylphenol	ND	1.6	ppm	7/22/02 7:38:00 A	
4-Bromophenyl phenyl ether	ND	0.33	ppm	7/22/02 7:38:00 A	
4-Chloro-3-methylphenol	ND	0.66	ppm	7/22/02 7:38:00 A	
4-Chloroaniline	ND	0.33	ppm	7/22/02 7:38:00 A	
4-Chlorophenyl phenyl ether	ND	0.33	ppm	7/22/02 7:38:00 A	
4-Methylphenol	ND	0.33	ppm	7/22/02 7:38:00 A	
4-Nitroaniline	ND	0.33	ppm	7/22/02 7:38:00 A	
4-Nitrophenol	ND	1.6	ppm	7/22/02 7:38:00 A	
Acenaphthene	ND	0.33	ppm	7/22/02 7:38:00 A	

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Muncie Indiana 47302
800-874-3563

CLIENT: SAIC
Lab Order: M02070406
Project: NSWC Crane OGTSL
Lab ID: M02070406-14
Date Received: 12-Jul-02

Client Sample ID: 34SS01071002
Tag Number:
Collection Date: 7/10/02 8:06:00 AM
Matrix: SOIL
Date Reported: 26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Acenaphthylene	ND	0.33	ppm	7/22/02 7:38:00 A	
Aniline	ND	0.66	ppm	7/22/02 7:38:00 A	
Anthracene	ND	0.33	ppm	7/22/02 7:38:00 A	
Benz(a)anthracene	ND	0.33	ppm	7/22/02 7:38:00 A	
Benzidine	ND	1.6	ppm	7/22/02 7:38:00 A	
Benzo(a)pyrene	ND	0.33	ppm	7/22/02 7:38:00 A	
Benzo(b)fluoranthene	ND	0.33	ppm	7/22/02 7:38:00 A	
Benzo(g,h,i)perylene	ND	0.33	ppm	7/22/02 7:38:00 A	
Benzo(k)fluoranthene	ND	0.33	ppm	7/22/02 7:38:00 A	
Benzoic acid	ND	1.6	ppm	7/22/02 7:38:00 A	
Benzyl alcohol	ND	0.66	ppm	7/22/02 7:38:00 A	
Bis(2-chloroethoxy)methane	ND	0.33	ppm	7/22/02 7:38:00 A	
Bis(2-chloroethyl)ether	ND	0.33	ppm	7/22/02 7:38:00 A	
Bis(2-chloroisopropyl)ether	ND	0.33	ppm	7/22/02 7:38:00 A	
Bis(2-ethylhexyl)phthalate	ND	0.33	ppm	7/22/02 7:38:00 A	
Butyl benzyl phthalate	ND	0.33	ppm	7/22/02 7:38:00 A	
Carbazole	ND	0.33	ppm	7/22/02 7:38:00 A	
Chrysene	ND	0.33	ppm	7/22/02 7:38:00 A	
Di-n-butyl phthalate	ND	0.33	ppm	7/22/02 7:38:00 A	
Di-n-octyl phthalate	ND	0.33	ppm	7/22/02 7:38:00 A	
Dibenz(a,h)anthracene	ND	0.33	ppm	7/22/02 7:38:00 A	
Dibenzofuran	ND	0.33	ppm	7/22/02 7:38:00 A	
Diethyl phthalate	ND	0.33	ppm	7/22/02 7:38:00 A	
Dimethyl phthalate	ND	0.33	ppm	7/22/02 7:38:00 A	
Fluoranthene	ND	0.33	ppm	7/22/02 7:38:00 A	
Fluorene	ND	0.33	ppm	7/22/02 7:38:00 A	
Hexachlorobenzene	ND	0.33	ppm	7/22/02 7:38:00 A	
Hexachlorobutadiene	ND	0.33	ppm	7/22/02 7:38:00 A	
Hexachlorocyclopentadiene	ND	0.33	ppm	7/22/02 7:38:00 A	
Hexachloroethane	ND	0.33	ppm	7/22/02 7:38:00 A	
Indeno(1,2,3-cd)pyrene	ND	0.33	ppm	7/22/02 7:38:00 A	
Isophorone	ND	0.33	ppm	7/22/02 7:38:00 A	
N-Nitrosodi-n-propylamine	ND	0.33	ppm	7/22/02 7:38:00 A	
N-Nitrosodimethylamine	ND	0.33	ppm	7/22/02 7:38:00 A	
N-Nitrosodiphenylamine	ND	0.66	ppm	7/22/02 7:38:00 A	

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Muncie Indiana 47302
800-874-3563

CLIENT:	SAIC	**Client Sample ID:**	34SS01071002
Lab Order:	M02070406	**Tag Number:**	
Project:	NSWC Crane OGTSL	**Collection Date:**	7/10/02 8:06:00 AM
Lab ID:	M02070406-14	**Matrix:**	SOIL
Date Received:	12-Jul-02	**Date Reported:**	26-Jul-02

Analyses	Result	Detection Limit	Units	Date Analyzed	Analyst
Naphthalene	ND	0.33	ppm	7/22/02 7:38:00	A
Nitrobenzene	ND	0.33	ppm	7/22/02 7:38:00	A
o-Toluidine	ND	0.66	ppm	7/22/02 7:38:00	A
Pentachlorophenol	ND	1.6	ppm	7/22/02 7:38:00	A
Phenanthrene	ND	0.33	ppm	7/22/02 7:38:00	A
Phenol	ND	0.33	ppm	7/22/02 7:38:00	A
Pyrene	ND	0.33	ppm	7/22/02 7:38:00	A
Pyridine	ND	1.6	ppm	7/22/02 7:38:00	A
Surr: 2,4,6-Tribromophenol	88.7	19-122	%REC	7/22/02 7:38:00	A
Surr: 2-Fluorobiphenyl	75.0	30-115	%REC	7/22/02 7:38:00	A
Surr: 2-Fluorophenol	65.9	25-121	%REC	7/22/02 7:38:00	A
Surr: 4-Terphenyl-d14	81.4	18-137	%REC	7/22/02 7:38:00	A
Surr: Nitrobenzene-d5	59.7	23-120	%REC	7/22/02 7:38:00	A
Surr: Phenol-d5	67.9	24-113	%REC	7/22/02 7:38:00	A
METALS IN SOIL OR SLUDGE BY ICP		**SW6010A**			**FJR**
Cadmium	0.69	0.030	ppm	7/16/02 12:21:38	P
Chromium	5.0	0.10	ppm	7/16/02 12:21:38	P
Lead	31	0.25	ppm	7/16/02 12:21:38	P
PCBS IN SOIL OR SOLID WASTE		**SW8082**			**SDW**
Aroclor 1016	ND	2.00	ppm	7/23/02	
Aroclor 1221	ND	2.00	ppm	7/23/02	
Aroclor 1232	ND	2.00	ppm	7/23/02	
Aroclor 1242	ND	2.00	ppm	7/23/02	
Aroclor 1248	ND	2.00	ppm	7/23/02	
Aroclor 1254	ND	2.00	ppm	7/23/02	
Aroclor 1260	ND	2.00	ppm	7/23/02	
Surr: Decachlorobiphenyl	Diluted Out	70-130	%REC	7/23/02	

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812-375-0531 Fax 812-375-0731

☐ 5738 Industrial Rd., Fort Wayne, IN 46825
219-471-7000 Fax 219-471-7777

☐ 2417 W. Pinhook Rd, Lafayette, LA 70508
337-235-0483/800-737-2376
Fax 337-233-6540

☐ 3445 S Sheridan, Tulsa, OK 74145
918-828-9977/800-324-5757
Fax 918-828-7756

Chain of Custody Record

Laboratory Number

Client Name: NSWC Crane
Contact Name: Thomas J. Brent
Phone/Fax: 812-854-6160/3981 fax

Project Name: OGTSL
Project #:
Sampler's Signature: Thomas J. Brent

Collection Date	Collection Time	Grab	Comp	Sample Identification / Description	Preservative	Number / Type of Container	Matrix Code	SVOC	PCBs	Cd/Cr/Pb						Comments / Remarks
7/10/02	1106	X		Rinsate	4°C	1/G	OT	X								
"	"	X		Rinsate	4°C	1/G	OT		X							
"	"	X		Rinsate	HNO_3	1/P	OT			X						
"	0936		X	343B06071002	4°C	2/G	SO	X	X	X						
"	1046		X	345S10071002	4°C	2/G	SO	X	X	X						
"	1030		X	345S09071002	4°C	2/G	SO	X	X	X						
"	1000		X	345B07071002	4°C	2/G	SO	X	X	X						
"	1056		X	345S11071002	4°C	2/G	SO	X	X	X						
"	1018		X	345S08071002	4°C	2/G	SO	X	X	X						UPS / FedEx / Airborne / Sherry Hand / Mail
"	0911		X	345S05071002	4°C	2/G	SO	X	X	X						

All samples submitted to Sherry Laboratories for analysis are accepted on a custodial basis only. Ownership of the material remains with the client submitting the samples. Sherry Laboratories reserves the right to return unused sample portions.

P.O. Number

Relinquished by: (Signature)	Received by: (Signature)	Date	Time	Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Thomas J. Brent 7/11/02							
Relinquished by: (Signature)	Received by: (Signature)	Date	Time	Relinquished by: (Signature)	Received by Laboratory: (Signature)	Date	Time
					Wendy Moon	7/12/02	

Matrix Codes
DW = Drinking Water MW = Monitoring Well
WW = Waste Water SL = Sludge
SO = Soil O = Oil OT = Other

Container Types
G = Glass
P = Plastic

Shipping Conditions
☒ Iced
Temp. 4°C
☐ Ambient

Which Regulations Apply
☒ RCRA ☐ Drinking Water
☐ POTW ☐ Other_____
☐ NPDES

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Part 1 - Laboratory Copy Part 2 - Report Copy Part 3 - Client's Temporary Copy

PART 2

SHERRY Laboratories
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812-375-0531 Fax 812-375-0731
☐ 5738 Industrial Rd., Fort Wayne, IN 46825
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☐ 2417 W. Pinhook Rd, Lafayette, LA 70508
337-235-0483/800-737-2378
Fax 337-233-6540
☐ 3445 S Sheridan, Tulsa, OK 74145
918-828-9977/800-324-5757
Fax 918-828-7756

Chain of Custody Record

Laboratory Number: M02-07-04-L

Client Name: NSWC Crane
Contact Name: Thomas J. Brent
Phone/Fax: 812-854-6160/Fax 3981
Project Name: OGTSL
Project #:
Sampler's Signature: Thomas J. Brent

Collection Date	Collection Time	Grab	Comp	Sample Identification / Description	Preservative	Number / Type of Container	Matrix Code	SVOCs	PCBs	Cd/Cr/Pb						Comments / Remarks
7/10/02	0954		X	345507071002	4°C	2/G	SO	X	X	X						
"	0930		X	345506071002	4°C	2/G	SO	X	X	X						
"	0856		X	345504071002	4°C	2/G	SO	X	X	X						
"	0820		X	345502071002	4°C	2/G	SO	X	X	X						
"	0840		X	345503071002	4°C	2/G	SO	X	X	X						
"	0806		X	345501071002	4°C	2/G	SO	X	X	X						
																UPS / FedEx / Airborne / Sherry / Hand / Mail

All samples submitted to Sherry Laboratories for analysis are accepted on a custodial basis only. Ownership of the material remains with the client submitting the samples. Sherry Laboratories reserves the right to return unused sample portions.

P.O. Number

Relinquished by: (Signature)	Received by: (Signature)	Date	Time	Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Thomas J. Brent 7/11/02							
Relinquished by: (Signature)	Received by: (Signature)	Date	Time	Relinquished by: (Signature)	Received by Laboratory: (Signature)	Date	Time
					[illegible]	7/12	

Matrix Codes
DW = Drinking Water, MW = Monitoring Well
WW = Waste Water, SL = Sludge
SO = Soil, O = Oil, OT = Other

Container Types
G = Glass
P = Plastic

Shipping Conditions
☒ Iced
Temp. 4°C
☐ Ambient

Which Regulations Apply
☒ RCRA ☐ Drinking Water
☐ POTW ☐ Other _____
☐ NPDES

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Part 1 - Laboratory Copy Part 2 - Report Copy Part 3 - Client's Temporary Copy

PART 2

Science Applications International Corporation

PURCHASE ORDER
PO Number / Date
4400056285 / 06/11/2002

For Delivery To:
SAIC
HIGHWAY 231 S ROUTE 6 BOX 28
BLOOMFIELD IN 47424

Attn: A.Netherland

Bill To:
SAIC
Attn: Accounts Payable
Highway 231 South Route 8 Box 28
Bloomfield, IN 47424

Supplier:
SHERRY LABORATORIES INCORPORATED
2203 SOUTH MADISON STREET
MUNCIE IN 47302

Supplier Contact: Dan Klaybor
Supplier Phone: 800-874-3563

Partials Accepted
Delivery Date: 07/10/2002

FOB: Origin
Supplier Ref.: 89
Tax Reg. #: 0036874220017
Currency: USD
Payment Terms: Within 30 days Due net

Buyer {S}	Telephone	Fax Number	P.Org./ Proc. Code
Stempeck, Edward	505 830-7430	505 830-0447	0035

Non Taxable

Prime Contract Number: N00164-98-D-0008

Delivery Order: 0512

Item	Quantity/ Description	Unit	Unit Price	Extended Price	Extended Tax
00001	7.000 SVOC Analysis	each	225.00	1,575.00	0.00
00002	7.000 PCBs Analysis	each	75.00	525.00	0.00
00003	7.000 Cadmium Analysis	each	9.00	63.00	0.00

Next Page 2

Science Applications International Corporation

PURCHASE ORDER
PO Number / Date
4400056285 / 06/11/2002

Item	Quantity/ Description	Unit	Unit Price	Extended Price	Extended Tax
00004	7.000 Chromium Analysis	each	9.00	63.00	0.00
00005	7.000 Lead Analysis	each	9.00	63.00	0.00
	Subtotal excluding tax				2,289.00
	Sales/Use tax				0.00
	Total Order				2,289.00

Buyer's Signature: _____ Date: 6/11/02

Purchase Order number must appear on all Invoices, Packing Slips and Correspondence.

Acknowledgement of this Purchase Order is required:

Supplier's Name: DANIEL C. KLAYBOR Signature: _____ Date: 6-11-02

SHIPPING CONTAINER TALLY → 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

REQUISITION AND INVOICE/SHIPPING DOCUMENT

Form Approved
OMB No. 0704-0246
Expires Dec 31, 1999

The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0246), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

PLEASE DO NOT RETURN YOUR FORM TO THIS ADDRESS. RETURN COMPLETED FORM TO THE ADDRESS IN ITEM 2.

1. FROM: (Include ZIP Code)
NAVSURFWARCENDIV
CODE 1121 BLDG 41SE
300 HIGHWAY 361
CRANE, IN 47522-5001

SHEET NO.	NO. OF SHEETS	5. REQUISITION DATE	6. REQUISITION NUMBER
1	1	2002-07-11	

7. DATE MATERIAL REQUIRED (YYYYMMDD): 2002-07-12
8. PRIORITY: 03

2. TO: (Include ZIP Code)
SHERRY LABORATORIES
2203 S. MADISON ST.
MUNCIE, IN 47302

9. AUTHORITY OR PURPOSE: ENVIRONMENTAL SAMPLES FOR ANALYSIS

10. SIGNATURE: DANA WILLIAMS
11a. VOUCHER NUMBER & DATE (YYYYMMDD): N00164-2192-3104

3. SHIP TO - MARK FOR
AMY KIESEL

12. DATE SHIPPED (YYYYMMDD)
b.

13. MODE OF SHIPMENT: FED EX
14. BILL OF LADING NUMBER

15. AIR MOVEMENT DESIGNATOR OR PORT REFERENCE NO.

4. APPROPRIATIONS DATA

			AMOUNT
TRANSPORTATION:	A1 97X4930.	NH1J 000 77777 0 000164 2F 000000 096958373454	
LABOR:	A1 97X4930.	NH1J 000 77777 0 000164 2F 000000 096958318006	
MATERIAL:	A1 97X4930.	NH1J 000 77777 0 000164 2F 000000 096958373454	

ITEM NO. (a)	FEDERAL STOCK NUMBER, DESCRIPTION, AND CODING OF MATERIAL AND/OR SERVICES (b)	UNIT OF ISSUE (c)	QUANTITY REQUESTED (d)	SUPPLY ACTION (e)	TYPE CONTAINER (f)	CONTAINER NOS. (g)	UNIT PRICE (h)	TOTAL COST (i)
	POC: DANA WILLIAMS PHONE NO: 812-854-3590 RETURN COPY TO: TOM BRENT SHOP CD: 09695							
01	ENVIRONMENTAL SAMPLES FOR ANALYSIS - ONE (1) COOLER	EA	1			130		

16. TRANSPORTATION VIA MATS OR MSTS CHARGEABLE TO

17. SPECIAL HANDLING

18. RECAPITULATION OF SHIPMENT

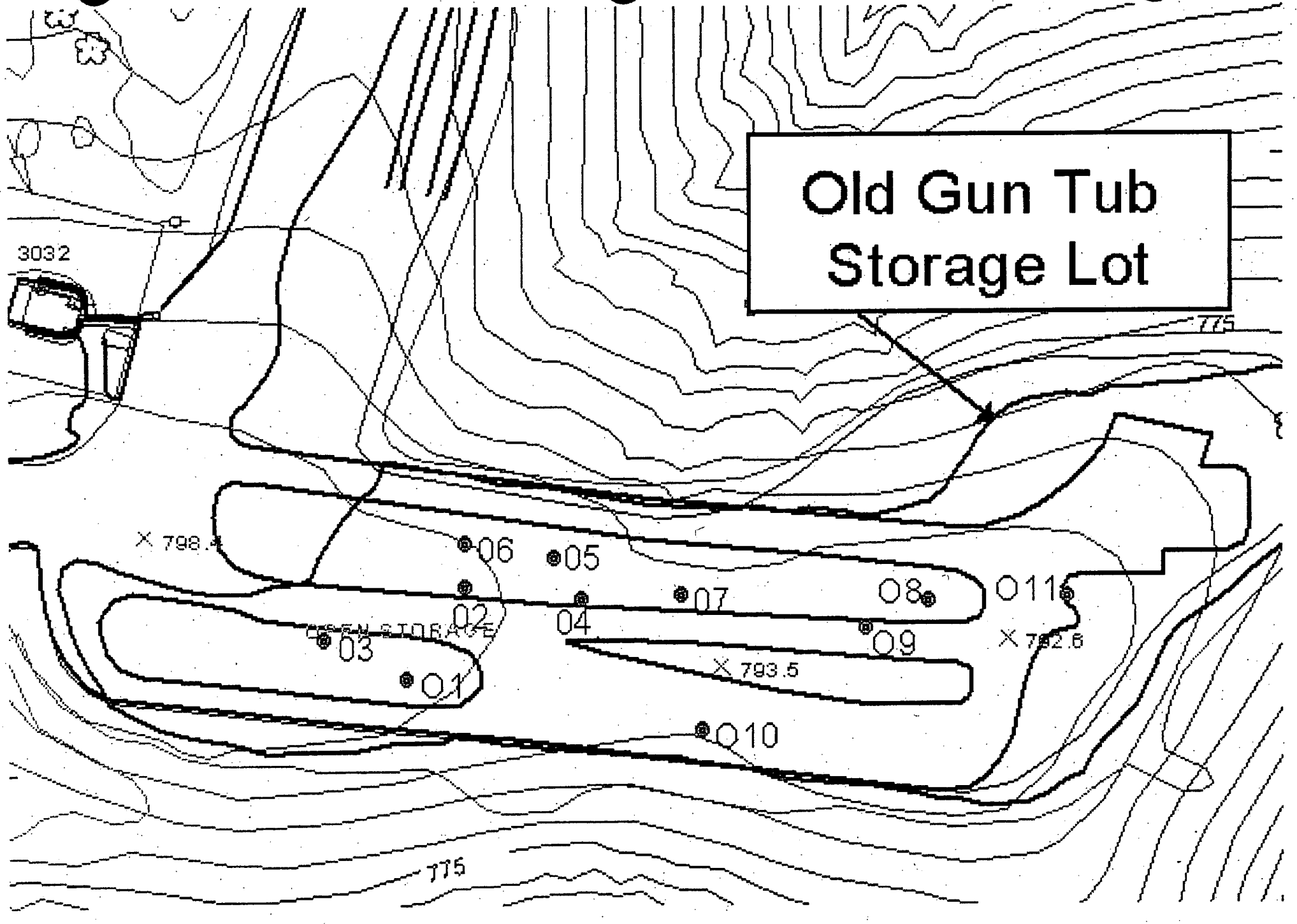
ISSUED BY	TOTAL CONTAINERS	TYPE CONTAINER	DESCRIPTION	TOTAL WEIGHT	TOTAL CUBE
DW3948					
CHECKED BY DL 2192	1	C5	26 x 14 x 17	54	4.0
KJB842					
PACKED BY					
			← TOTAL →		

19. RECEIPT

CONTAINERS RECEIVED EXCEPT AS NOTED	DATE (YYYYMMDD)	BY	SHEET TOTAL
QUANTITIES RECEIVED EXCEPT AS NOTED	DATE (YYYYMMDD)	BY	GRAND TOTAL
POSTED	DATE (YYYYMMDD)	BY	20. RECEIVER'S VOUCHER NO.

DD FORM 1149, JAN 1997

PREVIOUS EDITION MAY BE USED.


Old Gun Tub
Storage Lot
3032
775
X 798.4
06
05
07
08
011
02
04
03
09
X 792.6
X 793.5
01
010
775

Sample Date: 7/10/2002

Sample #		Depth (in)
01	SS	0-12
02	SS	0-8
03	SS	0-24
04	SS	0-24
05	SS	0-24
06	SS	0-24
06	SB	24-48
07	SS	0-24
07	SB	24-48
08	SS	0-24
09	SS	0-25
010	SS	0-26
011	SS	0-27

APPENDIX B

TABULAR PRESENTATION OF RBSLs

APPENDIX B

TABLE 1
TABULAR PRESENTATION OF SOIL AND SEDIMENT RBSLs FOR RBTL SELECTION
NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	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 DEFAULT RESIDENTIAL GW CLOSURE LEVELS (ug/L)	FOOTNOTE	IDEM DEFAULT INDUSTRIAL GW CLOSURE LEVELS (ug/L)	FOOTNOTE	REGION 9 TAP WATER PRGS (ug/L)	FOOTNOTE	MINIMUM CRITERIA VALUE (ug/L)
EXPLOSIVES (NITROAROMATICS AND NITRAMINES)																
SW-846 METHOD 8330																
1,3,5-Trinitrobenzene	99-35-4													1100		1100
1,3-Dinitrobenzene	99-65-0	22												3.6		3.6
2,4,6-Trinitrotoluene (TNT)	118-96-7													2.2		2.2
2,4-Dinitrotoluene	121-14-2	44								1.3	1	4.2	1	73		1.3
2,6-Dinitrotoluene	606-20-2	81								1.3	1	4.2	1	36		1.3
2-Amino-4,6-dinitrotoluene	35572-78-2													7.3	2	7.3
2-Nitrotoluene	99-08-1													61		61
3-Nitrotoluene	99-08-1													61		61
4-Amino-2,6-dinitrotoluene	1946-51-0													7.3	2	7.3
4-Nitrotoluene	99-99-0													61		61
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4													0.61		0.61
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	479-45-8													360		360
Nitrobenzene	98-95-3	220								4.3		51		3.4		3.4
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0													1800		1800
APPENDIX IX HERBICIDES (SW-846 METHOD 8151A)																
2,4-D	94-75-7	220		70						70		1000		360		70
2,4,5-T	93-76-5	686								370		1000		360		360
2,4,5-TP (Silvex)	93-72-1	30		50										290		30
Dinoseb	88-85-7	0.48		7										36		0.48
Pentachlorophenol	87-86-5	4		1		19		15		1		24		0.56		0.56
Hexachlorophene	70-30-4	0.228												11		0.228
ORGANOCHLORINE PESTICIDES (SW-846 METHOD 8081A)																
Aldrin	309-00-2	0.017				3				0.05		0.17		0.004		0.004
Alpha-BHC	319-84-6	12.4								0.14		0.45		0.011		0.011
Alpha-chlordane	5103-71-9			2	3	2.4	3	0.0043	3	2	3	8.2	3	0.19	3	0.0043
Beta-BHC	319-85-7	0.495								0.47		1.6		0.037		0.037
4,4'-DDD	72-54-8									3.5		12		0.28		0.28
4,4'-DDE	72-55-9	4.51E-09								2.5		8.4		0.2		4.51E-09
4,4'-DDT	50-29-3	0.000011				1.1		0.001		2.5		8.4		0.2		0.000011
Delta-BHC	319-86-8	667								0.14	4	0.45	4	0.011	4	0.011
Dieldrin	60-57-1	0.000071				0.24		0.056		0.053		0.18		0.0042		0.000071
Endosulfan I	115-29-7					0.22		0.056		220	5	510	5	220	5	0.056
Endosulfan II	33213-65-9	0.056				0.22		0.056		220	5	510	5	220	5	0.056
Endosulfan sulfate	1031-07-8									220	5	510	5	220	5	220
Endrin	72-20-8	0.036		2		0.086		0.036		2		31		11		0.036
Endrin aldehyde	7421-93-4	0.15								2	6	31	6	11	6	0.15
Endrin Ketone	53494-70-5									2	6	31	6	11	6	2
Gamma-BHC (Lindane)	58-89-9	0.026		0.2		0.95				0.2		2.2		0.052		0.026
Gamma-chlordane	12789-03-6			2	3	2.4	3	0.0043	3	2	3	8.2	3	0.19	3	0.0043
Heptachlor	76-44-8	0.0038		0.4		0.52		0.0038		0.4		0.64		0.015		0.0038
Heptachlor epoxide	1024-57-3	0.0038		0.2		0.52		0.0038		0.2		0.31		0.0074		0.0038
Methoxychlor	72-43-5	0.019		40				0.03		40		45		180		0.019
Toxaphene	8001-35-2	0.00014		3		0.73		0.0002		3		3		0.061		0.00014
POLYCHLORINATED BIPHENYLS (SW-846 METHOD 8082)																
Aroclor-1016	12674-11-2			0.5	7			0.014	7	0.5	7	0.5	7	0.96		0.014
Aroclor-1221	11104-28-2			0.5	7			0.014	7	0.5	7	0.5	7	0.034		0.014
Aroclor-1232	11141-16-5			0.5	7			0.014	7	0.5	7	0.5	7	0.034		0.014
Aroclor-1242	53469-21-9			0.5	7			0.014	7	0.5	7	0.5	7	0.034		0.014
Aroclor-1248	12672-29-6			0.5	7			0.014	7	0.5	7	0.5	7	0.034		0.014
Aroclor-1254	11097-69-1			0.5	7			0.014	7	0.5	7	0.5	7	0.034		0.014
Aroclor-1260	11096-82-5			0.5	7			0.014	7	0.5	7	0.5	7	0.034		0.014
POLYCYCLIC AROMATIC HYDROCARBONS																
SW-846 METHOD 8270C WITH SELECTIVE ION MONITORING																
2-Methylnaphthalene	91-57-6	330								150		2000		6.2	8	6.2
Acenaphthene	83-32-9	38								460		4200		370		38
Acenaphthylene	208-96-8	4840								71		730		370	9	71
Anthracene	120-12-7	0.035								43		43		1800		0.035
Benzo(a)anthracene	56-55-3	0.025								1.2		3.9		0.092		0.025

APPENDIX B

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NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	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 DEFAULT RESIDENTIAL GW CLOSURE LEVELS (ug/L)	FOOTNOTE	IDEM DEFAULT INDUSTRIAL GW CLOSURE LEVELS (ug/L)	FOOTNOTE	REGION 9 TAP WATER PRGS (ug/L)	FOOTNOTE	MINIMUM CRITERIA VALUE (ug/L)
Benzo(a)pyrene	50-32-8	0.014		0.2						0.2		0.39		0.0092		0.0092
Benzo(b)fluoranthene	205-99-2	9.07								1.2		1.5		0.092		0.092
Benzo(g,h,i)perylene	191-24-2	7.64								0.26		0.26		180	10	0.26
Benzo(k)fluoranthene	207-08-9									0.8		0.8		0.92		0.8
Carbazole	86-74-8									43		140		3.4		3.4
Chrysene	218-01-9									1.6		1.6		9.2		1.6
Dibenzo(a,h)anthracene	53-70-3									0.12		0.39		0.0092		0.0092
Fluoranthene	206-44-0	1.9								210		210		1500		1.9
Fluorene	86-73-7	19								310		2000		240		19
Indeno(1,2,3-cd)pyrene	193-39-5	4.31								0.022		0.022		0.092		0.022
Naphthalene	91-20-3	13								8.3		2000		6.2		6.2
Phenanthrene	85-01-8									23		310		180	10	23
Pyrene	129-00-0									140		140		180		140
SEMIVOLATILE ORGANIC COMPOUNDS (EXCEPT PAHs)																
SW-846 METHOD 8270C																
1,2,4,5-Tetrachlorobenzene	95-94-3	3												11		3
1,2,4-Trichlorobenzene	120-82-1	30		70						70		1000		190		30
1,2-Dichlorobenzene	95-50-1	14		600						600		9200		370		14
1,3-Dichlorobenzene	541-73-1	38								6.9		92		5.5		5.5
1,4-Dichlorobenzene	106-46-7	9.4		75						75		120		0.5		0.5
1,4-Naphthoquinone	130-15-4	----														
1,4-Phenylenediamine	106-50-3													6900		6900
1-Naphthylamine	134-32-7	----														
2,3,4,6-Tetrachlorophenol	58-90-2	1.2												1100		1.2
2,4,5-Trichlorophenol	95-95-4									3700		10000		3600		3600
2,4,6-Trichlorophenol	88-06-2									3.7		10		0.96		0.96
2,4-Dichlorophenol	120-83-2	11								110		310		110		11
2,4-Dimethylphenol	105-67-9	100								730		2000		730		100
2,4-Dinitrophenol	51-28-5	19								73		200		73		19
2,6-Dichlorophenol	87-65-0															
2-Acetylaminofluorene	53-96-3	535														535
2-Chloronaphthalene	91-58-7	0.396								610		8200		490		0.396
2-Chlorophenol	95-57-8	24								38		510		30		24
2-Methylphenol	95-48-7	67								1800		5100		1800		67
2-Naphthylamine	91-59-8															
2-Nitroaniline	88-74-4									2.1		5.8		1		1
2-Nitrophenol	88-75-5	---														
2-Picoline	109-06-8															
3,3'-Dichlorobenzidine	91-94-1	4.5								1.9		6.4		0.15		0.15
3,3'-Dimethylbenzidine	119-93-7													0.0073		0.0073
3-Methylcholanthrene	56-49-5	0.0891														0.0891
3-Methylphenol	108-39-4	62								1800		5100		1800		62
4-Methylphenol	106-44-5	25								180		510		180		25
3-Nitroaniline	99-09-2															
4,6-Dinitro-2-methylphenol	534-52-1	23														23
4-Aminobiphenyl	92-67-1															0
4-Bromophenyl phenyl ether	101-55-3	1.5														1.5
4-Chloro-3-methylphenol	59-50-7	34.8														34.8
4-Chloroaniline	106-47-8	232								150		410		150		150
4-Chlorophenyl phenyl ether	7005-72-3															
4-Nitroaniline	100-01-6															
4-Nitrophenol	100-02-7															
4-Nitroquinoline-1-oxide	56-57-5															
5-Nitro-o-toluidine	99-55-8													2		2
7,12-Dimethylbenz(a)anthracene	57-97-6	0.548														0.548
Acetophenone	98-86-2	-----														
Aniline	62-53-3	4.1												12		4.1
Aramite	140-57-8	3.09												2.7		2.7
Benzyl alcohol	100-51-6	8.6								11000		31000		11000		8.6
Bis(2-chloroethoxy)methane	111-91-1	-----														

APPENDIX B

TABLE 1
TABULAR PRESENTATION OF SOIL AND SEDIMENT RBSLs FOR RBTL SELECTION
NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	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 DEFAULT RESIDENTIAL GW CLOSURE LEVELS (ug/L)	FOOTNOTE	IDEM DEFAULT INDUSTRIAL GW CLOSURE LEVELS (ug/L)	FOOTNOTE	REGION 9 TAP WATER PRGS (ug/L)	FOOTNOTE	MINIMUM CRITERIA VALUE (ug/L)
Bis(2-chloroethyl)ether	111-44-4	19000								0.15		2.6		0.0098		0.0098
Bis(2-chloroisopropyl)ether	108-60-1	-----								4.2		41		0.27		0.27
Bis(2-ethylhexyl)phthalate	117-81-7	0.3		6						6		200		4.8		0.3
Butyl benzyl phthalate	85-68-7	23								2700		2700		7300		23
Chlorobenzilate	510-15-6	7.16												0.25		0.25
Diallate	2303-16-4	----												1.1		1.1
Di-n-butyl phthalate	84-74-2	9.7								3700		10000		3600		9.7
Di-n-octyl phthalate	117-84-0	30								20		20		1500		20
Dibenzofuran	132-64-9	4								15		200		24		4
Diethyl phthalate	84-66-2	110								29000		82000		29000		110
p-(Dimethylamino)azobenzene	60-11-7	1.65														1.65
a,a-Dimethylphenethylamine	122-09-8													36		36
Dimethyl phthalate	131-11-3	----								370000		1000000		360000		360000
Diphenylamine	122-39-4	412												910		412
Ethyl methane sulfonate	62-50-0															
Hexachlorobenzene	118-74-1	0.0003		1						1		1.8		0.042		0.0003
Hexachlorobutadiene	87-68-3	0.053								7.3		20		0.86		0.053
Hexachlorocyclopentadiene	77-47-4	77		50						50		610		220		50
Hexachloroethane	67-72-1	8								37		100		4.8		4.8
Hexachloropropene	1888-71-7	-----														
Isodrin	465-73-6	0.0309														0.0309
Isophorone	78-59-1	920								900		3000		71		71
Isosafrole	120-58-1															
Kepone	143-50-0	0.132												0.0084		0.0084
Methapyrilene	91-80-5															
Methyl methane sulfonate	66-27-3															
n-Nitrosodi-n-butylamine	924-16-3													0.002		0.002
n-Nitrosodiethylamine	55-18-5	768												0.00045		0.00045
n-Nitrosodimethylamine	62-75-9													0.0013		0.0013
n-Nitrosodi-n-propylamine	621-64-7									0.12		0.41		0.0096		0.0096
n-Nitrosomethylethylamine	62-75-9													0.0013		0.0013
n-Nitrosomorpholine	59-89-2															
n-Nitrosopiperidine	100-75-4															
n-Nitrosopyrrolidine	930-55-2													0.032		0.032
Pentachlorobenzene	608-93-5	0.019												29		0.019
Pentachloroethane	76-01-7															
Pentachloronitrobenzene	82-68-8													0.26		0.26
Phenacetin	62-44-2															
Phenol	108-95-2	180								11000		31000		22000		180
Pronamide	23950-58-5													2700		2700
Pyridine	110-86-1	2380												36		36
Safrole	94-59-7															
o-Toluidine	95-53-4													0.28		0.28
O,O,O-Triethyl phosphorothioate	102-86-3	0.0038														0.0038
TAL METALS PLUS TIN																
SW-846 Method 6020																
Aluminum	7429-90-5					750		87						36000		87
Antimony	7440-36-0	80		6						6		41		15		6
Arsenic	7440-38-2	148		10		340		150		50		50		0.045		0.045
Barium	7440-39-3	220		2000						2000		7200		2600		220
Beryllium	7440-41-7	3.6		4						4		200		73		3.6
Cadmium	7440-43-9	0.15		5		2	11	0.25	11	5		51		18		0.15
Calcium	7440-70-2															
Chromium (total)	7440-47-3	42		100		16	12	11	12	100	12	310	12	110	12	11
Cobalt	7440-48-4	24												730		24
Copper	7440-50-8	1.58		1300	13	13	11	9	11	1300	13	3800		1500		1.58
Iron	7439-89-6							1000						11000		1000
Lead	7439-92-1	1.17		15	13	65	11	2.5	11	15	13	42				1.17
Magnesium	7439-95-4															
Manganese	7439-96-5													880		880

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PARAMETERS	CAS NUMBER	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 DEFAULT RESIDENTIAL GW CLOSURE LEVELS (ug/L)	FOOTNOTE	IDEM DEFAULT INDUSTRIAL GW CLOSURE LEVELS (ug/L)	FOOTNOTE	REGION 9 TAP WATER PRGS (ug/L)	FOOTNOTE	MINIMUM CRITERIA VALUE (ug/L)
Nickel	7440-02-0					470	11	52	11					730		52
Potassium	7440-09-7															
Selenium	7782-49-2	5		50				5		50		510		180		5
Silver	7440-22-4	0.12				3.2	11			180		510		180		0.12
Sodium	7440-23-5															
Thallium	7440-28-0	10		2						2		7.2		2.4		2
Tin	7440-31-5	180														180
Vanadium	7440-62-2	12												260		12
Zinc	7440-66-6	65.7				120	11	120	11	11000		31000		11000		65.7
SW-846 7470A/7471A																
Mercury	7439-97-6	0.0013		2		1.4		0.77		2		31		11	14	0.0013
VOLATILE ORGANIC COMPOUNDS																
SW-846 METHOD 5035B/8260B																
1,1,1-Trichloroethane	71-55-6	76		200						200		29000		3200		76
1,1,1,2-Tetrachloroethane	630-20-6									6.9		110		0.43		0.43
1,1,2,2-Tetrachloroethane	79-34-5	380								0.9		14		0.055		0.055
1,1,2-Trichloroethane	79-00-5			5						5		50		0.2		0.2
1,2,3-Trichloropropane	96-18-4													0.0056		0.0056
1,1-Dichloroethane	75-34-3	47								990		10000		810		47
1,1-Dichloroethene	75-35-4	65		7						7		5100		340		7
1,2-Dibromo-3-chloropropane	96-12-8			0.2										0.0016		0.0016
1,2-Dibromoethane	106-93-4			0.05										0.00076		0.00076
1,2-Dichloroethane	107-06-2			5						5		31		0.12		0.12
1,2-Dichloropropane	78-87-5	360		5						5		42		0.16		0.16
2-Butanone	78-93-3	2200								8400		61000		1900		1900
2-Chloro-1,3-butadiene (chloroprene)	126-99-8													14		14
2-Hexanone	591-78-6	99														99
4-Methyl-2-pentanone	108-10-1	170								2200		8200		160		160
Acetone	67-64-1	1700								950		92000		610		610
Acrolein	107-02-8	0.19								0.055		51		0.042		0.042
Acrylonitrile	107-13-1	66												0.039		0.039
Allyl chloride (3-chloro-1-propene)	107-05-1													1800		1800
Benzene	71-43-2	114		5						5		52		0.34		0.34
Bromodichloromethane	75-27-4			80	15					80		80		0.18		0.18
Bromoform	75-25-2	230		80	15					80		360		8.5		8.5
Bromomethane	74-83-9	16								11		140		8.7		8.7
Carbon disulfide	75-15-0	15								1300		10000		1000		15
Carbon tetrachloride	56-23-5	240		5						5		22		0.17		0.17
Chlorobenzene	108-90-7	47		100						100		2000		110		47
Chloroethane	75-00-3									62		990		4.6		4.6
Chloroform	67-66-3	140		80	15					80		1000		6.2		6.2
Chloromethane	74-87-3													1.5		1.5
cis-1,2-Dichloroethene	156-59-2			70						70		1000		61		61
cis-1,3-Dichloropropene	10061-01-5									5.6	16	29	16	0.4	16	0.4
Dibromochloromethane	124-48-1			80	15									0.13		0.13
Dibromomethane	74-95-3													61		61
Dichlorodifluoromethane	75-71-8													390		390
Ethylbenzene	100-41-4	14		700						700		10000		2.9		2.9
Ethyl methacrylate	97-63-2													550		550
Methacrylonitrile	126-98-7													1		1
Methylene chloride	75-09-2			5						5		380		4.3		4.3
Methyl iodide	74-88-4									0.85		2.9				0.85
Methyl methacrylate	80-62-6	2800												1400		1400
Methyl tert-Butyl Ether	1634-04-4													13		13
Styrene	100-42-5	32		100						100		20000		1600		32
Tetrachloroethene	127-18-4	45		5						5		55		0.66		0.66
Toluene	108-88-3	253		1000						1000		20000		720		253
trans-1,2-Dichloroethene	156-60-5	970		100						100		2000		120		100
trans-1,3-Dichloropropene	10061-02-6									5.6	16	29	16	0.4	16	0.4
trans-1,4-Dichloro-2-butene	110-57-6													0.0012	17	0.0012

APPENDIX B

TABLE 1
TABULAR PRESENTATION OF SOIL AND SEDIMENT RBSLs FOR RBTL SELECTION
NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	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 DEFAULT RESIDENTIAL GW CLOSURE LEVELS (ug/L)	FOOTNOTE	IDEM DEFAULT INDUSTRIAL GW CLOSURE LEVELS (ug/L)	FOOTNOTE	REGION 9 TAP WATER PRGS (ug/L)	FOOTNOTE	MINIMUM CRITERIA VALUE (ug/L)
Trichloroethene	79-01-6			5						5		7.2		0.028		0.028
Trichlorofluoromethane	75-69-4													1300		1300
Vinyl acetate	108-05-4									550		100000		410		410
Vinyl chloride	75-01-4			2						2		2				2
Total Xylenes	1330-20-7	27		10000						10000		20000		210		27
SW-846 Method 5035B/8015B																
1,4-Dioxane	123-91-1	22000												6.1		6.1
Acetonitrile	75-05-8	12000												100		100
Ethylene Glycol	107-21-1													73000		73000
Isobutanol	78-83-1													1800		1800
Propionitrile	107-12-0													0.12		0.12
MISCELLANEOUS PARAMETERS																
CEC SW-846 Method 9081																
Perchlorate EPA Method 314.0	7601-90-3													3.6		3.6
pH SW-846 Method 9045C	---															
TOC SW-846 Method 9060/Lloyd Khan	---															
Total Petroleum Hydrocarbons (TPH) EPA Method 413.2																

1 Dinitrotoluene mixture.
2 EPA Region 3 risk-based concentration (USEPA Region 3 RBC Tables, April 2004).
3 Value for chlordane presented.
4 Value for alpha-BHC presented.
5 Value for endosulfan presented.
6 Value for endrin presented.
7 Total for all Aroclor congeners.
8 Value for naphthalene presented.
9 Value for acenaphthene presented.
10 Value for pyrene presented.
11 Criteria are hardness dependent.
12 Hexavalent Chromium
13 Federal Action Level at the Tap.
14 Value is for mercury chloride presented.
15 1994 Proposed rule for Disinfectants and Disinfection By-Products. Total for all trihalomethanes combined cannot exceed 80 ug/L.
16 Value for 1,3-dichloropropene presented.
17 Value for 1,4-dichloro-2-butene presented.

APPENDIX B

TABLE 2
TABULAR PRESENTATION OF SOIL AND SEDIMENT RBSLs FOR RBTL SELECTION
NSWC CRANE, CRANE, INDIANA

PARAMETERS	CAS NUMBER	EPA GENERIC SSLs INHALATION (mg/kg)	FOOTNOTE	EPA GENERIC SSLs MIGRATION TO GW (mg/kg) DAF=1	FOOTNOTE	IDEM DEFAULT RESIDENTIAL SOIL CLOSURE LEVELS (mg/kg)	FOOTNOTE	IDEM DEFAULT INDUSTRIAL SOIL CLOSURE LEVELS (mg/kg)	FOOTNOTE	REGION 9 SOIL PRGs FOR INDUSTRIAL LAND USE (mg/kg)	FOOTNOTE	REGION 9 SOIL PRGs FOR RESIDENTIAL LAND USE (mg/kg)	FOOTNOTE	REGION 5 ECO DQLs SOIL (mg/kg)	FOOTNOTE	REGION 5 ECO DQLs SEDIMENT (mg/kg)	FOOTNOTE	MINIMUM CRITERIA VALUE SOIL (mg/kg)	MINIMUM CRITERIA VALUE SEDIMENT (mg/kg)	MINIMUM CRITERIA VALUE SOIL AND SEDIMENT (mg/kg)
EXPLOSIVES (NITROAROMATICS AND NITRAMINES)																				
SW-846 METHOD 8330																				
1,3,5-Trinitrobenzene	99-35-4			0.25						18000		1800		0.376				0.25	0.25	0.25
1,3-Dinitrobenzene	99-65-0			0.00096						62		6.1		0.655		0.00861		0.00096	0.00096	0.00096
2,4,6-Trinitrotoluene (TNT)	118-96-7			0.00057						57		16						0.00057	0.00057	0.00057
2,4-Dinitrotoluene	121-14-2			0.000049		0.0091	1	0.031	1	1200		120		1.28		0.0144		0.000049	0.000049	0.000049
2,6-Dinitrotoluene	606-20-2			0.000042		0.0091	1	0.031	1	620		61		0.0328		0.0398		0.000042	0.000042	0.000042
2-Amino-4,6-dinitrotoluene	35572-78-2									16	2	200	2					16	16	16
2-Nitrotoluene	99-08-1			0.6						1000	sat	370						0.6	0.6	0.6
3-Nitrotoluene	99-08-1			0.6						1000	sat	370						0.6	0.6	0.6
4-Amino-2,6-dinitrotoluene	1946-51-0									16	2	200	2					16	16	16
4-Nitrotoluene	99-99-0			0.0021						1000	sat	370						0.0021	0.0021	0.0021
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4									16		4.4						4.4	4.4	4.4
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	479-45-8									6200		610						610	610	610
Nitrobenzene	98-95-3	91		0.006		0.028		0.34		100		20		1.31		0.145		0.006	0.006	0.006
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0									31000		3100						3100	3100	3100
APPENDIX IX HERBICIDES (SW-846 METHOD 8151A)																				
2,4-D	94-75-7			0.074		0.35		5.2		7700		690		0.0272		1.273		0.0272	0.074	0.0272
2,4,5-T	93-76-5			0.54		2.2		6.1		6200		610		0.596		58.7		0.54	0.54	0.54
2,4,5-TP (Silvex)	93-72-1			1						4900		490		0.109		0.675		0.109	0.675	0.109
Dinoseb	88-85-7			0.019						620		61		0.0218		0.0145		0.019	0.0145	0.0145
Pentachlorophenol	87-86-5			0.0014		0.028		0.66		9		3		0.119		23		0.0014	0.0014	0.0014
Hexachlorophene	70-30-4			570						180		18		0.199		231		0.199	18	0.199
ORGANOCHLORINE PESTICIDES (SW-846 METHOD 8081A)																				
Aldrin	309-00-2	0.48		0.00049		0.25		0.8		0.1		0.029		0.00332		0.002		0.00049	0.00049	0.00049
Alpha-BHC	319-84-6	0.76		0.000036		0.0072		0.024		0.36		0.09		0.0994		0.006		0.000036	0.000036	0.000036
Alpha-chlordane	5103-71-9	72	3	0.48	3	9.6	3	39	3	6.5	3	1.6	3	0.224	3	0.00324	3	0.224	0.00324	0.00324
Beta-BHC	319-85-7	6		0.00013		0.026		0.086		1.3		0.32		0.00398		0.005		0.00013	0.00013	0.00013
4,4'-DDD	72-54-8			0.71		28		120		10		2.4		0.758				0.71	0.71	0.71
4,4'-DDE	72-55-9			2.2		20		86		7		1.7		0.596		0.00316		0.596	0.00316	0.00316
4,4'-DDT	50-29-3	750		1.3		20		86		7		1.7		0.0035		0.00416		0.0035	0.00416	0.0035
Delta-BHC	319-86-8					0.0072	4	0.024	4	0.36	4	0.09	4	9.94		71.5		0.0072	0.0072	0.0072
Dieldrin	60-57-1	1.1		0.00023		0.046		0.15		0.11		0.03		0.00238		0.0019		0.00023	0.00023	0.00023
Endosulfan I	115-29-7			0.98	5	20	5	46	5	3700	5	370	5					0.98	0.98	0.98
Endosulfan II	33213-65-9			0.98	5	20	5	46	5	3700	5	370	5	0.119		0.00194		0.119	0.00194	0.00194
Endosulfan sulfate	1031-07-8			0.98	5	20	5	46	5	3700	5	370	5					0.98	0.98	0.98
Endrin	72-20-8			0.05		0.99		15		180		18		0.0101		0.00222		0.0101	0.00222	0.00222
Endrin aldehyde	7421-93-4			0.05	6	0.99	6	15	6	180	6	18	6	0.0105		0.48		0.0105	0.05	0.0105
Endrin Ketone	53494-70-5			0.05	6	0.99	6	15	6	180	6	18	6					0.05	0.05	0.05
Gamma-BHC (Lindane)	58-89-9			0.00047		0.0094		0.1		1.7		0.44		0.005		0.00237		0.00047	0.00047	0.00047
Gamma-chlordane	12789-03-6	72	3	0.48	3	9.6	3	39	3	6.5	3	1.6	3	0.224	3	0.00324	3	0.224	0.00324	0.00324
Heptachlor	76-44-8	4.2		1.1		0.93		2.9		0.38		0.11		0.00598		0.0006		0.00598	0.0006	0.0006
Heptachlor epoxide	1024-57-3	4.8		0.033		0.47		1		0.19		0.053		0.152		0.00247		0.033	0.00247	0.00247
Methoxychlor	72-43-5			7.8		160		180		3100		310		0.0199		0.0136		0.0199	0.0136	0.0136
Toxaphene	8001-35-2	88		1.5		3.9		12		1.6		0.44		0.119		0.000077		0.119	0.000077	0.000077
POLYCHLORINATED BIPHENYLS (SW-846 METHOD 8082)																				
Aroclor-1016	12674-11-2	2		0.0028		1.8	7	5.3	7	21		3.9		0.000332		0.0598		0.000332	0.0028	0.000332
Aroclor-1221	11104-28-2	5600				1.8	7	5.3	7	0.74		0.22		0.000332		0.0598		0.000332	0.0598	0.000332
Aroclor-1232	11141-16-5	5600				1.8	7	5.3	7	0.74		0.22		0.000332		0.0598		0.000332	0.0598	0.000332
Aroclor-1242	53469-21-9	1.5		0.0028		1.8	7	5.3	7	0.74		0.22		0.000332		0.0598		0.000332	0.0028	0.000332
Aroclor-1248	12672-29-6	5600				1.8	7	5.3	7	0.74		0.22		0.000332		0.0598		0.000332	0.0598	0.000332
Aroclor-1254	11097-69-1	2.2		0.017		1.8	7	5.3	7	0.74		0.22		0.000332		0.0598		0.000332	0.017	0.000332
Aroclor-1260	11096-82-5	1.9		0.025		1.8	7	5.3	7	0.74		0.22		0.000332		0.0598		0.000332	0.025	0.000332
POLYCYCLIC AROMATIC HYDROCARBONS																				
SW-846 METHOD 8270C WITH SELECTIVE ION MONITORING																				
2-Methylnaphthalene	91-57-6					16		210		190	8	56	8	3.24		0.0202		3.24	0.0202	0.0202
Acenaphthene	83-32-9			31		130		1200		29000		3700		682		0.00671		31	0.00671	0.00671
Acenaphthylene	208-96-8					18		180		29000	9	3700	9	682		0.00587		18	0.00587	0.00587
Anthracene	120-12-7			650		51		51		100000	max	22000		1480		0.0572		51	0.0572	0.0572
Benzo(a)anthracene	56-55-3					5		15		2.1		0.62		5.21		0.108		0.62	0.108	0.108
Benzo(a)pyrene	50-32-8			0.41		0.5		1.5		0.21		0.062		1.52		0.15		0.062	0.062	0.062
Benzo(b)fluoranthene	205-99-2					5		15		2.1		0.62		59.8		10.4		0.62	0.62	0.62
Benzo(g,h,i)perylene	191-24-2					16		16		29000	10	2300	10	119		0.17		16	0.17	0.17
Benzo(k)fluoranthene	207-08-9					39		39		21		6.2						6.2	6.2	6.2
Carbazole	86-74-8			0.03		5.9		20		86		24						0.03	0.03	0.03
Chrysene	218-01-9					25		25		210		62						25	25	25
Dibenzo(a,h)anthracene	53-70-3					0.5		1.5		0.21		0.062		18.4		0.033		0.062	0.033	0.033
Fluoranthene	206-44-0			310		880		880		22000		2300		122		0.423		122	0.423	0.423
Fluorene	86-73-7			41		170		1100		26000		2700		122		0.0774		41	0.0774	0.0774

APPENDIX B

TABLE 2
TABULAR PRESENTATION OF SOIL AND SEDIMENT RBSLs FOR RBTL SELECTION
NSWC CRANE, CRANE, INDIANA
PAGE 2 OF 4

PARAMETERS	CAS NUMBER	EPA GENERIC SSLs INHALATION (mg/kg)	FOOTNOTE	EPA GENERIC SSLs MIGRATION TO GW (mg/kg) DAF=1	FOOTNOTE	IDEM DEFAULT RESIDENTIAL SOIL CLOSURE LEVELS (mg/kg)	FOOTNOTE	IDEM DEFAULT INDUSTRIAL SOIL CLOSURE LEVELS (mg/kg)	FOOTNOTE	REGION 9 SOIL PRGs FOR INDUSTRIAL LAND USE (mg/kg)	FOOTNOTE	REGION 9 SOIL PRGs FOR RESIDENTIAL LAND USE (mg/kg)	FOOTNOTE	REGION 5 ECO DQLs SOIL (mg/kg)	FOOTNOTE	REGION 5 ECO DQLs SEDIMENT (mg/kg)	FOOTNOTE	MINIMUM CRITERIA VALUE SOIL (mg/kg)	MINIMUM CRITERIA VALUE SEDIMENT (mg/kg)	MINIMUM CRITERIA VALUE SOIL AND SEDIMENT (mg/kg)
Indeno(1,2,3-cd)pyrene	193-39-5					3.1		3.1		2.1		0.62		109		0.2		0.62	0.2	0.2
Naphthalene	91-20-3	170		3.1		0.7		170		190		56		0.0994		0.176		0.0994	0.176	0.0994
Phenanthrene	85-01-8					13		170		29000	10	2300	10					13	13	13
Pyrene	129-00-0			230		570		570		29000		2300						230	230	230
SEMIVOLATILE ORGANIC COMPOUNDS (EXCEPT PAHs)																				
SW-846 METHOD 8270C																				
1,2,4,5-Tetrachlorobenzene	95-94-3			0.1						180		18		2.02		1.252		0.1	0.1	0.1
1,2,4-Trichlorobenzene	120-82-1	180		0.26		5.3		77		3000	sat	650		11.1		5.062		0.26	0.26	0.26
1,2-Dichlorobenzene	95-50-1	600		0.86		17		220		370	sat	370	sat	2.96		0.294		0.86	0.294	0.294
1,3-Dichlorobenzene	541-73-1					0.2		2.7		63		16		37.7		1.315		0.2	0.2	0.2
1,4-Dichlorobenzene	106-46-7	11000		0.11		2.2		3.4		7.9		3.4		0.546		0.318		0.11	0.11	0.11
1,4-Naphthoquinone	130-15-4													1.67				1.67		1.67
1,4-Phenylenediamine	106-50-3			1.5						100000	max	12000		6.16				1.5	1.5	1.5
1-Naphthylamine	134-32-7													9.34				9.34		9.34
2,3,4,6-Tetrachlorophenol	58-90-2			110						18000		1800		0.199		0.129		0.199	0.129	0.129
2,4,5-Trichlorophenol	95-95-4			12		250		690		62000		6100		14.1				12	12	12
2,4,6-Trichlorophenol	88-06-2	200		0.0074		0.07		0.2		25		6.9						0.0074	0.0074	0.0074
2,4-Dichlorophenol	120-83-2			0.054		1.1		3		1800		180		87.5		0.0817		0.054	0.054	0.054
2,4-Dimethylphenol	105-67-9			0.45		9		25		12000		1200		0.01		0.304		0.01	0.304	0.01
2,4-Dinitrophenol	51-28-5			0.015		0.29		0.82		1200		120		0.0609		0.00621		0.015	0.00621	0.00621
2,6-Dichlorophenol	87-65-0													1.17				1.17		1.17
2-Acetylaminofluorene	53-96-3													0.596		0.0153		0.596	0.0153	0.0153
2-Chloronaphthalene	91-58-7			14		42		560		23000		4900		0.0122		0.417		0.0122	0.417	0.0122
2-Chlorophenol	95-57-8			0.18		0.75		10		240		63		0.243		0.0319		0.18	0.0319	0.0319
2-Methylphenol	95-48-7			0.7		14		39		31000		3100		40.4		0.0554		0.7	0.0554	0.0554
2-Naphthylamine	91-59-8													3.03				3.03		3.03
2-Nitroaniline	88-74-4	1.2		0.026		0.013		0.036		18		1.7		74.1				0.013	0.013	0.013
2-Nitrophenol	88-75-5													1.6				1.6		1.6
2-Picoline	109-06-8																			
3,3'-Dichlorobenzidine	91-94-1			0.00031		0.062		0.21		3.8		1.1		0.646		0.127		0.00031	0.00031	0.00031
3,3'-Dimethylbenzidine	119-93-7			0.00023						0.19		0.053		0.104				0.00023	0.00023	0.00023
3-Methylcholanthrene	56-49-5													0.0779		8190		0.0779	8190	0.0779
3-Methylphenol [5]	108-39-4			0.4		9.8		28		31000		3100		3.49		0.0524		0.4	0.0524	0.0524
4-Methylphenol [5]	106-44-5			0.066		1.1		3		3100		310		163		0.0202		0.066	0.0202	0.0202
3-Nitroaniline	99-09-2	1370000		0.0012														0.0012	0.0012	0.0012
4,6-Dinitro-2-methylphenol	534-52-1			0.0051										0.144		0.104		0.0051	0.0051	0.0051
4-Aminobiphenyl	92-67-1													0.00305				0.00305		0.00305
4-Bromophenyl phenyl ether	101-55-3															1.55			1.55	1.55
4-Chloro-3-methylphenol	59-50-7													7.95		0.388		7.95	0.388	0.388
4-Chloroaniline	106-47-8			0.049		0.97		2.7		2500		240		1.1		0.146		0.049	0.049	0.049
4-Chlorophenyl phenyl ether	7005-72-3																			
4-Nitroaniline	100-01-6	5490000		0.0012														0.0012	0.0012	0.0012
4-Nitrophenol	100-02-7																			
4-Nitroquinoline-1-oxide	56-57-5													0.122				0.122		0.122
5-Nitro-o-toluidine	99-55-8									52		15		8.73				8.73	15	8.73
7,12-Dimethylbenz(a)anthracene	57-97-6													16.3		66.4		16.3	66.4	16.3
Acetophenone	98-86-2			0.89										300				0.89	0.89	0.89
Aniline	62-53-3	99		0.0034						300		85		0.0568		0.00031		0.0034	0.00031	0.00031
Aramite	140-57-8	55		0.11						69		19		166				0.11	0.11	0.11
Benzyl alcohol	100-51-6			3.2		48		140		100000	max	18000		65.8		0.00104		3.2	0.00104	0.00104
Bis(2-chloroethoxy)methane	111-91-1													0.302				0.302		0.302
Bis(2-chloroethyl)ether	111-44-4	0.24		0.000018		0.0007		0.012		0.55		0.21		23.7		3.52		0.000018	0.000018	0.000018
Bis(2-chloroisopropyl)ether	108-60-1	7		0.00039		0.027		0.26		7.4		2.9		19.9				0.00039	0.00039	0.00039
Bis(2-ethylhexyl)phthalate	117-81-7			180		300		980		120		35		0.925		0.182		0.925	0.182	0.182
Butyl benzyl phthalate	85-68-7			840		310		310		100000	max	12000		0.239		1.97		0.239	1.97	0.239
Chlorobenzilate	510-15-6	43		0.00057						6.4		1.8		5.05		0.86		0.00057	0.00057	0.00057
Diallate	2303-16-4									28		8		0.452				0.452	8	0.452
Di-n-butyl phthalate	84-74-2			250		760		760		62000		6100		0.15		1.114		0.15	1.114	0.15
Di-n-octyl phthalate	117-84-0			240000		2000		2000		25000		2400		709		40.6		709	40.6	40.6
Dibenzofuran	132-64-9			2.4		4.9		65		3100		290				0.449		2.4	0.449	0.449
Diethyl phthalate	84-66-2			23		450		840		100000	max	49000		24.8		0.295		23	0.295	0.295
p-(Dimethylamino)azobenzene	60-11-7													0.04		0.318		0.04	0.318	0.04
a,a-Dimethylphenethylamine	122-09-8									620		61						61	61	61
Dimethyl phthalate	131-11-3					1100		1100		100000	max	100000	max	734				734	1100	734
Diphenylamine	122-39-4			5						15000		1500		1.01		0.0346		1.01	0.0346	0.0346
Ethyl methane sulfonate	62-50-0																			
Hexachlorobenzene	118-74-1	0.96		0.11		2.2		3.9		1.1		0.3		0.199		0.02		0.11	0.02	0.02
Hexachlorobutadiene	87-68-3	7.9		0.12		16		44		22		6.2		0.0398		0.0265		0.0398	0.0265	0.0265
Hexachlorocyclopentadiene	77-47-4	29		20		400		720		3700		370		0.755		0.901		0.755	0.901	0.755

APPENDIX B

TABLE 2
TABULAR PRESENTATION OF SOIL AND SEDIMENT RBSLs FOR RBTL SELECTION
NSWC CRANE, CRANE, INDIANA
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PARAMETERS	CAS NUMBER	EPA GENERIC SSLs INHALATION (mg/kg)	FOOTNOTE	EPA GENERIC SSLs MIGRATION TO GW (mg/kg) DAF=1	FOOTNOTE	IDEM DEFAULT RESIDENTIAL SOIL CLOSURE LEVELS (mg/kg)	FOOTNOTE	IDEM DEFAULT INDUSTRIAL SOIL CLOSURE LEVELS (mg/kg)	FOOTNOTE	REGION 9 SOIL PRGs FOR INDUSTRIAL LAND USE (mg/kg)	FOOTNOTE	REGION 9 SOIL PRGs FOR RESIDENTIAL LAND USE (mg/kg)	FOOTNOTE	REGION 5 ECO DQLs SOIL (mg/kg)	FOOTNOTE	REGION 5 ECO DQLs SEDIMENT (mg/kg)	FOOTNOTE	MINIMUM CRITERIA VALUE SOIL (mg/kg)	MINIMUM CRITERIA VALUE SEDIMENT (mg/kg)	MINIMUM CRITERIA VALUE SOIL AND SEDIMENT (mg/kg)
Hexachloroethane	67-72-1	54		0.023		2.8		7.7		120		35		0.596		0.584		0.023	0.023	0.023
Hexachloropropene	1888-71-7																			
Isodrin	465-73-6													0.00332		0.0552		0.00332	0.0552	0.00332
Isophorone	78-59-1			0.026		5.3		18		1800		510		139		0.432		0.026	0.026	0.026
Isosafrole	120-58-1													9.94				9.94		9.94
Kepone	143-50-0									0.22		0.061		0.0327		0.00331		0.0327	0.00331	0.00331
Methapyrilene	91-80-5													2.78				2.78		2.78
Methyl methane sulfonate	66-27-3													0.315				0.315		0.315
n-Nitrosodi-n-butylamine	924-16-3	2000		0.000017						0.058		0.024		0.267				0.000017	0.000017	0.000017
n-Nitrosodiethylamine	55-18-5	0.005		1.5E-07						0.011		0.0032		0.0693		0.0228		0.00000015	0.00000015	0.00000015
n-Nitrosodimethylamine	62-75-9	0.017		4.6E-07						0.034		0.0095		3.21E-05				0.00000046	0.00000046	0.00000046
n-Nitrosodi-n-propylamine	621-64-7			0.000003		0.0006		0.002		0.25		0.069		0.544				0.000003	0.000003	0.000003
n-Nitrosomethylethylamine	62-75-9	0.017		4.6E-07						0.034		0.0095		3.21E-05				0.00000046	0.00000046	0.00000046
n-Nitrosomorpholine	59-89-2																			
n-Nitrosopiperidine	100-75-4													0.00665				0.00665		0.00665
n-Nitrosopyrrolidine	930-55-2	5250		9.4E-06						0.82		0.23		0.0126				0.0000094	0.0000094	0.0000094
Pentachlorobenzene	608-93-5			3.7						490		49		0.497		0.024		0.497	0.024	0.024
Pentachloroethane	76-01-7																			
Pentachloronitrobenzene	82-68-8			0.023						6.6		1.9		7.09				0.023	0.023	0.023
Phenacetin	62-44-2													11.7				11.7		11.7
Phenol	108-95-2			2.8		56		160		100000	max	37000		120		0.0491		2.8	0.0491	0.0491
Pronamide	23950-58-5			16						46000		4600		0.0136				0.0136	16	0.0136
Pyridine	110-86-1			0.0076						620		61		1.03		0.108		0.0076	0.0076	0.0076
Safrole	94-59-7													0.404				0.404		0.404
o-Toluidine	95-53-4			0.00016						7.2		2		2.97				0.00016	0.00016	0.00016
O,O,O-Triethyl phosphorothioate	102-86-3													0.152		0.00247		0.152	0.00247	0.00247
TAL METALS PLUS TIN																				
SW-846 Method 6020																				
Aluminum	7429-90-5	6860000		8.3						100000	max	76000						8.3	8.3	8.3
Antimony	7440-36-0			0.27		5.4		37		410		31		0.142				0.142	0.27	0.142
Arsenic	7440-38-2	745		0.29		3.9		20		1.6		0.39		5.7		9.79		0.29	0.29	0.29
Barium	7440-39-3	686000		82		1600		5900		67000		5400		1.04				1.04	82	1.04
Beryllium	7440-41-7	1330		3.2		63		2300		1900		150		1.06				1.06	3.2	1.06
Cadmium	7440-43-9	1780		0.38		7.5		77		450		37		0.00222		0.99		0.00222	0.38	0.00222
Calcium	7440-70-2																			
Chromium (total)	7440-47-3	267	11	2.1	11	38	11	120	11	64	11	30	11	0.4		43.4		0.4	2.1	0.4
Cobalt	7440-48-4	1140		0.17						1900		900		0.14		50		0.14	0.17	0.14
Copper	7440-50-8			560		920		2700		41000		3100		5.4		31.6		5.4	31.6	5.4
Iron	7439-89-6									100000	max	23000						23000	23000	23000
Lead	7439-92-1					81		230		750		400	12	0.0537		35.8		0.0537	35.8	0.0537
Magnesium	7439-95-4																			
Manganese	7439-96-5	68600		110						19000		1800						110	110	110
Nickel	7440-02-0			48						20000		1600						48	48	48
Potassium	7440-09-7																			
Selenium	7782-49-2			0.26		5.2		53		5100		390		0.0276				0.0276	0.26	0.0276
Silver	7440-22-4			1.6		31		87		5100		390		4.04		0.5		1.6	0.5	0.5
Sodium	7440-23-5																			
Thallium	7440-28-0					2.8		10		67		5.2		0.0569				0.0569	2.8	0.0569
Tin	7440-31-5													7.62				7.62		7.62
Vanadium	7440-62-2			260						7200		550		1.59				1.59	260	1.59
Zinc	7440-66-6			680		10000		10000		100000	max	23000		6.62		121		6.62	121	6.62
SW-846 7470A/7471A																				
Mercury	7439-97-6					2.1		32		310	13	23	13	0.1		0.174		0.1	0.174	0.1
VOLATILE ORGANIC COMPOUNDS																				
SW-846 METHOD 5035B/8260B																				
1,1,1-Trichloroethane	71-55-6	1200		0.097		1.9		280		1200	sat	1200	sat	29.8		0.213		0.097	0.097	0.097
1,1,1,2-Tetrachloroethane	630-20-6	8.7		0.0071		0.053		0.85		7.3		3.2		225				0.0071	0.0071	0.0071
1,1,2,2-Tetrachloroethane	79-34-5	0.57		0.00017		0.007		0.11		0.93		0.41		0.127		0.85		0.00017	0.00017	0.00017
1,1,2-Trichloroethane	79-00-5	0.98		0.00091		0.03		0.3		1.6		0.73						0.00091	0.00091	0.00091
1,2,3-Trichloropropane	96-18-4			3.7E-06						0.011		0.005		3.36				0.0000037	0.0000037	0.0000037
1,1-Dichloroethane	75-34-3	1300		1		5.6		58		1700		510		20.1		0.000575		1	0.000575	0.000575
1,1-Dichloroethene	75-35-4	300		0.0029		0.058		42		410		120		8.28		0.0194		0.0029	0.0029	0.0029
1,2-Dibromo-3-chloropropane	96-12-8	23		0.000092						0.046		0.019		0.0352				0.000092	0.000092	0.000092
1,2-Dibromoethane	106-93-4	0.28		0.000029						0.028		0.0069		1.23				0.000029	0.000029	0.000029
1,2-Dichloroethane	107-06-2	0.36		0.0012		0.024		0.15		0.6		0.28						0.0012	0.0012	0.0012
1,2-Dichloropropane	78-87-5	15		0.0015		0.03		0.25		0.74		0.34		32.7		0.333		0.0015	0.0015	0.0015
2-Butanone	78-93-3	24000		4.4		35		250		27000		7300		89.6		0.0424		4.4	0.0424	0.0424
2-Chloro-1,3-butadiene (chloroprene)	126-99-8	84		0.56						12		3.6		0.0029				0.0029	0.56	0.0029
2-Hexanone	591-78-6													12.6		0.0582		12.6	0.0582	0.0582

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4-Methyl-2-pentanone	108-10-1	2700		0.62		20		75		2800		790		443		0.0251		0.62	0.0251	0.0251
Acetone	67-64-1			6.6		3.8		370		6000		1600		2.5		0.0099		2.5	0.0099	0.0099
Acrolein	107-02-8	0.19		0.0037		0.00027		0.25		0.34		0.1		5.27		1.52E-06		0.00027	0.00000152	0.00000152
Acrylonitrile	107-13-1	0.28		0.000032						0.49		0.21		0.0239		0.0012		0.000032	0.000032	0.000032
Allyl chloride (3-chloro-1-propene)	107-05-1	1.8								30000		3000		0.0134				0.0134	1.8	0.0134
Benzene	71-43-2	0.84		0.0017		0.034		0.35		1.3		0.6		0.255		0.142		0.0017	0.0017	0.0017
Bromodichloromethane	75-27-4			0.032		0.51		0.51		1.8		0.82		0.54				0.032	0.032	0.032
Bromoform	75-25-2	53		0.038		0.6		2.7		220		62		15.9		0.492		0.038	0.038	0.038
Bromomethane	74-83-9	9.5		0.012		0.052		0.7		13		3.9		0.235		0.00137		0.012	0.00137	0.00137
Carbon disulfide	75-15-0	720		1.5		10		82		720	sat	360		0.0941		0.0239		0.0941	0.0239	0.0239
Carbon tetrachloride	56-23-5	0.33		0.0033		0.066		0.29		0.55		0.25		2.98		1.45		0.0033	0.0033	0.0033
Chlorobenzene	108-90-7	130		0.065		1.3		27		530		150		13.1		0.291		0.065	0.065	0.065
Chloroethane	75-00-3	1200				0.65		10		6.5		3						0.65	0.65	0.65
Chloroform	67-66-3	0.28		0.029		0.47		1.2		12		3.6		1.19		0.121		0.029	0.029	0.029
Chloromethane	74-87-3	2.1		0.002						2.6		1.2		10.4				0.002	0.002	0.002
cis-1,2-Dichloroethene	156-59-2			0.02		0.4		5.8		150		43						0.02	0.02	0.02
cis-1,3-Dichloropropene	10061-01-5	1.1	14	0.0003	14	0.04	14	0.2	14	1.8	14	0.78	14	0.398	14			0.0003	0.0003	0.0003
Dibromochloromethane	124-48-1			0.02						2.6		1.1		2.05				0.02	0.02	0.02
Dibromomethane	74-95-3			0.077						230		67		65				0.077	0.077	0.077
Dichlorodifluoromethane	75-71-8	250		28						310		94		39.5				28	28	28
Ethylbenzene	100-41-4	400		0.67		13		160		20		8.9		5.16		0.175		0.67	0.175	0.175
Ethyl methacrylate	97-63-2			0.81						140	sat	140	sat	30				0.81	0.81	0.81
Methacrylonitrile	126-98-7	8.1		0.001						8.4		2.1		0.057				0.001	0.001	0.001
Methylene chloride	75-09-2	13		0.0012		0.023		1.8		21		9.1						0.0012	0.0012	0.0012
Methyl iodide	74-88-4					0.0044		0.015						1.23				0.0044	0.0044	0.0044
Methyl methacrylate	80-62-6	2700		12						2700	sat	2200		984		0.168		12	0.168	0.168
Methyl tert-Butyl Ether	1634-04-4	8700								160		62						62	62	62
Styrene	100-42-5	14000		0.18		3.5		550		1700	sat	1700	sat	4.69		0.254		0.18	0.18	0.18
Tetrachloroethene	127-18-4	11		0.0029		0.058		0.64		3.4		1.5		9.92		0.99		0.0029	0.0029	0.0029
Toluene	108-88-3	650		0.59		12		240		520	sat	520	sat	5.45		1.22		0.59	0.59	0.59
trans-1,2-Dichloroethene	156-60-5			0.034		0.68		14		230		69		0.784		0.654		0.034	0.034	0.034
trans-1,3-Dichloropropene	10061-02-6	1.1	14	0.0003	14	0.04	14	0.2	14	1.8	14	0.78	14	0.398	14			0.0003	0.0003	0.0003
trans-1,4-Dichloro-2-butene	110-57-6									0.018	15	0.0079	15					0.0079	0.0079	0.0079
Trichloroethene	79-01-6	0.071		0.0028		0.057		0.082		0.11		0.053						0.0028	0.0028	0.0028
Trichlorofluoromethane	75-69-4	1100		8						2000	sat	390		16.4				8	8	8
Vinyl acetate	108-05-4	990		7.8		2.3		430		1400		430						2.3	2.3	2.3
Vinyl chloride	75-01-4	0.28		0.00067		0.013		0.013		0.75								0.00067	0.00067	0.00067
Total Xylenes	1330-20-7	710		7.1		170		170		420	sat	270		10		0.433		7.1	0.433	0.433
SW-846 Method 5035B/8015B																				
1,4-Dioxane	123-91-1			0.0017						160		44		2.05		0.119		0.0017	0.0017	0.0017
Acetonitrile	75-05-8	1400								1800		420		1.37		0.056		1.37	0.056	0.056
Ethylene Glycol	107-21-1			15						100000	max	100000	max					15	15	15
Isobutanol	78-83-1			2.3						40000	sat	13000		20.8				2.3	2.3	2.3
Propionitrile	107-12-0									0.6		0.28		0.0498				0.0498	0.28	0.0498
MISCELLANEOUS PARAMETERS																				
CEC SW-846 Method 9081																				
Perchlorate EPA Method 314.0	7601-90-3									100		7.8						7.8	7.8	7.8
pH SW-846 Method 9045C	---																			
TOC SW-846 Method 9060/Lloyd Khan	---																			
Total Petroleum Hydrocarbons (TPH) EPA Method 413.2																				

1 Dinitrotoluene mixture.
2 EPA Region 3 risk-based concentration (USEPA Region 3 RBC Tables, April 2004).
3 Value for chlordane presented.
4 Value for alpha-BHC presented.
5 Value for endosulfan presented.
6 Value for endrin presented.
7 Total for all Aroclor congeners.
8 Value for naphthalene presented.
9 Value for acenaphthene presented.
10 Value for pyrene presented.
11 Hexavalent Chromium
12 OSWER soil screening level for residential land use (USEPA, July 1994).
13 Value is for mercury chloride presented.
14 Value for 1,3-dichloropropene presented.
15 Value for 1,4-dichloro-2-butene presented.

APPENDIX C
HUMAN HEALTH RISK ASSESSMENT METHODOLOGY

This section of the Quality Assurance Project Plan (QAPP) outlines the general methodologies and procedures that will be used to conduct baseline human health risk assessments (HHRAs) for the Building 106 Pond (SWMU 8) and the Roads and Grounds Area (SWMU 15). The objective of the HHRAs 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 methodology presented in this section is essentially the same methodology that was used to prepare the HHRAs for SWMUs 4, 5, 9, and 10 (TtNUS, 2003a) and SWMU 3 (TtNUS, 2003b).

The following current United States Environmental Protection Agency (U.S. EPA), the State of Indiana Department of Environmental Management (IDEM), and United States Navy risk assessment guidance documents were used to develop the framework for the baseline HHRAs:

- Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part A) (U.S. EPA, 1989a).
- Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors (U.S. EPA, 1991).
- Distribution of Preliminary Review Draft: Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure (U.S. EPA, 1993a).
- Soil Screening Guidance: Technical Background Document (U.S. EPA, 1996).
- Exposure Factors Handbook. Office of Health and Environmental Assessment (U.S. EPA, 1997a).
- 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, 2001a).

- Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Interim Guidance (U.S. EPA, 2001b).

- Supplemental Guidance for Developing Soil Screening Levels for Superfund Site. (U.S. EPA 2002a).

- Navy Final Policy on the Use of Background Chemical Levels (Navy, 2004).

- Conducting Human Health Risk Assessments under the Environmental Restoration Program (Navy, 2001).

- Risk Integrated System of Closure. User's Guide and Technical Resource Guidance Document (IDEM, 2004).

A baseline HHRA consists of five components: data evaluation, exposure assessment, toxicity assessment, risk characterization, and uncertainty analysis.

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 these factors is absent for a site, the exposure route is regarded as incomplete, and no potential risks are considered to exist for human receptors.

C.1 DATA EVALUATION

Data evaluation, the first component of a baseline HHRA, is a medium-specific task involving the compilation and evaluation of analytical data. The main objective of the data evaluation is to develop a medium-specific list of chemicals of potential concern (COPCs) that will be used to quantitatively determine potential human health risks for site media.

C.1.1 Data Usability

Data from samples collected for the proposed field investigations described in Section 3 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 the data validation protocol to be followed is provided in the Section 8 of this QAPP. A data evaluation 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 usability" evaluation worksheet suggested by U.S. EPA Risk Assessment Guidance for Superfund (RAGS) Part D (U.S. EPA, 2001a) will be completed as a part of the data evaluation.

Fixed base analytical results only from the target analyte lists for the proposed field investigations and U.S. EPA-approved historical 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 ground water results will be used for the risk assessment if the associated unfiltered ground water samples are found to be turbid. Field measurements, data regarded as unreliable (i.e., qualified as "R" during the data validation process), historical 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.

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 HHRA 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 the maximum concentration detected in a sampled medium exceeds the lowest screening level, and the chemical is determined to be present at concentrations exceeding background (only naturally occurring inorganics are eliminated as COPCs based on background comparisons). The criteria used for screening will be the lower of the IDEM Risk Integrated System Closure (RISC) residential and commercial defaults. When a constituent is not included in the IDEM RISC tables then the U.S. EPA Region 9 Preliminary Remedial Goals (PRGs) will be used. When a constituent is not available in the IDEM RISC and the U.S. EPA Region 9 PRG tables then the U.S. EPA Region 6 Medium Specific Screening Levels (SSLs) will be used. For consistency with the previous NSWC Crane Human Health Risk Assessments (HHRAs), the U.S. EPA Region 9 PRGs will be utilized first when IDEM RISC defaults are not available. Chemicals eliminated from further evaluation during this evaluation 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 SWMUs 8 and 15. Risk-based screening concentrations based on the most recent U.S. EPA Region 9 Preliminary Remediation Goals (PRGs) will be used, as well as other IDEM (IDEM, 2004) and U.S. EPA criteria. The risk-based U.S. EPA Region 9 screening concentrations will correspond to a systemic Hazard Quotient (HQ) of 0.1 (for noncarcinogens) or an incremental lifetime cancer risk (ILCR) of 1×10^{-6} (for carcinogens). It should be noted that the U.S. EPA Region 9 PRGs for noncarcinogens are based on a Hazardous Index (HI) of 1. The Region 9 PRG values for noncarcinogens will be multiplied by 0.1 to account for potential cumulative effects of several chemicals affecting the same target area or producing the same adverse noncarcinogenic health effect. The screening levels to be used for each medium in the risk assessments are briefly discussed below.

Soil/Sediment

Screening concentrations based on the following criteria will be used to select COPCs for surface and subsurface soil:

- U.S. EPA Region 9 PRGs for Residential Soil (U.S. EPA Region 9, 2002).
- U.S. EPA generic soil screening levels (SSLs) for migration to ground water will be calculated online at http://risk.lsd.ornl.gov/calc_start.shtml based on methodology from the U.S. EPA's Soil Screening Guidance (U.S. EPA, 1996).
- U.S. EPA generic SSLs for the inhalation of volatiles and fugitive dusts will be calculated online at http://risk.lsd.ornl.gov/calc_start.shtml based on methodology from the U.S. EPA's Soil Screening Guidance (U.S. EPA, July 1996).
- IDEM residential default closure levels for direct contact (IDEM, 2004)
- IDEM residential default closure levels for migration to ground water (IDEM, 2004)

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 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. The background comparisons for purposes of COPC selection will be limited to naturally occurring inorganics only. U.S. EPA and IDEM SSLs for migration to ground water and transfers from soil to air are based on default fate and transport parameters such as the fraction of organic carbon (foc) in soil. If site-specific soil information for these parameters becomes available through the investigation proposed in this QAPP, the site-specific data will be used to recalculate the SSLs using the methodology from the U.S. EPA Soil Screening Guidance (U.S. EPA, 1996 and 2002a) and IDEM Risk Integrated System of Closure (RISC) guidance (IDEM, 2004).

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 below ground surface (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 or vapors from the 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 screening levels based on the following:

- U.S. EPA Region 9 PRGs for residential soil (U.S. EPA Region 9, 2002)
- IDEM residential default closure levels for direct contact (IDEM, 2004)

A chemical detected in sediments will be selected as a COPC for sediments if the maximum detected concentration exceeds these screening values and upstream or background concentrations. 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 SSLs for sediment COPC identification is regarded as a conservative approach because exposure to sediment is anticipated to be less than exposure to soil.

Ground Water and Surface Water

The same screening levels will be used to select COPCs for ground water and surface water. Screening levels based on the following criteria will be used:

- U.S. EPA Region 9 PRGs for tap water (U.S. EPA Region 9, 2002)
- IDEM residential default closure levels for groundwater (IDEM, 2004)
- U.S. EPA Maximum Contaminant Levels (MCLs) (U.S. EPA, 2004a)

If the maximum concentration of a constituent exceeds any of these criteria (and the constituent is considered to be present at concentrations greater than site-specific upgradient, upstream, or background levels), the chemical will be selected as a COPC and carried through the quantitative risk assessment. Depending on the size of the background and site-specific ground water or surface water data sets, background comparisons will be accomplished either by a comparison of maximum site concentrations to maximum background concentrations or by statistical analyses that compare background and site-specific data sets. 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 SWMUs 8 and 15 because ground water at the sites is not used as a potable drinking water source. Potential human exposure to the surface water in intermittent ditches, streams, and ponds located within the SWMUs is expected to be limited to incidental exposures such as that which occurs during trespassing, which is anticipated to be significantly less than the daily exposure assumed for the tap water ingestion scenario.

Federal Ambient Water Quality Criteria (AWQCs) will not be used to select COPCs for surface water. AWQCs applicable to the protection of human health assuming routine consumption of water will not be used because the conservative U.S. EPA Region 9 PRGs for tap water, the IDEM residential closure levels for residential ground water, and the U.S. EPA MCLs will be used to select COPCs for ground water and surface water. In addition, the surface water bodies present within and downgradient of the sites do not support game fish populations because of their size and intermittent nature.

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 because the U.S. EPA has not derived toxicity values for lead. However, recommended screening levels are available for lead in soil that are used to indicate the need for response activities.

Guidance from both the Office of Prevention, Pesticides, and Toxic Substances (OPPTS) and the Office of Solid Waste and Emergency Response (OSWER) 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 in the HHRAs for SWMUs 8 and 15.

Guidance from the U.S. EPA Technical Review Workgroup (TRW) for Lead indicates that "a reasonable screening level for soil lead at commercial/industrial (i.e., non-residential) sites is 800 mg/kg" for a typical non-contact intensive worker (U.S. EPA, 2004). 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 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 because 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]. Surrogates will be selected for these chemicals based on similar chemical structures. If appropriate surrogates cannot be found, the chemicals will be discussed in the data evaluation section 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. Basewide background soil data and site-specific background ground water, surface water, and sediment data will be

used to determine whether detected chemicals are present at naturally occurring or non-site-related anthropogenic levels. The background data set used for these comparisons will be the soil type from the Naval Surface Warfare Center (NSWC) Crane Basewide Background Soil Investigation (TtNUS, 2001) that 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.

The elimination of chemicals as site-related COPCs on the basis of background comparisons will follow Navy Policy on the Use of Background Chemical Levels (Navy, 2004). This document provides the Navy's interpretation of the U.S. EPA guidance provided in the document titled Role of Background in the CERCLA Cleanup Program (U.S. EPA, 2002) and details the methodology to be used in evaluating background under the Navy's Environmental Restoration and Base Realignment and Closure (BRAC) programs. Navy policy applies to both screening-level and baseline risk assessments and requires the following:

1. A clear and concise understanding of chemicals released from a site thus ensuring that the Navy is focusing on remediating the release.

2. The use of background data in the screening-level risk assessment
   a. The comparison of site chemical levels to risk-based screening criteria.
   b. The comparison of site chemical levels to background concentrations.
   c. The identification of site-related COPCs based on screening criteria comparisons AND background comparisons. Site-related COPCs are those chemicals that exceed risk-based screening criteria AND background concentrations. To the extent possible, site-related COPCs are further evaluated quantitatively in the baseline risk assessment. (Non-site related COPCs are further discussed in the risk characterization section of the baseline risk assessment.)

3. The consideration of background in the baseline risk assessment
   a. The calculation of risk estimates for site-related COPCs only.
   b. The further evaluation of non-site related COPCs in the risk characterization section only (e.g., the evaluation of chemicals detected at concentrations exceeding screening criteria but less than background concentrations). Non-site related COPCs are compared to risk-based screening benchmarks and discussed in the risk characterization section. The Navy considers this comparison to be consistent with U.S. EPA's Role of Background in the CERCLA Cleanup Program (U.S. EPA, 2002b).

4. The selection of site cleanup remedial goals that are not less than background levels. Additionally, cleanup levels should not be developed for chemicals that are not identified as chemicals of concern (COCs). As defined in the Navy guidance, COCs are site-related COPCs that are found to be the risk drivers in the baseline risk assessment and that may pose unacceptable human or ecological risks.

Figure C-1 provides an overview of the statistical methodology that will be used to conduct the background analysis. The recommended statistical analysis follows guidance provided in the U.S. EPA's Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites (U.S. EPA, 2002c). As indicated in the U.S. EPA guidance, the background comparisons will involve statistical dataset-to-dataset comparisons rather than simple site concentration to background benchmark comparisons such as comparing maximum site concentrations to maximum background concentrations. According to the guidance, simple number-to-number comparisons "can be used with very small data sets but are highly uncertain."

The background data for surface and subsurface soil will be presented in the appendix to the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) report. Results of the background screen will be presented in the COPC selection tables for SWMUs 8 and 15.

C.1.2.5 Frequency of Detection

Chemicals may be eliminated from the COPC list if they are detected at a frequency of less than 5 percent in a medium. A frequency screen will be conducted only when there are 20 or more samples in the medium of concern. The decision to eliminate a chemical because of low detection frequency will also be based on site history (i.e., whether there a reason to believe that a chemical may be related to past site activities) and the magnitude of the concentration (i.e., whether the concentration of a chemical indicates a potential hotspot area).

C.1.2.6 Decision Rules for Establishing COPCs

The following decision rules will be used to select initial lists of COPCs for SWMUs 8 and 15:

- A chemical detected in soil will be selected as a site related COPC for soil if any detected chemical concentration exceeds the screening levels for soils and, for inorganics, if the background screen indicates that site concentrations are statistically greater than corresponding background concentrations.

- A chemical detected in ground water will be selected as a site related site related COPC for ground water if the maximum detected concentration in any downgradient well exceeds screening levels and, for inorganics, if background screen indicates that site contaminant concentrations are statistically greater than upgradient/cross-gradient concentrations.

- A chemical detected in surface water or sediment will be selected as a COPC for surface water or sediment if the maximum detected concentration in a potentially impacted surface water body exceeds the screening level for surface water or sediment and, for inorganics, the background screen indicates that site contaminant concentrations are statistically greater than upstream concentrations.

- Individual chemicals may be eliminated as COPCs if they are detected at a frequency of less than 5 percent in any given medium but only if there are no other indications that the chemical would pose an unacceptable risk to receptors (e.g., there is no evidence of a contaminant hot spot). Chemicals that exhibit unusually high concentrations may be retained as COPCs on that basis at the discretion of the human health risk assessor.

- If a chemical is not detected in any of the samples in a particular medium, and the detection limit exceeds the risk-based screening levels, the chemical will not be selected as a COPC but will be qualitatively discussed in the uncertainty analysis section.

- Chemicals that exceed toxicity screening concentrations but are determined to be less than background concentrations based on the background screen will not be selected as site related COPCs but will be retained as non-site related COPCs and further evaluated (qualitatively or quantitatively) in the risk characterization and in the uncertainty sections of the site-specific risk assessments. This evaluation is included in the HHRA as suggested by the following U.S. EPA guidance documents: Role of Background in the CERCLA Cleanup Program (U.S. EPA, 2002b) and Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites (U.S. EPA, 2002e).

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, to identify potentially exposed populations and applicable exposure pathways, to calculate concentrations of COPCs to which receptors might be exposed, and to estimate chemical intakes under the identified exposure scenarios.

Actual or potential exposures at SWMUs 8 and 15 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: a source of chemicals that can be released to the environment, a route of contaminant transport through an environmental medium, and an exposure or contact point for a human receptor.

C.2.1 Conceptual Site Model

A conceptual site model (CSM) facilitates consistent and comprehensive evaluation of the potential risks to human health by creating a framework for identifying the pathways by which human receptors may come in contact with contaminated media resulting from the source area. A CSM depicts the relationships among the following elements, which are necessary for defining complete exposure pathways:

- Site sources of contamination
- Contaminant release mechanisms and transport/migration pathways
- Exposure routes
- Potential receptors

Physical site characteristics, results of previous site investigations, hazard identification (detected chemicals of interest based on the previous investigations), and current and future land use scenarios also were considered during the development of the site-specific CSMs. Details on the site background, physical setting, previous investigations, and hazard identification were presented in Section 1.0. The site-specific CSMs for SWMUs 8 and 15 are presented in this section. Figures C-2 and C-3 illustrates the CSMs for SWMUs 8 and 15, respectively.

The elements of the CSM (contaminant source, release mechanisms, transport/migration pathways, exposure routes, and potential receptors) establish the manner and degree to which a potential receptor may be exposed to chemicals present at the site. The degree of risk incurred by a potential receptor varies according to the means of exposure, the duration of exposure, and the specific chemical to which the receptor is exposed. An exposure, however long in duration, does not necessarily result in an "unacceptable" health or environmental risk, although risks generally increase with increased frequency and/or duration of exposure.

The elements of the CSM, including how they pertain to SWMUs 8 and 15, are discussed below. Sources of contamination, contaminant release mechanisms, transport and migration pathways, exposure routes, and potential receptors are defined. The CSMs will be refined during the risk assessment process using the data and information collected as part of the proposed field investigations. Table C-1 provides a site-specific summary of the potential receptors to be evaluated for SWMUs 8 and 15. A summary of the exposure routes that will be addressed quantitatively for each human receptor is also provided in Table C-1.

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 at SWMUs 8 and 15:

SWMU 8

- Explosives [e.g., 2,4,6-trinitrotoluene (TNT) and cyclotetramethylene tetranitramine (HMX)]
- Metals
- Polychlorinated biphenyls (PCBs) (from PCB-contaminated fuels or materials)
- Semivolatile organic compounds (SVOCs)
- Volatile organic compounds (VOCs)
- Petroleum hydrocarbons (from waste oils and fuels)

SWMU 15

- Cyanide (from wash rack activities)
- Herbicides
- Metals
- PCBs (potentially from waste oil storage)
- Pesticides
- Petroleum hydrocarbons (from waste oils and fuels)
- SVOCs
- VOCs

Potential Contaminant Release Mechanisms and Transport/Migration Pathways

Based on available historical information for SWMUs 8 and 15, releases of potentially hazardous constituents to environmental media have occurred as a result of historical site operations at these sites. Because sampling and analysis of ground water at SWMU 8 and SWMU 15 have not occurred, little information concerning the ground water quality and hydrogeology of these sites is available. However, based on the fact that surface and subsurface soil contamination has occurred as a result of activities at SWMUs 8 and 15, contaminants may have migrated to ground water. Plausible contaminant release and migration mechanisms for these sites are discussed in the following paragraphs.

SWMU 8

Media of concern at the Building 106 Pond have historically included air, soil, surface water, and ground water (Halliburton NUS, 1992). Air was considered a medium of concern because particulates had been released from building ventilation systems in the past. However, air is no longer considered an important medium because a particulate abatement system was installed in 1973. Surface water was considered a medium of concern because explosive powders and particulates were generated from the operations in Buildings 106 and 107, and the wastewater (e.g., floor drains) for these buildings flowed into the Building 106 Pond, potentially contaminating nearby surface waters during pond overflow events (Halliburton NUS, 1992). Soil was considered a medium of concern because overflow from the Building 106 Pond could have resulted in the migration of contaminants to soil. Based on historical information, plausible contaminant release and migration mechanisms for SWMU 8 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.

- Overland runoff of surface waters and migration of sediments and surface soil from SWMU 8 via ditches and culverts to intermittent drainageways on the eastern and western borders of the Mine Fill. The intermittent drainage flows into larger intermittent drainageways that flow south-southeastward into Boggs Creek. Boggs Creek flows south-southeastward and merges with Turkey Creek.

- Migration of contaminants in ground water (i.e., lateral migration) to potential receptor locations downgradient of SWMU 8 source areas and beyond the NSWC Crane boundary.

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

SWMU 15

Media of concern at the Grounds and Road Area have historically included soil, surface water and ground water (Halliburton NUS, 1993). Surface water was considered a medium of concern because, reportedly, pesticide and drum residues released down the hillside south of Buildings 2716, 2717, and 2718 may have infiltrated the surface soils or have been washed into a small intermittent stream located at the base of the hill. Surface water drainage from SWMU 15 enters an intermittently flowing tributary of Turkey Creek, which flows in a general southward direction and exits the southern boundary of NSWC Crane, discharging to the eastern fork of the White River. Surface drainage also flows southeast of the Road and Grounds Area and enters intermittent drainageways that flow into Turkey Creek. Ground water and soil were considered media of concern because waste oils were observed to have been released to soil in the Roads and Grounds Area. In addition, pesticide residues were reportedly released to the soils and surface water.

Based on historical information, plausible contaminant release and migration mechanisms for SWMU 15 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.

- Overland runoff of surface waters and migration of sediments and surface soil from SWMU 15 via ditches and culverts to intermittent drainageways on the northwestern and southeastern borders of the SWMU, eventually flowing into Turkey Creek and Boggs Creek.

- Migration of contaminants in ground water (i.e., lateral migration) to potential receptor locations downgradient of SWMU 15 source areas and beyond the NSWC Crane boundary.

- Migration of fugitive dusts and VOCs from surface soils and subsurface soils (if construction and 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. SWMUs 8 and 15 are active facilities, and operations at these facilities are expected to continue in the foreseeable 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 areas:

- **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 areas would likely preclude excavation and construction. However, excavation and construction are plausible in other sections of the study areas. 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. It should be noted that significant exposures by a construction worker to ground water are unlikely because if a construction worker is going to have prolonged contact with ground water, he/she would most likely wear protective clothing such as rubber boots and/or hip waders, which would limit receptor exposure. In addition, most excavation activities would utilize construction equipment such as a back hoe, which would limit a construction worker's exposure. Also, if significant ground water was encountered during an excavation of a trench or foundation, ground water would most likely be pumped out of the excavation so that the construction activities could be completed.

- **Maintenance Workers** – A plausible receptor under current and future land use. This includes adult military or civilian personnel assigned duties on an infrequent basis within the study areas (e.g., groundskeeping activities, storm sewer and 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.

- **Occupational Worker** – A plausible receptor under current and future land use. 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). In addition, it will be conservatively assumed that the occupational worker may be exposed to ground water (ingestion; dermal contact). (It should be noted that a public water supply is not currently available within the study areas.) It is anticipated that this receptor would not be routinely exposed to subsurface soils, surface waters, or sediments. This receptor is expected to be exposed on a more frequent basis than the maintenance or construction worker.

- **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 areas is not limited by any physical constraints. In addition, hunting activities are permitted at the base. Because the study areas are relatively remote and surrounded by forested areas, hunters (particularly adolescents) may trespass within the study areas. This receptor 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 the intermittent streams. However, exposure to surface water is likely to be limited in some areas because of the intermittent nature of the surface water in swales and drainage ditches. Also potential exposures to surface water will be limited to wading because the streams at the sites are not deep enough for swimming. Direct contact with ground water or subsurface soils is not anticipated for this receptor.

- **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), surface water (incidental ingestion; dermal contact), and sediments (incidental ingestion; dermal contact). Exposures to surface water will be limited to wading because the streams at the sites are not deep enough for swimming. In addition, it will be conservatively assumed that the recreational user may be exposed to ground water (ingestion; dermal contact) while cleaning up (e.g., washing hands, face, and legs) after visiting the hypothetical park. (A public water supply is not currently available within the study area.) 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 United States 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). Potential exposures to surface water will be limited to wading because the streams at the sites are not deep enough for swimming.

Details regarding the assumed receptor characteristics (e.g., intake rate, frequency, duration of exposure) are defined in Section C.2.4.

Current/future occupational workers and future hypothetical residents are not assumed to be exposed to subsurface soil, although exposures to subsurface soil might occur if subsurface soil is brought to the surface as a result of excavation activities. A quantitative analysis of exposures to subsurface soils by occupational workers and hypothetic residents will be included in the uncertainty analysis to aid in risk management decision purposes. This analysis will consist of using a simple "risk ratio" technique that involves the comparison of a chemical's exposure point concentration (EPC) to it's U.S. EPA Region 9 PRG to calculate cancer and noncancer risks using the following equation:

$$\frac{EPC}{PRG} = \frac{HI}{HI \text{ of } 1} \text{ or } \frac{ILCR}{ILCR \text{ of } 1 \times 10^{-6}}$$

This is a value technique for estimating risk because all of the intake equations and risk characterization equations used to develop the risk-based concentrations are linear.

C.2.2 Central Tendency Exposure vs. Reasonable Maximum Exposure

Traditionally, exposures evaluated in the HHRA were based on the concept of a reasonable maximum exposure (RME) only, which is defined as "the maximum exposure that is reasonably expected to occur at a site" (U.S. EPA, 1989a). However, recent risk assessment guidance (U.S. EPA, 1992) 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 scenarios will be evaluated in the site-specific risk assessments for SWMUs 8 and 15. 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 EPC, which is calculated for COPCs only, is an estimate of the chemical concentrations within an exposure unit (EU) that are likely to be contacted over time by a receptor and is used to estimate exposure intakes. The following paragraphs discuss the EUs typically evaluated and the guidelines for calculating the EPC.

EUs for receptors potentially exposed to surface or subsurface soils will likely include all sampled locations within a study area unless:

The analytical data for soils suggest that significant contaminant hot spot(s)/sub-area(s) exist within the study area, and

The hot spot(s)/sub-area(s) is (are) large enough to be considered an EU for one or more of the receptors being evaluated.

For example, a residential lot size of ¼ acre to 2 acres is often used for the evaluation of a hypothetical future resident. The size of an EU will be based on the distribution of the chemical concentrations in soils and on presumed receptor activity patterns.

The EU for a ground water receptor may be one well or a cluster of wells (e.g., in the heavily contaminated part of a plume) and is highly dependent on the distribution of the contamination. If it is determined that a ground water contaminant plume is or may be moving beyond the study area boundaries, EPCs for ground water at receptor locations beyond the study area may be estimated using modeling techniques or measured by installing and monitoring additional wells. These ground water receptor locations may include the study area boundaries and the facility boundary. The locations will be selected, if necessary, based on the concentrations detected within a 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 EU for receptors potentially exposed to surface waters and sediments will likely include all sampled locations in the surface water bodies downstream of a study area. Additional EUs may be defined if, based on the analytical data for the surface water and sediment samples, there are significant contaminant hot spots/sub-areas within or downstream of a study area. As noted above, the distribution of the contamination and presumed activity patterns of the receptor will be used to determine the size of the EU.

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 RME and CTE cases 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. EPCs will be calculated following U.S. EPA's Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites (U.S. EPA, 2002c).

- 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 before the EPC is calculated. 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 ground water modeling techniques.

C.2.4 Chemical Intake Estimation

The methodologies and techniques used to estimate exposure intakes are presented in this section. Intakes for the identified potential receptor groups will be calculated using current U.S. EPA risk assessment guidance (e.g., U.S. EPA, 1991, 1997a, and 2001b) 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 Tables C-2 and C-3 for the RME and CTE scenarios, respectively.

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 and gases from soil will be calculated using the same equation, as follows (U.S. EPA, 1989a):

$$\text{Intake}_{ai} = \frac{(C_{ai})(IR_a)(ET)(EF)(ED)}{(BW)(AT)}$$

where:

Intake_{ai} = intake of chemical "i" from air via inhalation (mg/kg/day)

C_{ai}	=	concentration of chemical "i" in air (mg/m^3)
IR_a	=	inhalation rate (m^3/hour)
ET	=	exposure time (hours/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (year)
BW	=	body weight (kg)
AT	=	averaging time (days);
		for noncarcinogens, AT = ED x 365 days/year;
		for carcinogens, AT = 70 years x 365 days/year

The concentrations of chemicals in air resulting from emissions from soil are developed following procedures presented in U.S. EPA Soil Screening Guidance (U.S. EPA, 1996). The chemical concentration in air is calculated as follows:

$$C_{air} = C_{soil} \times \left[\frac{1}{PEF} + \frac{1}{VF} \right]$$

where:

C_a	=	chemical concentration in air, mg/m^3
C_s	=	chemical concentration in soil, mg/kg
PEF	=	particulate emission factor, m^3/kg
VF	=	volatilization factor, m^3/kg

If no volatile chemicals are retained as COPCs in surface and subsurface soil, the above equation reduces to:

$$C_{air} = C_{soil} \times \left[\frac{1}{PEF} \right]$$

The particulate emissions factor (PEF) relates the concentration of the chemical in soil with the concentration of dust particles in air. A PEF value of 1.316 x 10^{+9} will be used for SWMUs 8 and 15 (IDEM, 2004). This value is based on fugitive dust emissions from the site. Because air emissions resulting from fugitive dust emissions settings will be different than dust emissions generated during construction activities, a separate PEF will be used for construction activities. The PEF for construction workers (1.58 x 10^{+6} m^3/kg) was calculated using the equations presented in the supplemental SSL guidance document (U.S. EPA, 2002a).

As mentioned 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 2001b):

$$Intake_{si} = \frac{(C_{si})(SA)(AF)(ABS)(CF)(EF)(ED)}{(BW)(AT)}$$

where:

$Intake_{si}$	=	amount of chemical "i" absorbed during contact with soil/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 (1×10^{-6} kg/mg)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (year)
BW	=	body weight (kg)
AT	=	averaging time (days); for noncarcinogens, AT = ED x 365 days/year; for carcinogens, AT = 70 years x 365 days/year

Exposed surface areas of body available for dermal contact are determined on a receptor-specific basis because they correspond with assumed human activities and clothing worn during exposure events. Current guidance documents (U.S. EPA, 1997a and 2001b) will be 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., TtNUS, 2003a, 2003b) will also be reviewed when developing the exposed surface areas. The rationales used to select the skin areas are as follows:

- For construction workers, maintenance workers, and occupational workers exposed to surface soil or sediment, the surface area available for soil contact is assumed to be the head, hands, and forearms. The skin surface area is 3,300 cm^2 for the CTE and RME scenarios. These values represent the 50th-percentile areas for the head, hands, and forearms (U.S. EPA, 2001b).

- For adolescent trespassers, 25 percent of the total body surface area for an adolescent (aged 6 to 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 soil/sediment, the exposed surface area available for contact is the sum of the head, arms, hands, lower legs, and feet of an adult male. This skin surface area is 9,070 cm^2 for the RME and CTE scenarios. This value represents the 50th-percentile areas for the arms, hands, lower legs, and feet (U.S. EPA, 1997a). For a small child recreational user (0 to 6 years old), it was assumed that 50 percent of the body surface area was exposed to surface soil and sediment (i.e., 3,300 cm^2). This value represents the 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 area available for contact will be the U.S. EPA recommended value of 5,700 cm^2 for the RME and CTE scenarios (U.S. EPA 2001b). This value assumes that the adult resident is wearing a short-sleeved shirt, shorts, and shoes; therefore, the exposed skin surface is limited to the head, hands, forearms, and lower legs. For a child resident, the recommended value of 2,800 cm^2 was used as the exposed skin surface area for the RME and CTE scenarios (U.S. EPA, 2001b). This value assumes that the child resident is wearing a short-sleeved shirt, shorts, and no shoes; therefore, the exposed skin surface area is limited to the head, hands, forearms, lower legs, and feet.

The following values of soil adherence factors provided in RAGS Part E (U.S. EPA, 2001b) will be used to evaluate risks from exposure to soil and sediment:

- Construction workers - 0.3 mg/cm^2 for the RME and 0.1 mg/cm^2 for the CTE. These values are the 95th-percentile and geometric mean values for construction workers, respectively (U.S. EPA, 2001b and 2002a).

- Maintenance workers and occupational workers - 0.2 mg/cm^2 for the RME and 0.02 mg/cm^2 for the CTE (U.S. EPA, 2001b).

- Adolescent trespassers, child recreational users, and child residents - 0.2 mg/cm^2 for the RME and 0.04 mg/cm^2 for the CTE. These values are the 95th-percentile and geometric mean values presented for soccer players (teens) playing in moist conditions (U.S. EPA, 2001b).

- Adult recreational users and adult residents - 0.07 mg/cm^2 for the RME and 0.01 mg/cm^2 for the CTE (U.S. EPA, 2001b).

For the constituents identified as COPCs in soil, the following absorption factors will be used (U.S. EPA, 2001b):

- Polynuclear aromatic hydrocarbons (PAHs) - 0.13
- Dioxins/furans - 0.03
- Arsenic - 0.03
- Cadmium - 0.001
- Semivolatile organics - 0.1

As indicated in RAGS Part E, absorption factors for other metals have not been developed due to insufficient data to support a default value. Therefore, risks from dermal absorption of metals (other than arsenic and cadmium) from soil will not be quantified in these risk assessments. The uncertainty associated with the omission of these constituents will be discussed in the uncertainty analysis.

C.2.4.3 Incidental Ingestion of Soil and 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, 1989a):

$$Intake_{si} = \frac{(C_{si})(IR_s)(FI)(EF)(ED)(CF)}{(BW)(AT)}$$

where:

$Intake_{si}$	=	intake of contaminant "i" from soil or sediment (mg/kg/day)
C_{si}	=	concentration of contaminant "i" in soil or sediment (mg/kg)
IR_s	=	ingestion rate (mg/day)
FI	=	fraction ingested from contaminated source (dimensionless)

EF	=	exposure frequency (days/year)
ED	=	exposure duration (year)
CF	=	conversion factor (1×10^{-6} kg/mg)
BW	=	body weight (kg)
AT	=	averaging time (days);
		for noncarcinogens, AT = ED x 365 days/year;
		for carcinogens, AT = 70 years x 365 days/year

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 will be used for the fraction of soil ingested from the source for both the RME and CTE scenarios. Sediment ingestion rates will be the same as those assumed for soil ingestion except that, for recreational users, the fraction ingested is assumed to be 0.5 for both the RME and CTE scenarios.

C.2.4.4 Dermal Contact with Ground Water and 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 SWMUs 5 and 18 is limited to exposure that would occur under 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 dermal exposure. Short-term dermal exposure is assumed to occur for the construction worker during excavation activities and for the hypothetical recreational user or occupational worker receptors that may occasionally use restroom facilities (supplied by ground water pumped from the underlying aquifer) while working or recreating. (It should be noted that neither restroom facilities nor ground water supply wells exist at SWMUs 5 and 18 at this time). Dermal contact with surface water may also occur while receptors are involved in certain activities such as landscaping (maintenance worker), trespassing, or recreational sport (e.g., hiking, wading, etc.).

The following equation will be used to assess exposures resulting from dermal contact with water (U.S. EPA, 2001b):

$$DAD_{wi} = \frac{(DA_{event})(EV)(ED)(EF)(A)}{(BW)(AT)}$$

where:

DAD_{wi}	=	dermally absorbed dose of chemical "i" from water (mg/kg/day)
DA_{event}	=	absorbed dose per event (mg/cm^2-event)
EV	=	event frequency (events/day)

ED	=	exposure duration (year)
EF	=	exposure frequency (days/year)
A	=	skin surface area available for contact (cm^2)
BW	=	body weight (kg)
AT	=	averaging time (days);
		for noncarcinogens, AT = ED x 365 days/year;
		for carcinogens, AT = 70 years x 365 days/year

Ground water exposure for hypothetical future on-base residential receptors using the ground 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 will be based on assumed activities and is similar to the assumptions outlined for dermal contact with soil and sediment. Tables C-2 and C-3 summarize recommendations for exposure parameters that will be evaluated in the baseline risk assessments.

The absorbed dose per event (DA_{event}) will be estimated using a non-steady-state approach for organic compounds and a traditional steady-state approach for inorganics. For organics, the following equations apply:

$$\text{If } t_{event} < t^{*}, \text{ then: } DA_{event} = (2)(K_p)(FA)(C_{wi})(CF)\left(\sqrt{\frac{6\,\tau\, t_{event}}{\pi}}\right)$$

$$\text{If } t_{event} > t^{*}, \text{ then: } DA_{event} = (K_p)(FA)(C_w)(CF)\left(\frac{t_{event}}{1+B} + 2\,\tau\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right)$$

where:

t_{event}	=	duration of event (hour/event)
t^{*}	=	time it takes to reach steady-state conditions (hour)
K_p	=	permeability coefficient from water through skin (cm/hour)
FA	=	Chemical-specific fraction absorbed (dimensionless)
C_{wi}	=	concentration of chemical "i" in water (mg/L)
τ	=	lag time (hour)
π	=	Pi (dimensionless; equal to 3.1416)

CF = conversion factor (0.001 L/cm^3)

B = Dimensionless ratio of the permeability of the stratum corneum relative to the permeability across the viable epidermis.

Values for the chemical-specific parameters (t^*, K_p, τ, FA, and B) will be obtained from RAGS Part E the current dermal guidance (U.S. EPA, 2001b). If no published values are available for a particular compound, they will be calculated using equations provided in the cited guidance.

The following non-steady-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 0.001 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 Direct Ingestion of Ground Water and Incidental Ingestion of Surface Water

Residents may be exposed to ground water via direct ingestion. In addition, maintenance workers, trespassers, recreational users, and residents may incidentally ingest surface water while at the site. Intakes associated with ingestion of water will be evaluated using the following equation (U.S. EPA, 1989a):

$$Intake_{wi} = \frac{(C_{wi})(IR_w)(EF)(ED)}{(BW)(AT)}$$

where:

$Intake_{wi}$ = intake of chemical "i" from water (mg/kg/day)

C_{wi} = concentration of chemical "i" in water (mg/L)

IR_w = ingestion rate for ground water (L/day)

IR_w = ingestion rate for surface water (L/day) = (CR)(ET)

- CR = contact rate for surface water (L/hour)
- ET = exposure time for surface water (hour/day)

EF = exposure frequency (days/year)

ED = exposure duration (year)

BW = body weight (kg)

AT = averaging time (days);
for noncarcinogens, AT = ED x 365 days/year;
for carcinogens, AT = 70 years x 365 days/year

The same exposure 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 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 that is employed is as follows (U.S. EPA, 1989a and Foster and Chrostowski, 1987):

$$\text{Intake}_{si} = \frac{(S)(IR_{sh})(K)(EF)(ED)}{(BW)(AT)(R_a)(CF)}$$

$$K = D_s + \frac{\exp(-R_a \times D_t)}{R_a} - \frac{\exp[R_a \times (D_s - D_t)]}{R_a}$$

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/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time or period of exposure (days)
R_a	=	air exchange rate (min^{-1})
CF	=	conversion factor (1 x 10^{-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. For most metals anticipated at the SWMUs 8 and 15, volatilization is not a significant pathway because these substances do not vaporize at room temperature.

Construction workers may be exposed to COPCs that have volatilized from ground water when excavation exposes the shallow water table. Exposures for construction workers associated with the inhalation route is estimated in the following manner (U.S. EPA, 1989a):

$$\text{Intake}_{ai} = \frac{(C_{ai})(IR_a)(ET)(EF)(ED)}{(BW)(AT)}$$

where: Intake_{ai} = intake of chemical "i" from air via inhalation (mg/kg/day)

C_{ai} = concentration of chemical "i" in air (mg/m^3)

IR_a = inhalation rate (m^3/hr)

ET = exposure time (hours/day)

EF = exposure frequency (days/year)

ED = exposure duration (year)

BW = body weight (kg)

AT = averaging time (days);
for noncarcinogens, AT = ED x 365 days/year;
for carcinogens, AT = 70 year x 365 days/year

The same exposure frequency and exposure time used to estimate intake from dermal contact with ground water is used to evaluate intake from inhalation of VOCs from ground water during construction activities.

There are no well-established models available for estimating migration of volatiles from ground water into a construction/utility trench. To estimate the EPC for air in a construction trench, the HHRAs will use an approach suggested by the Virginia Department of Environmental Quality (VDEQ, 2004), which is based on a combination of a vadose zone model (to estimate volatilization of gases from contaminated groundwater into a trench) and a box model (to estimate dispersion of the contaminants from the air inside the trench into the above-ground atmosphere). The VDEQ methodology is described in the following paragraphs.

The airborne concentration of a contaminant in a trench can be estimated using the following equation:

$$C_{air} = C_{GW} \times VF$$

where:

C_{air} = air concentration of contaminant in the trench µg/m^3

C_{GW} = concentration of contaminant in ground water µg/L

VF = volatilization factor L/m^3

It is assumed that a construction project could result in an excavation of 15 feet bgs or less. If the depth to ground water at a site is less than 15 feet, the VDEQ model assumes that a worker would encounter ground water when digging an excavation or a trench. The worker would then have direct exposure to the ground water. The worker would also be exposed to contaminants in the air inside the trench that would result from volatilization from the ground water pooling at the bottom of the trench.

The following equation is used to calculate the volatilization factor (VF) for a trench less than 15 feet deep:

$$VF = (K_i \times A \times F \times 10^{-3} \times 10^{4} \times 3{,}600) / (ACH \times V)$$

where:

K_i	=	overall mass transfer coefficient of contaminant (cm/s)
A	=	area of the trench (m^2)
F	=	fraction of floor through which contaminant can enter (unitless)
ACH	=	air changes per hour (h^{-1}) = 360 h^{-1}
V	=	volume of trench (m^3)
10^{-3}	=	conversion factor (L/cm^3)
10^4	=	conversion factor (cm^2/m^2)
3,600	=	conversion factor (seconds/hour)

Studies of urban canyons suggest that if the ratio of trench width, relative to wind direction, relative to trench depth is less than or equal to 1, a circulation cell or cells will be set up within the trench that limits the degree of gas exchange with the atmosphere and, based upon measured ventilation rates of buildings, the air changes per hour (ACH) is assumed to be 2. Based upon the ratio of trench depth to the average wind speed, if the ratio of trench width to trench depth is greater than 1, the air exchange

between the trench and above-ground atmosphere is not restricted, and the ACH is assumed to be 360. The exposure assessment performed for these HHRAs will assume the width-to-trench depth ratio is greater than 1; therefore, the ACH is set at 360.

K_i is calculated using the following equation:

$$K_i = 1 / \{(1/k_iL) + [(RT) / (H_i\, k_iG)]\}$$

where:

K_i	=	overall mass transfer coefficient of containment (cm/s)
k_iL	=	liquid-phase mass transfer coefficient of i (cm/s)
R	=	ideal gas constant (atm-m^3/mole-°K) = 8.2×10^{-5}
T	=	average system absolute temperature (°K) (Default = 298°K)
H_i	=	Henry's Law constant of i (atm-m^3/mole)
k_iG	=	gas-phase mass transfer coefficient of i (cm/s)

The formulas for calculating k_iL and k_iG are as follows:

$$k_iL = (MWO_2/MW_i)^{0.5} \times (T/298) \times kL,O_2$$

where:

k_iL	=	liquid-phase mass transfer coefficient of component i (cm/s)
MWO_2	=	molecular weight of oxygen (g/mole)
MW_i	=	molecular weight of component i (g/mole)
kL,O_2	=	liquid-phase mass transfer coefficient of oxygen at 25°C (cm/s) = 0002 cm/s

$$k_iG = (MWH_2O/MW_i)^{0.335} \times (T/298)^{1.005} \times kG,H_2O$$

where:

k_iG	=	gas-phase mass transfer coefficient of component i (cm/s)
MWH_2O	=	molecular weight of water (g/mole)
kG,H_2O	=	gas-phase mass transfer coefficient of water vapor at 25°C (cm/s)= 0.833 cm/s (Superfund Exposure Assessment Manual, U.S. EPA, 1988).

Site-specific values will be used whenever possible. Model default values will be used when they are believed to be representative of site conditions. Chemical properties will be obtained from the Soil Screening Guidance: User's Guide (U.S. EPA, 1996 and 2002a).

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 SWMUs 5 and 18. In general, standard default parameters (e.g., U.S. EPA, 1991; 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, 1989a 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 U.S. EPA's Integrated Exposure Uptake Biokinetic (IEUBK) Model for lead, (U.S. EPA, 2002d). This model is typically used to evaluate lead exposure assuming a residential land use scenario.

- The U.S. EPA's TRW Model for Lead (U.S. EPA, 2003a). This model is typically used to evaluate lead exposure assuming a non-residential land use scenario.

The IEUBK Model for lead (U.S. EPA, 2002d) 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 to 15 µg/dL. Blood-lead levels greater than 10 µg/dL are considered to be a "concern."

For SWMUs 8 and 15, the IEUBK Model for lead will be used to address exposure to lead in children when detected ground water or surface water concentrations exceed the 15 µg/L Federal Action Level promulgated under the Safe Drinking Water Act and when detected soil or 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 will be appended to the site-specific risk assessments.

Non-residential adult exposure to lead in soil will be evaluated using U.S. EPA's TRW for Model for lead (U.S. EPA, 2003a). 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 that is evaluated (i.e., industrial, recreational). The output 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 in accordance with the following EPA guidelines:

- Use of the TRW Interim Adult Lead Methodology in Risk Assessment (U.S. EPA, 1999c).
- Frequently Asked Questions (FAQs) on the Adult Lead Model (U.S. EPA, 2004).

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 assessments will be integrated with outputs of the exposure assessments 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 SWMUs 8 and 15 will be obtained from the following primary literature sources (U.S. EPA 2003b):

- Integrated Risk Information System (IRIS) (online).
- U.S. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs) – The Office of Research and Development/National Center for Environmental Assessment (NCEA) Superfund Health Risk Technical Support Center develops PPRTVs on a chemical-specific basis when requested by U.S. EPA's Superfund program.
- Other Toxicity Values – These sources include but are not limited to California Environmental Protection Agency (Cal EPA) toxicity values, the Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels (MRLs), and the Annual Health Effects Assessment Summary Tables (HEAST) (U.S. EPA, 1997b).

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. The U.S. EPA Region 9 PRG Tables and Region 3 Risk-Based Concentration (RBC) Tables will also be used as a source of toxicity criteria when these 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 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 evaluation of 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, 2001b (the primary reference), IRIS, 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 U.S. EPA's current dermal assessment guidance (U.S. EPA, 2001b).

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 U.S. EPA as a probable human carcinogen. Although CSFs are available for benzo(a)pyrene, insufficient data are available to calculate CSFs for other carcinogenic PAHs. Toxic effects for these chemicals will be evaluated using the concept of estimated orders of potential potency, which relate the potency of the other potentially carcinogenic PAHs to the potency of benzo(a)pyrene, as presented in current U.S. EPA guidance (U.S. EPA, 1993b). The equivalent oral and inhalation CSFs for these chemicals are derived by multiplying the CSFs for benzo(a)pyrene by the orders 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) that relate the toxicity of other CDDs/CDFs to the toxicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) (WHO, 1998 and U.S. EPA, 1989b). The U.S. EPA and others have developed TEFs for other dioxins and furans from structure-activity relationships and 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 the significant dioxin and 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 SWMUs 8 and 15. However, risks

associated with this chemical are assessed by conservatively assuming that 100 percent of the reported total chromium result is attributable to hexavalent chromium.

C.3.2 Toxicity Profiles

Toxicological profiles for each COPC will be presented as an appendix to each 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 HHRA.

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 that contribute significantly to elevated risks will be identified as "risk drivers" or COCs. All the numeric estimates of risk will be contained in the risk assessment spreadsheets, which will be appended to the assessments 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, 1989a). 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 HQs determined through a comparison of intakes with published RfDs.

ILCR estimates are generated for each COPC using estimated exposure intakes and published CSFs, as follows:

$$\text{ILCR} = (\text{Estimated Exposure Intake})(\text{CSF})$$

If the above equation results in an ILCR greater than 0.01, the following equation will be used:

$$\text{ILCR} = 1\text{-}[\exp(\text{-Estimated Exposure Intake})(\text{CSF})]$$

An ILCR of 1×10^{-6} indicates that the exposed receptor has a one-in-one-million chance of developing cancer under the defined exposure scenario. Alternatively, such a risk may be interpreted as representing one additional case of cancer in an exposed population of one million persons.

As mentioned previously, noncarcinogenic risks will be assessed using the concepts of HQs and HIs. The HQ for a COPC is the ratio of the estimated intake to the RfD, as follows:

$$HQ = (\text{Estimated Exposure Intake}) / (RfD)$$

An HI 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" (1×10^{-6} to 1×10^{-4}), and HIs will be evaluated using a value of 1.0.

U.S. EPA has defined the range of 1×10^{-6} to 1×10^{-4} as the ILCR "target range" for most hazardous waste facilities addressed under CERCLA and RCRA. Individual or cumulative ILCRs greater than 1×10^{-4} will typically not be considered as protective of human health, and ILCRs less than 1×10^{-6} will typically be regarded as protective. Risk management decisions are necessary when the ILCR is within the 1×10^{-4} to 1×10^{-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 organ effects associated with exposure to COPCs will be performed. Only those chemicals that 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.

C.4.1.2 Characterization of Risks Associated with Non-Site Related COPCs

Potential risks resulting from exposures to non-site related COPCs (i.e., inorganics detected at concentrations exceeding risk-based screening levels but within background levels) will be qualitatively evaluated in the risk characterization section. The qualitative evaluation will consist of a comparison of detected concentrations of the non-site related COPCs to the U.S. EPA Region IX PRGs and IDEM default closure levels.

C.5 UNCERTAINTY ANALYSIS

The goal of the uncertainty analysis is to identify important uncertainties and limitations associated with the baseline HHRA. 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 that 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 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 presented discussion will be based, in part, on the evaluation presented in the Data Useability Worksheet, as suggested by 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 EPCs (for example, the use of maximum concentrations to estimate risks), uncertainty in the selection of potential receptors and exposure scenarios, uncertainty in the selection of exposure parameters (RME versus CTE), and an evaluation of the risks associated with exposures to subsurface soils by current/future occupational workers and future hypothetical residents. 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 that 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 that results primarily from assumptions made regarding additivity and 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. 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 assessments will be reviewed with the regulatory reviewers before they are incorporated into the uncertainty sections of the baseline risk assessments.

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TABLE C-1

RECEPTORS AND EXPOSURE ROUTES FOR QUANTITATIVE EVALUATION
SWMUs 8 AND 15
NSWC CRANE, CRANE INDIANA

Receptors	Exposure Routes
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)
Maintenance Workers (current and future land use)	• Soil dermal contact (surface) • Soil ingestion (surface) • Inhalation of air/dust/emissions (surface) • Surface water/sediment dermal contact • Sediment (Incindental ingestion)
Occupational Worker (current and future)(1)	• Soil dermal contact (surface) • Soil ingestion (surface) • Inhalation of air/dust/emissions (surface) • Direct ingestion of ground water • Ground water dermal contact
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
Small Child (0 to 6 years) 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)(1)	• 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

1 – Occupational workers and residents will also be evaluated for exposures to chemicals of concern in subsurface soil in the uncertainty section of the risk assessments. This scenario is included to account for the possibility that subsurface soil could be brought to the surface in future excavation projects.

TABLE C-2

SUMMARY OF EXPOSURE INPUT PARAMETERS
REASONABLE MAXIMUM EXPOSURES
SWMUs 8 AND 15
NSWC CRANE
CRANE INDIANA

Exposure Parameter	Construction Worker	Maintenance Worker	Occupational Worker	Adolescent Trespasser	Child Recreational User	Adult Recreational User	On-Site Child Resident	On-Site Adult Resident
All Exposures								
C_{soil}/C_{sed} (mg/kg)	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]
C_{gw} (µg/L)	Average	NA	Average	NA	Average	Average	Average	Average
C_{sw} (µg/L)	NA	Maximum or 95% UCL[1]	NA	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]
ED (years)	1[2]	25[3]	25[3]	11[4]	6[5]	24[5]	6[5]	24[5]
BW (kg)	70[5]	70[5]	70[5]	43[6]	15[5]	70[5]	15[5]	70[5]
AT_n (days)	365[6]	9,125[6]	9,125[6]	4,015[6]	2,190[6]	8,760[6]	2,190[6]	8,760[6]
AT_c (days)	25,550[6]	25,550[6]	25,550[6]	25,550[6]	25,550[6]	25,550[6]	25,550[6]	25,550[6]
Incidental Ingestion/Dermal Contact with Soil								
IR (mg/day)	330[7]	100[5]	100[5]	100[5]	200[5]	100[5]	200[5]	100[5]
EF-Soil (days/year)	150[8]	24[9]	250[5]	26[10]	52[11]	52[11]	350[5]	350[5]
FI (unitless)	1[5]	1[5]	1[5]	1[5]	0.5[2]	0.5[2]	1[5]	1[5]
SA (cm^2/day)	3,300[12]	3,300[12]	3,300[12]	3,280[13]	3,300[14]	9,070[15]	2,800[12]	5,700[12]
AF (mg/cm^2)	0.3[12]	0.2[12]	0.2[12]	0.2[12]	0.2[12]	0.07[12]	0.2[12]	0.07[12]
ABS (unitless)	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]
CF (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Inhalation Fugitive Dust/Volatile Emissions from Surface Soil								
C_{air} (mg/m^3)	calculated[16]	calculated[16]	calculated[16]	calculated[16]	calculated[16]	calculated[16]	calculated[16]	calculated[16]
InhR (m^3/hour)	2.5[17]	20 m^3/day[3]	20 m^3/day[3]	1.2[17]	1.2[17]	1.6[17]	15 m^3/day[17]	20 m^3/day[17]
ET (hours/day)	8[18]	8[18]	8[18]	4[2]	4[2]	4[2]	24[17]	24[17]
PEF (m^3/kg)	1.58E+06[7]	1.316E+09[19]	1.316E+09[19]	1.316E+09[19]	1.316E+09[19]	1.316E+09[19]	1.316E+09[19]	1.316E+09[19]
Ingestion/Dermal Contact with Ground Water								
IR_{gw} (L/day)	NA	NA	1[2]	NA	1[2]	1[2]	1.5[17]	2[5]
EF (days/year)	150[8]	NA	250[5]	NA	52[11]	52[11]	350[5]	350[5]
ET (hours/day) and t_{event} (hours/event)	2[2]	NA	0.25[2]	NA	0.25[2]	0.25[2]	0.25[17]	0.25[17]
EV (events/day)	1[2]	NA	1[2]	NA	1[2]	1[2]	1[2]	1[2]
A (cm^2/day)	3,300[12]	NA	3,300[12]	NA	3,300[14]	9,070[15]	6,600[12]	18,000[12]
K_p (cm/hour)	chemical-specific[12]	NA	chemical-specific[12]	NA	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]

TABLE C-2

SUMMARY OF EXPOSURE INPUT PARAMETERS
REASONABLE MAXIMUM EXPOSURES
SWMUs 8 AND 15
NSWC CRANE
CRANE INDIANA

Exposure Parameter	Construction Worker	Maintenance Worker	Occupational Worker	Adolescent Trespasser	Child Recreational User	Adult Recreational User	On-Site Child Resident	On-Site Adult Resident
t* (hour/event), τ (hour), and B (unitless)	chemical-specific[12]	NA	chemical-specific[12]	NA	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]
Inhalation of Volatile Emissions from Ground Water								
C_{air} (mg/m^3)	calculated[20]	NA	NA	NA	NA	NA	Calculated[21]	Calculated[21]
InhR (m^3/hour)	2.5[17]	NA	NA	NA	NA	NA	0.6[3]	0.6[3]
ET (hours/day)	2[2]	NA	NA	NA	NA	NA	0.33[2]	0.33[2]
Ingestion/Dermal Contact with Surface Water								
CR_{sw} (ml/hr)	NA	NA	NA	0.05[22]	0.05[22]	0.01[22]	0.05[22]	0.01[22]
EF (days/year)	NA	24[9]	NA	26[10]	52[11]	52[11]	52[11]	52[11]
ET (hours/day) and t_{event} (hours/event)	NA	2[2]	NA	4[2]	4[2]	4[2]	4[2]	4[2]
EV (events/day)	NA	1[2]	NA	1[2]	1[2]	1[2]	1[2]	1[2]
A (cm^2/day)	NA	3,300[12]	NA	3,280[13]	3,300[14]	9,070[15]	3,300[14]	9,070[15]
K_p (cm/hour)	NA	chemical-specific[12]	NA	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]
t* (hour/event), τ (hour), and B (unitless)	NA	chemical-specific[12]	NA	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]
CF (L/cm^3)	NA	1E-03	NA	1E-03	1E-03	1E-03	1E-03	1E-03
Incidental Ingestion/Dermal Contact with Sediment								
IR (mg/day)	NA	100[5]	NA	100[5]	200[5]	100[5]	100[2]	50[2]
EF-Sediment (days/year)	NA	24[9]	NA	26[10]	52[11]	52[11]	52[11]	52[11]
FI (unitless)	NA	1[5]	NA	1[5]	0.5[2]	0.5[2]	1[5]	1[5]
SA (cm^2/day)	NA	3,300[12]	NA	3,280[13]	3,300[14]	9,070[15]	2,800[12]	5,700[12]
AF (mg/cm^2)	NA	0.2[12]	NA	0.2[12]	0.2[12]	0.07[12]	0.2[12]	0.07[12]
ABS (unitless)	NA	chemical-specific[12]	NA	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]
CF (kg/mg)	NA	1E-06	NA	1E-06	1E-06	1E-06	1E-06	1E-06

TABLE C-2

SUMMARY OF EXPOSURE INPUT PARAMETERS
REASONABLE MAXIMUM EXPOSURES
SWMUs 8 AND 15
NSWC CRANE
CRANE INDIANA

Notes:

A	Skin surface area available for contact
ABS	Absorption factor
AF	Soil-to-skin adherence factor
AT_c	Averaging time for carcinogenic effects
AT_n	Averaging time for noncarcinogenic effects
B	Bunge Model partitioning coefficient
BW	Body weight
CF	Conversion factor
CR	Contact rate
$C_{soil/sed}$	Exposure concentration for soil/sediment
$C_{gw/sw}$	Exposure concentration for ground water/surface water
C_{air}	Exposure concentration for air
ED	Exposure duration
EF	Exposure frequency
ET	Exposure time
EV	Event frequency
FI	Fraction ingested from contaminated source
InhR	Inhalation rate
IR	Ingestion rate (soil or groundwater)
K_p	Permeability coefficient from water through skin
SA	Skin surface area available for contact
PEF	Particulate emission factor
τ	Lag time
t^*	Time it takes to reach steady-state conditions
t_{event}	Duration of event

1 - U.S. EPA, 2002c.
2 - Professional judgment.
3 - U.S. EPA, 1991.
4 - Adolescents ages 7 to 16 years old.
5 - U.S. EPA, 1993a.
6 - U.S. EPA, 1989.
7 - U.S. EPA, 2002a.
8 - Ground is assumed to be frozen or snow covered 22 weeks/year.
9 - Assume two days a month for reasonable maximum exposure and one day a month for central tendency exposure.
10 - Assume one day a week in warm weather months for resonable maximum exposure and every other week for central tendency exposure.
11 - Assume two days a week in warm weather months for reasonable maximum exposure and one day a week for central tendency exposure.
12 - U.S. EPA, 2001a.
13 - Assume 25 percent of total body surface area is exposed, U.S. EPA, 1997.
14 - Assume 50 percent of total body surface area is exposed, U.S. EPA, 2001b.
15 - Assume that head, arms, hands, lower legs, and feet are exposed, U.S. EPA, 1997a.
16 - U.S. EPA, 1996.
17 - U.S. EPA, 1997a.
18 - Assume an 8-hour work shift.
19 - IDEM, 2004.
20 - VDEQ 2004.
21 - Foster, S.A. and P.C. Chrostowski, 1987.
22 - U.S. EPA Region 4, 1995.

TABLE C-3

SUMMARY OF EXPOSURE INPUT PARAMETERS
CENTRAL TENDENCY EXPOSURES
SWMUs 8 AND 15
NSWC CRANE
CRANE INDIANA

Exposure Parameter	Construction Worker	Maintenance Worker	Occupational Worker	Adolescent Trespasser	Child Recreational User	Adult Recreational User	On-Site Child Resident	On-Site Adult Resident
All Exposures								
C_{soil}/C_{sed} (mg/kg)	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]
C_{gw} (µg/L)	Average	NA	Average	NA	Average	Average	Average	Average
C_{sw} (µg/L)	NA	Maximum or 95% UCL[1]	NA	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]
ED (years)	1[2]	9[3]	9[3]	11[4]	2[3]	7[3]	2[3]	7[3]
BW (kg)	70[3]	70[3]	70[3]	43[5]	15[3]	70[3]	15[3]	70[3]
AT_n (days)	365[5]	3,285[5]	3,285[5]	4,015[5]	730[5]	2,555[5]	730[5]	2,555[5]
AT_c (days)	25,550[5]	25,550[5]	25,550[5]	25,550[5]	25,550[5]	25,550[5]	25,550[5]	25,550[5]
Incidental Ingestion/Dermal Contact with Soil								
IR (mg/day)	165[6]	50[3]	50[3]	50[3]	100[3]	50[3]	100[3]	50[3]
EF-Soil (days/year)	150[7]	12[8]	219[3]	13[9]	26[10]	26[10]	234[3]	234[3]
FI (unitless)	1[3]	1[3]	1[3]	1[3]	0.5[2]	0.5[2]	1[3]	1[3]
SA (cm^2/day)	3,300[11]	3,300[11]	3,300[11]	3,100[12]	3,300[13]	9,070[14]	2,800[11]	5,700[11]
AF (mg/cm^2)	0.1[11]	0.02[11]	0.02[11]	0.04[11]	0.04[11]	0.01[11]	0.04[11]	0.01[11]
ABS (unitless)	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]
CF (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Inhalation Fugitive Dust/Volatile Emissions from Surface Soil								
C_{air} (mg/m^3)	calculated[15]	calculated[15]	calculated[15]	calculated[15]	calculated[15]	calculated[15]	calculated[15]	calculated[15]
InhR (m^3/hour)	2.5[16]	20 m^3/day[17]	20 m^3/day[17]	1.2[16]	1.2[16]	1.6[16]	15 m^3/day[16]	20 m^3/day[16]
ET (hours/day)	8[18]	8[18]	8[18]	2[2]	2[2]	2[2]	24[16]	24[16]
PEF (m^3/kg)	1.58E+06[19]	1.316E+09[20]	1.316E+09[20]	1.316E+09[20]	1.316E+09[20]	1.316E+09[20]	1.316E+09[20]	1.316E+09[20]
Ingestion/Dermal Contact with Ground Water								
IR_{gw} (L/day)	NA	NA	1[2]	NA	1[2]	1[2]	0.66[16]	1.4[3]
EF (days/year)	150[7]	NA	219[3]	NA	26[10]	26[10]	234[3]	234[3]
ET (hours/day) and t_{event} (hours/event)	1.5[2]	NA	0.167[2]	NA	0.167[2]	0.167[2]	0.167[16]	0.167[16]
EV (events/day)	1[2]	NA	1[2]	NA	1[2]	1[2]	1[2]	1[2]
A (cm^2/day)	3,300[11]	NA	3,300[11]	NA	3,300[13]	9,070[14]	6,600[11]	18,000[11]
K_p (cm/hour)	chemical-specific[11]	NA	chemical-specific[11]	NA	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]

TABLE C-3

SUMMARY OF EXPOSURE INPUT PARAMETERS
CENTRAL TENDENCY EXPOSURES
SWMUs 8 AND 15
NSWC CRANE
CRANE INDIANA

Exposure Parameter	Construction Worker	Maintenance Worker	Occupational Worker	Adolescent Trespasser	Child Recreational User	Adult Recreational User	On-Site Child Resident	On-Site Adult Resident
Ingestion/Dermal Contact with Ground Water (Continued)								
t* (hour/event), τ (hour), and B (unitless)	chemical-specific[11]	NA	chemical-specific[11]	NA	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]
Inhalation of Volatile Emissions from Ground Water								
C_{air} (mg/m^3)	calculated[21]	NA	NA	NA	NA	NA	Calculated[22]	Calculated[22]
InhR (m^3/hour)	2.5[16]	NA	NA	NA	NA	NA	0.6[17]	0.6[17]
ET (hours/day)	1.5[2]	NA	NA	NA	NA	NA	0.25[2]	0.25[2]
Ingestion/Dermal Contact with Surface Water								
CR_{sw} (ml/hr)	NA	NA	NA	0.05[23]	0.05[23]	0.01[23]	0.05[23]	0.01[23]
EF (days/year)	NA	12[8]	NA	13[9]	26[10]	26[10]	26[10]	26[10]
ET (hours/day) and t_{event} (hours/event)	NA	1.5[2]	NA	2[2]	2[2]	2[2]	2[2]	2[2]
EV (events/day)	NA	1[2]	NA	1[2]	1[2]	1[2]	1[2]	1[2]
A (cm^2/day)	NA	3,300[11]	NA	3,100[12]	3,300[13]	9,070[14]	3,300[13]	9,070[14]
K_p (cm/hour)	NA	chemical-specific[11]	NA	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]
t* (hour/event), τ (hour), and B (unitless)	NA	chemical-specific[11]	NA	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]
CF (L/cm^3)	NA	1E-03	NA	1E-03	1E-03	1E-03	1E-03	1E-03
Incidental Ingestion/Dermal Contact with Sediment								
IR (mg/day)	NA	50[3]	NA	50[3]	100[3]	50[3]	50[2]	25[2]
EF-Sediment (days/year)	NA	12[8]	NA	13[9]	26[10]	26[10]	26[10]	26[10]
FI (unitless)	NA	1[3]	NA	1[3]	0.5[2]	0.5[2]	1[3]	1[3]
SA (cm^2/day)	NA	3,300[11]	NA	3,100[12]	3,300[13]	9,070[14]	2,800[11]	5,700[11]
AF (mg/cm^2)	NA	0.02[11]	NA	0.04[11]	0.04[11]	0.01[11]	0.04[11]	0.01[11]
ABS (unitless)	NA	chemical-specific[11]	NA	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]
CF (kg/mg)	NA	1E-06	NA	1E-06	1E-06	1E-06	1E-06	1E-06

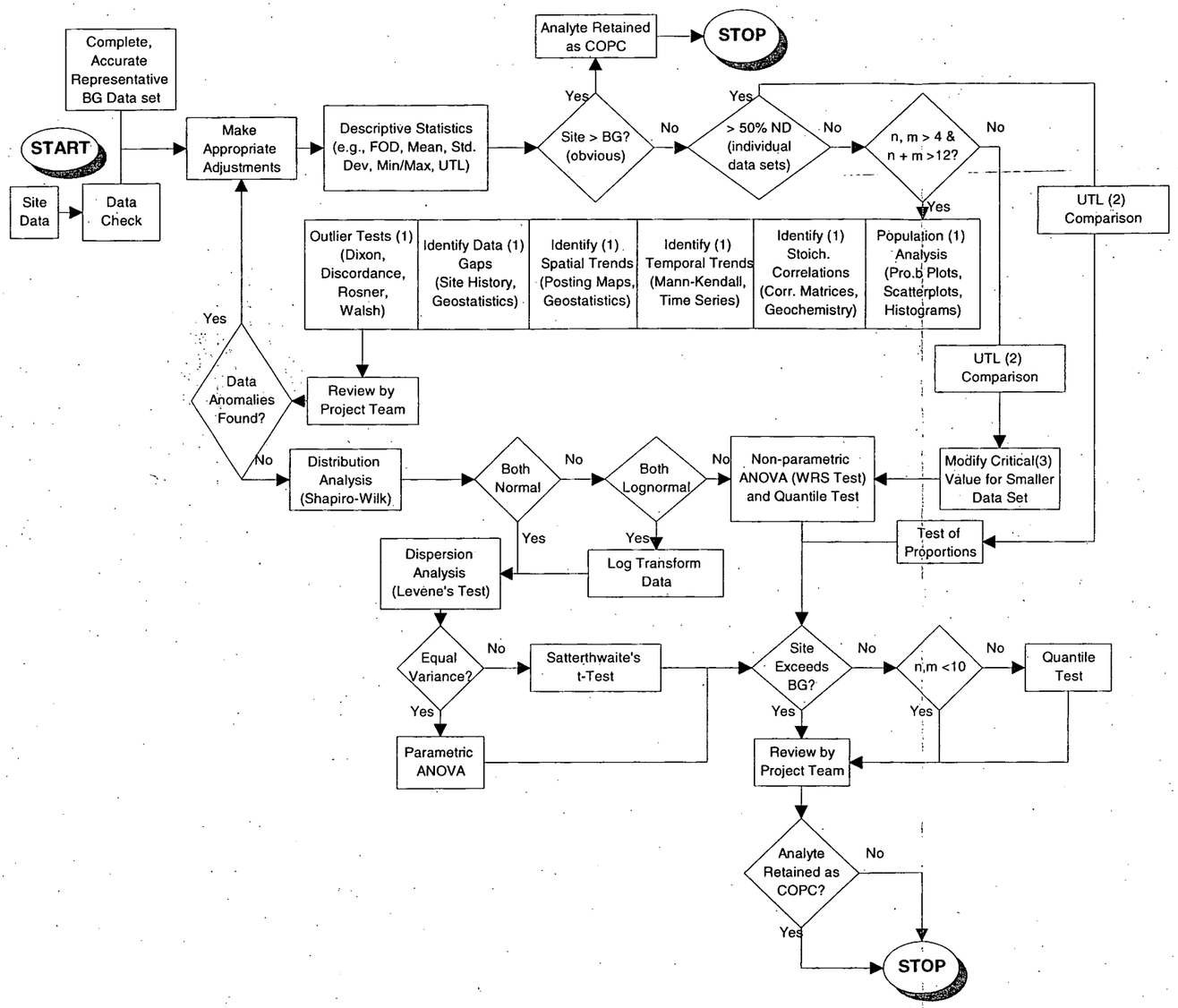
TABLE C-3

SUMMARY OF EXPOSURE INPUT PARAMETERS
CENTRAL TENDENCY EXPOSURES
SWMUs 8 AND 15
NSWC CRANE
CRANE INDIANA

Notes:

A	Skin surface area available for contact
ABS	Absorption factor
AF	Soil-to-skin adherence factor
AT_c	Averaging time for carcinogenic effects
AT_n	Averaging time for noncarcinogenic effects
B	Bunge Model partitioning coefficient
BW	Body weight
CF	Conversion factor
CR	Contact rate
$C_{soil/sed}$	Exposure concentration for soil/sediment
$C_{gw/sw}$	Exposure concentration for ground water/surface water
C_{air}	Exposure concentration for air
ED	Exposure duration
EF	Exposure frequency
ET	Exposure time
EV	Event frequency
FI	Fraction ingested from contaminated source
InhR	Inhalation rate
IR	Ingestion rate (soil or groundwater)
K_p	Permeability coefficient from water through skin
NA	Not applicable
SA	Skin surface area available for contact
PEF	Particulate emission factor
τ	Lag time
t^*	Time it takes to reach steady-state conditions
t_{event}	Duration of event
UCL	Upper confidence limit on arithmetic mean

1 - U.S. EPA, 2002c.
2 - Professional judgment.
3 - U.S. EPA, 1993a.
4 - Adolescents ages 7 to 16 years.
5 - U.S. EPA, 1989a.
6 - Central tendency exposure is assumed to be one-half the reasonable maximum expousre value.
7 - Ground is assumed to be frozen or snow covered 22 weeks per year.
8 - Assume 2 days a month for RME and one day a month for CTE.
9 - Assume 1 day a week in warm weather months for RME and every other week for CTE.
10 - Assume 2 days a week in warm weather months for RME and one day a week for CTE.
11 - U.S. EPA, 2001b.
12 - Assume 25 percent of total body surface area is exposed (U.S. EPA, 1997a).
13 - Assume 50 percent of total body surface area is exposed (U.S. EPA, 2001b).
14 - Assume that head, arms, hands, lower legs, and feet are exposed (U.S. EPA, 1997a).
15 - U.S. EPA, 1996 (PEF values site specific).
16 - U.S. EPA, 1997a.
17 - U.S. EPA, 1991.
18 - Assume an 8-hour work shift.
19 - U.S. EPA, 2002a.
20 - IDEM, 2004.
21 - VDEQ, 2004.
22 - Foster, and Chrostowski, 1987.
23 - U.S. EPA Region 4, 2000.



ANOVA –	Analysis of variance
BG –	Background
COPC –	Chemical of potential concern
Corr. –	Correlation
FOD –	Frequency of detection
HOV –	Homogeneity of variance
m –	Number of values in the background data set
n –	Number of values in the site data set
ND –	Non-detect
Prob. –	Probability
Std. Dev. –	Standard deviation
Stoich. –	Stoichiometric
UTL –	Upper tolerance limit
WRS –	Wilcoxon Rank-SuM

Footnotes:

(1) These tests will be completed as necessary and useful. Project requirements and needs will determine methods for assessment. The data analysis suggests that this procedure may also be useful when $n,m \leq 2$ and $n + m \leq 12$. However, small data sets limit the power and significance of all of the suggested techniques and, in some cases, the data analysis is not possible.

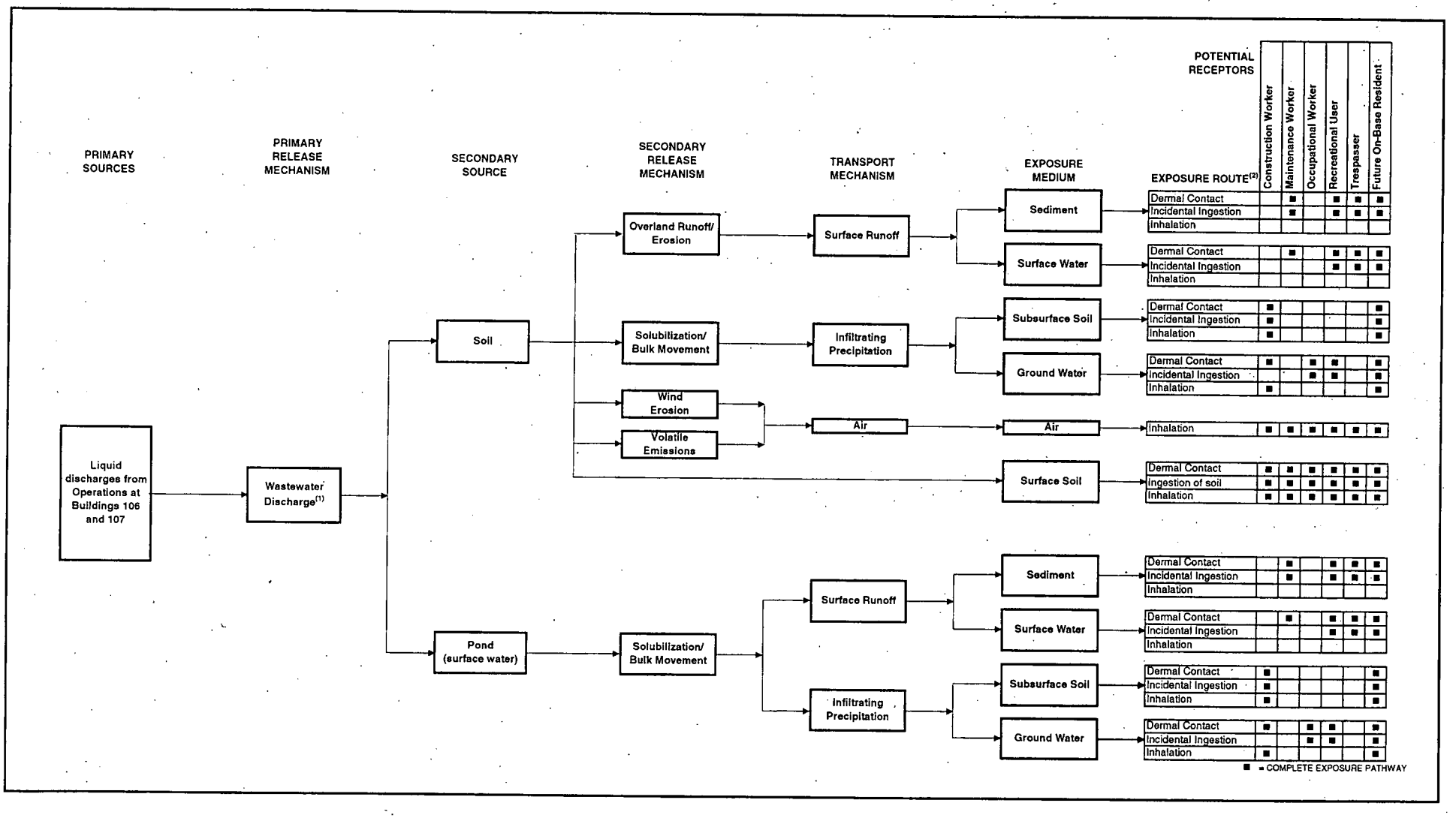
(2) Three data points are necessary to calculate the UTL. Otherwise, the maximum background is used as the critical value for comparison.

(3) $n + m$ must be ≥ 3.

Figure C-1
Statistical Analysis Diagram
Background Investigation
September 2004

FIGURE C-2

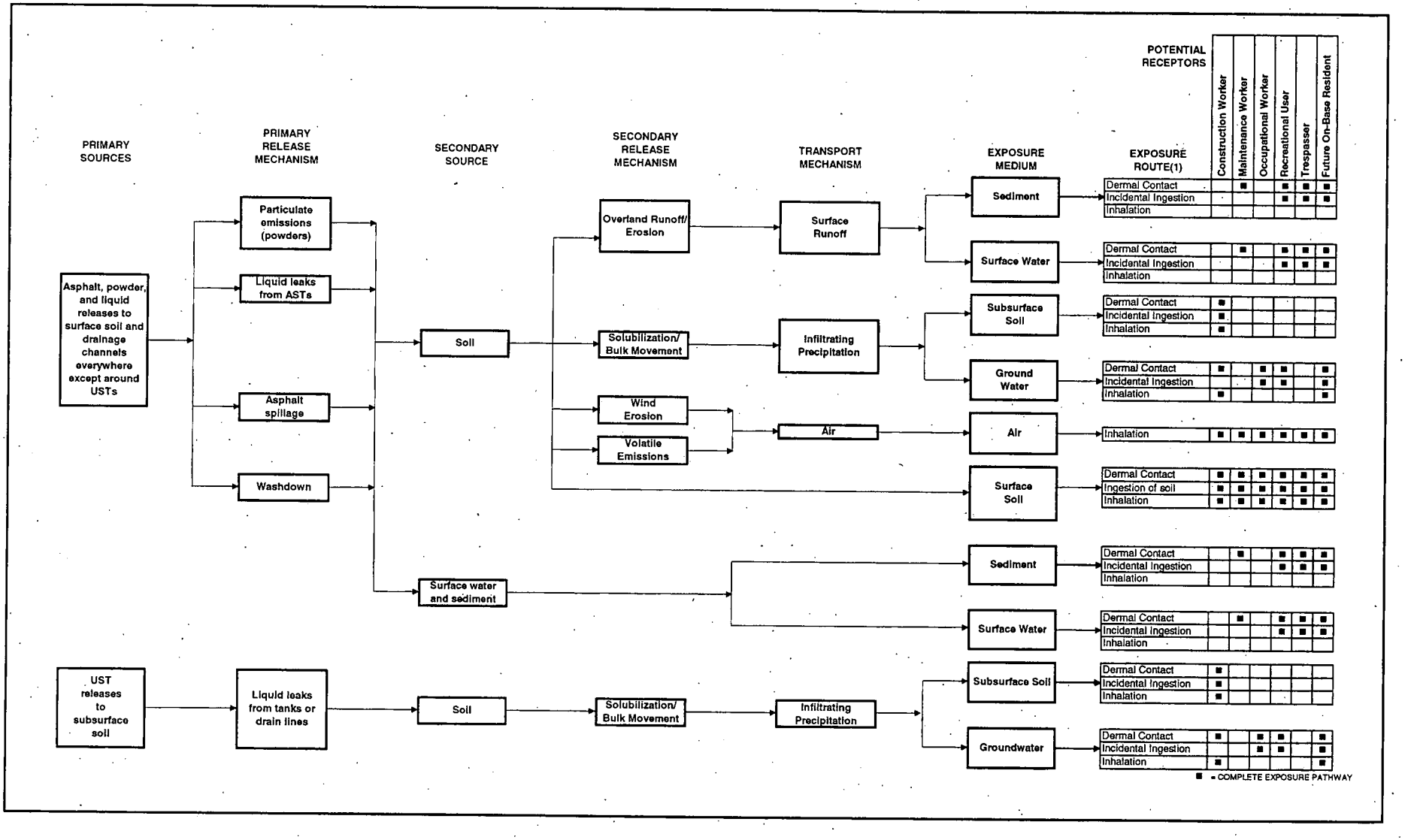
HUMAN HEALTH CONCEPTUAL SITE MODEL
SWMU 8 (BUILDING 106 POND)
NSWC CRANE, INDIANA



1 - Wastewater containing explosives was collected in sumps from which the water was released directly to surface drainage that flows into Boggs Creek.
2 - Blank space indicates incomplete exposure pathway or relatively insignificant or not applicable potential exposure.

FIGURE C-3

HUMAN HEALTH CONCEPTUAL SITE MODEL
SWMU 15 (ROADS AND GROUND AREA)
NSWC CRANE, INDIANA



1- Blank space indicates incomplete exposure pathway or relatively insignificant or not applicable potential exposure.
USTs = Underground storage tanks.
ASTs = Aboveground storage tanks.

APPENDIX D

ECOLOGICAL RISK ASSESSMENT METHODOLOGY

ACRONYMS

%	percentage
%L	percentage of lipids in fish
%TOC	percentage of total organic carbon in sediment
µg	microgram
ATSDR	Agency for Toxic Substances and Disease Registry
BAF	Bioaccumulation factor
BERA	Baseline Ecological Risk Assessments
bgs	below ground surface
BSAF	biota-sediment accumulation factor
BTEX	benzene, toluene, ethylbenzene, and xylene
BW	Body weight
CDI	chronic daily intake
COC	chemical of concern
COPC	contaminants of potential concern
Csd	contaminant concentration in sediment
Css	contaminant concentration in surface soil
Csw	contaminant concentration in surface water
EEQ	Ecological effects quotient
EMRs	Environmental Monitoring Reports
ERA	Ecological Risk Assessment
ESLs	ecological screening levels
FC	contaminant concentration in food
FI	food ingestion rate
HMX	octahydro 1,3,5,7 tetranitro 1,2,5,7-tetrazocine or cyclotetramethylene tetranitramine
IA	Installation Assessment
IAS	Initial Assessment Study
IRIS	Integrate Risk Information System
kg	kilogram
L	liter
LOAEL	lowest-observed-adverse-effect-level
MEK	methyl-ethyl ketone
mg	milligram
MTBE	methyl tert-butyl ether

NOAELs	No-observed-adverse-effects levels
NSWC	Naval Surface Warfare Center
ORNL	Oak Ridge National Laboratory
PAHs	polynuclear aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PEC	probable effect concentration
QAPP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SC	soil/sediment concentration
SC	contaminant concentration in surface soil or sediment
SDSL	sediment screening level
SERA	screening-level ecological risk assessment
SI	incidental soil/sediment ingestion rate
SQG	Sediment Quality Guideline
SSSL	surface soil screening level for plants or invertebrates
SVOC	semivolatile organic compound
SW	surface water concentration
SWMU	Solid Waste Management Unit
SWSL	surface water screening level
TEC	threshold effect concentration
TNT	2,4,6-trinitrotoluene
TRV	toxicity reference value
U.S. EPA	United States Environmental Protection Agency
UCL	Upper Confidence Level
VOC	volatile organic compound
WI	surface water ingestion rate
WQC	Water Quality Criteria
WQS	Water Quality Standard

APPENDIX D
ECOLOGICAL RISK ASSESSMENT METHODOLOGY

The goal of the screening-level ecological risk assessment (SERA) to be performed as part of the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) is to identify the contaminants of potential concern (COPC) detected at concentrations that exceed screening levels, to identify the locations of these exceedances, and to establish whether or not further investigation and/or remedial action at Solid Waste Management Units(SWMUs) 8 and 15 at Naval Surface Warfare Center (NSWC) Crane is warranted from an ecological perspective.

D.1 INTRODUCTION

The SERA methodology used at NSWC Crane is in accordance with the following guidance documents:

- Department of Navy Environmental Policy Memorandum 97-04: Use of Ecological Risk Assessments dated May 16, 1997.
- Navy Policy for Conducting Ecological Risk Assessment (Navy, 1999).
- Risk Integrated System of Closure. User's Guide and Technical Resource Guidance Document (IDEM, 2004).
- Final Guidelines for Ecological Risk Assessment (U.S. EPA, 1998).
- Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (U.S. EPA, 1997a).

The SERA will consist of Steps 1, 2, and 3a of the eight ecological risk evaluation steps required by United States Environmental Protection Agency (U.S. EPA) guidance (U.S. EPA, 1997a and 1998) and the Navy Policy for Conducting Ecological Risk Assessments (ERAs) (Navy, 1999). These eight steps comprise Steps 1 and 2, which constitute a SERA, followed by four additional steps, which constitute a Baseline ERA (BERA), and conclude with Step 8, a risk management evaluation. Step 3a is technically the first step of the BERA and it consists of a refinement of the conservative exposure assumptions. Steps 3b through 7 are conducted if additional evaluations or investigations are necessary. Aspects of

Step 8, risk management, are addressed throughout the ERA process, in cooperation with the Region 5 regulators.

A schematic diagram of the general risk assessment process is provided in Figure D-1. In addition, Figures D-2, D-3, and D-4 are flow charts that summarize the ERA process that will be used to evaluate risks for ecological receptors exposed to chemicals to surface soil, sediment, and surface water, respectively. These flow charts are discussed later in this methodology.

D.2 SCREENING-LEVEL PROBLEM FORMULATION

The screening-level problem formulation includes identification of potential receptor groups, COPCs, and the mechanisms for contaminant 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. These characteristics, as they apply to ecological risk, are described in the following subsections.

D.2.1 Environmental Setting

D.2.1.1 Basewide Environmental Setting

A biological characterization of NSWC Crane, including a list 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 (EMRs) (Halliburton NUS, 1992a and 1992b). A list of the species that may inhabit NSWC Crane and are protected under the United States Endangered Species Act, Indiana Department of Natural Resources Heritage Data Center, or the United States Fish and Wildlife Service is summarized in the RCRA Facility Permit (U.S. EPA, 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. Open spaces 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 animal species diversity (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, and mice; birds such as ducks, geese, wild turkey, bobwhite quail, red-tailed hawks, and American robins; and various amphibians, reptiles, fish, and invertebrates.

The Endangered Species Management Plan for NSWC Crane (Andrews, 2000) identified the federal and State threatened and endangered species and species of special concern potentially present at NSWC Crane. Information included in the Endangered Species Management Plan was obtained from studies and surveys conducted by the Navy and other agencies and groups such as research institutions. A small subset of these studies include the Inventory of Neotropical Migratory Birds, Mist Net and Radiotelemetry Surveys for the Indiana bat, Bobcat Trapping, Rattlesnake Survey, Purdue University Wildlife Studies, and several fish surveys and bird counts. These studies and others that were used in compiling the list of endangered species present at NSWC Crane are described in more detail in the Endangered Species Management Plan (Andrews, 2000).

The Indiana bat and bald eagle are the only federally threatened or endangered species at NSWC Crane. The bald eagle is not likely present at either SWMU due to a lack of vast expanses of open water (i.e., the preferred hunting habitat for the bald eagle). In addition, a number of State endangered and federal and State species of concern have been listed (Andrews, 2000). The State endangered species list includes two mammals (bobcat and Indiana bat), one reptile (timber rattlesnake), and several birds (bald eagle, osprey, loggerhead shrike, yellow-crowned night-heron, Virginia rail, king rail, and Henslow's sparrow. The Rare Animals of Indiana list (Indiana DNR, 2002) was also reviewed to verify that no changes in the status of these species had occurred since October 2000. This list is much larger than that presented in Andrews (2000) and is not reiterated here. An internet search was conducted to verify that the species listed above did not experience a change in status.

Six main creeks receive drainage in five separate drainage basins at NSWC Crane: Furst Creek, Sulphur Creek, Little Sulphur Creek, Boggs Creek, Turkey Creek, and Seed Tick Creek. There also are many smaller streams, creeks, and drainage ditches located at the facility, along with several small man-made ponds and one large lake (Lake Greenwood). Lake Greenwood is the source of potable water for NSWC Crane. Surface water from the facility eventually discharges to the eastern fork of the White River, which is located south of the facility.

D.2.1.2 Site Specific Environmental Setting

This section presents the environmental setting at each SWMU. Figures showing the locations of the SWMUs are presented in Section 1.0 of the Quality Assurance Project Plan (QAPP). Figures D-5 and D-6 are aerial photographs of the SWMUs and indicate the SWMU boundaries.

SWMU 8 - Building 106 Pond Area

SWMU 8 is a relatively industrialized area consisting of buildings, roads, railroad lines, parking lots, a retention pond, maintained grass, and wooded areas. The wooded area at the SWMU represents sufficient ecological habitat, however, the SWMU is surrounded to the north and west by parking lots and buildings. Surface drainage from the Building 106 Pond is routed via ditches and culverts to intermittent drainageways that traverse slopes on the southern border of the site. These swales are generally grass covered, and the solid medium in these ditches could be considered either soil or sediment. Whether the swales will be evaluated as soil or sediment in the risk assessment depends on field observations during sample collection. Drainage from these ditches flows into larger intermittent drainageways, which flow south-southeastward into Boggs Creek. Boggs Creek flows south-southeastward to merge with Turkey Creek, which continues southward past the southern boundary of the base. Although the Building 106 Pond is not regularly stocked and is relatively small (approximately 50 feet by 75 feet), the pond supports a small aquatic community. During the field investigation, the pond will be visually inspected to determine if the pond supports fish. Other ecological receptors likely present in the areas surrounding SWMU 8 include a number of small mammals and birds. Some of these species may include white-tailed deer, coyote, hawks, red fox, rabbits, raccoons, and mice, and birds such as ducks, geese, wild turkey, bobwhite quail, red-tailed hawks, and American robins.

SWMU 15 - Roads and Grounds Area

The SWMU 15 setting is similar to that described for SWMU 8 and includes buildings, roads, railroad lines, parking lots, and a grass-covered hillside. There is little ecological habitat at SWMU 15 except for the hillside area east of the SWMU. The forested hillside likely supports ecological receptors similar to those described for SWMU 8. Surface drainage at the Roads and Grounds Area is routed via ditches and culverts to intermittent drainageways within the SWMU that flow into a single intermittent drainageway that continues to flow towards the south-southeast under Highway 99. Surface flow continues towards the south while gaining volume from other intermittent sources until it enters Turkey Creek. Turkey Creek flows south-southwest to merge with Boggs Creek. Boggs Creek continues to flow south, exiting the

southern boundary of NSWC Crane. South of NSWC Crane, Boggs Creek eventually flows into the eastern fork of the White River.

D.2.2 Contaminants, Ecotoxicity, and Fate and Transport

Based on the limited historical site data available, the following parameters are among the site-related chemical contaminants known to be present or potentially present in environmental media in SWMUs 8 and 15:

SWMU 8

- Explosives [e.g., 2,4,6-trinitrotoluene (TNT) and octahydro 1,3,5,7 tetranitro 1,2,5,7-tetrazocine or cyclotetramethylene tetranitramine (HMX)]
- Metals
- Polychlorinated biphenyls (PCBs).
- Semivolatile organic compounds (SVOCs)
- Volatile organic compounds (VOCs) [including methyl-ethyl ketone (MEK)]
- Petroleum hydrocarbons

SWMU 15

- Cyanide
- Herbicides
- Metals
- PCBs
- Pesticides
- Petroleum hydrocarbons
- SVOCs [including polynuclear aromatic hydrocarbons (PAHs) and carbazole]
- VOCs [including benzene, toluene, ethylbenzene, and xylene (BTEX) and methyl tert-butyl ether (MTBE)]

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 BAFs are briefly discussed in this section.

The SERA will use various BAFs to predict contaminant loading in food items consumed by wildlife. The following list presents the sources of the BAFs that may be used in the SERA:

- Plant BAFs (Organics): Toxicity and Chemical-Specific Factors Database (ORNL, 2002).
- Plant BAFs (Inorganics): Empirical Model for the Uptake of Inorganic Chemicals from Soil by Plants (ORNL, 1998a).
- Soil Invertebrate BAFs: Development and Validation of Bioaccumulation Models for Earthworms (Sample et al., 1998).

Other plant and invertebrate BAFs obtained from the literature may be used for contaminants that are not listed in the above-referenced sources. Contaminants that do not have BAFs (i.e., chemicals for which literature values could not be found) will be assigned a default value of 1.

If it is determined during the field investigation that the pond at SWMU 8 and/or the intermittent streams at SWMU 8 and/or SWMU 15 support adequate numbers of fish to conduct food-chain modeling, biota-sediment accumulation factors (BSAFs) will be used to predict contaminant concentrations in fish tissue from contaminant concentrations in sediment. The BSAFs for organic compounds will be obtained from The Incidence and Severity of Sediment Contamination in Surface Waters of the United States, Volume 1: National Sediment Quality Survey (U.S. EPA, 1997b) and other literature, as deemed appropriate. Fish BSAFs for metals are not available, so sediment invertebrate bioaccumulation factors (ORNL, 1998b) will be used as default values for metals.

D.2.3 Potential Exposure Pathways

Section 1.3 of the QAPP presents detailed descriptions of the potential sources of contamination for each of the SWMUs. The contaminants from these sources may have migrated to soil, sediment, surface water, and/or ground water via various transport pathways (e.g., particulate emissions, runoff, leaks, direct discharge, etc.). Section 1.4.1 describes the operational history, deposition mechanisms, and potential contaminant migration patterns for SWMUs 8 and 15.

D.2.3.1 Surface Soil

Several groups of terrestrial ecological receptors can be exposed to contaminants in surface soil. Invertebrates such as earthworms are exposed to 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. Contaminants are then translocated to different parts of the plants (e.g., leaves, seeds). These pathways will be evaluated in the SERA.

Small mammals may be exposed to contaminants in soil via several exposure routes. They may be exposed by direct contact as they search for food or burrow into the soil. Exposure of terrestrial wildlife to contaminants in the soil via dermal contact is unlikely to represent a major exposure pathway because fur, feathers, and chitinous exoskeletons are expected to minimize transfer of contaminants across dermal tissue. Therefore, the dermal pathway will not be evaluated in the SERA. Small mammals also may be exposed to contaminants in the soil via incidental ingestion of soil and ingestion of plants and/or invertebrates that have accumulated contaminants from the soil. These pathways will be evaluated in the SERA.

Larger predatory species such as the red fox and red-tailed hawk can be indirectly exposed to soil contaminants by ingesting small mammals that have accumulated contaminants from soil. These pathways will not be quantitatively evaluated in the SERA for reasons discussed in Section D.2.4.1.

D.2.3.2 Ground Water

Ecological receptors are not directly exposed to contaminants in ground water at the site. Exposure to ground water discharging as a seep or directly to a surface water body represents a complete exposure pathway and will be evaluated as part of the surface water pathway.

D.2.3.3 Surface Water/Sediment

As mentioned above, contaminants in ground water may discharge as a seep that flows into surface water or may discharge directly into a surface water body. Contaminants in soil may also enter the intermittent drainage channels at SWMUs 8 and 15 via overland flow.

The only aquatic habitats at the SWMUs include the industrial wastewater pond at SWMU 8 and intermittent drainage channels that support benthic macroinvertebrates and possibly small fish in some areas at SWMUs 8 and 15. These receptors could be exposed to chemical contamination by direct

contact with, and ingestion of, contaminated surface water or sediments. Piscivorous wildlife may consume fish that have accumulated chemicals from surface water and sediment. Although it is unlikely that piscivorous wildlife will obtain significant portions of their diet from these surface water sources, this exposure pathway may be evaluated to address potential impacts of these receptors (see Section D.2.4.3).

D.2.3.4 Air

Although inhalation of particulates by mammals and birds may be a complete pathway, it is expected to be insignificant compared to other pathways such as ingestion of food items that have bioaccumulated contaminants from soil. Also, inhalation pathways typically are not evaluated in SERAs because of the uncertainty inherent in estimating exposure levels and toxicological effects. Therefore, the air inhalation pathway will not be evaluated in the SERA.

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 (U.S. EPA, 1997a). The selection of these endpoints is based on the habitats present, the migration pathways of probable contaminants, and the relevant exposure routes for the receptors.

As already discussed in D.2.1.2, the habitat at and adjacent to SWMUs 8 and 15 consists primarily of open areas with grasses and shrubs surrounded by wooded areas; however, a large portion of both SWMUs, especially SWMU 15, consists of buildings and paved areas that provide little habitat for ecological receptors (see Figures D-5 and D-6). The drainageways adjacent to the sites are intermittent, but they ultimately drain to larger water bodies. Based on the habitats at the SWMUs, the assessment endpoints include protection of the following groups of receptors from adverse effects of contaminants on their growth, survival, and reproduction:

- Soil invertebrates
- Terrestrial vegetation
- Herbivorous birds and mammals
- Soil invertebrate-eating birds and mammals (invertivores)
- Benthic invertebrates
- Fish (if present)

- Piscivorous birds and mammals (Building 106 pond)
- Amphibians and reptiles

The following paragraphs discuss the reasons that the above assessment endpoints were selected for evaluation in the SERA.

Soil Invertebrates: Soil invertebrates are expected to be present in the soil at the SWMUs. They aid in the formation of soil and the redistribution and decomposition of organic matter in the soil, and they serve as a food source for higher trophic-level organisms. They also can accumulate some bioaccumulative contaminants that can then be transferred to the higher trophic-level organisms that consume invertebrates.

Terrestrial Vegetation: Terrestrial vegetation at the SWMUs (where present) consists of grasses, shrubs, and trees. They serve as a food source and provide shade and cover for many organisms, and they help to 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 (i.e., animals that consume only plant tissue) may be present in vegetative habitats at the SWMUs. Their role in the community is essential because, without them, higher trophic levels could not exist (Smith, 1966). They may be exposed to and accumulate contaminants present in the plants they consume.

Soil Invertebrate-Eating Birds and Mammals: Soil invertebrate-eating birds and mammals are present throughout the base in different terrestrial habitats (i.e., forested, open field) and are likely present at the SWMUs. These are considered first-level carnivores, and they serve as a food source for higher trophic-level carnivores. They may be exposed to and accumulate contaminants present in the food items they consume.

Benthic Macroinvertebrates: Benthic macroinvertebrates are similar to soil invertebrates in that they serve as a food source for higher trophic-level organisms (i.e., fish, amphibians, birds, mammals). They also can accumulate some contaminants that can then be transferred to higher trophic-level organisms that consume invertebrates. Their presence in the intermittent drainageways will be ephemeral because of a lack of suitable habitat and water flow.

Fish: Fish are potentially present in the Building 106 Pond, but fish are not expected to be present in the drainageways leading away from SWMUs 8 or 15 because the drainageways are usually dry. Additionally, SWMUs 8 and 15 are located within the Boggs and Turkey Creek Drainage Basin, which is one of five drainage basins that carry surface water off the installation. Boggs Creek and Turkey Creek are perennial streams and support fish year-round. Turkey Creek is located adjacent to and downstream of SWMU 15. Fish in Boggs Creek and Turkey Creek may be exposed to and can accumulate contaminants from the food items they consume or from the surface water in which they live. However, fish in these water bodies will not be evaluated as part of the SERA because no surface water or sediment samples will be collected from Boggs Creek or Turkey Creek.

Piscivorous Birds and Mammals: Piscivorous birds and mammals may occasionally feed on fish if present in the Building 106 Pond.

Amphibians and Reptiles: Amphibians are expected to inhabit water bodies and the surrounding areas, and 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, or surface soil in which they live.

Not all of the potential assessment endpoints listed above will be evaluated in the SERA. As indicated in U.S. EPA guidance (U.S. EPA, 1997a), "it is not practical or possible to directly evaluate risks to all of the individual components of the ecosystem at a site. Instead, assessment endpoints focus the risk assessment on particular components of the ecosystem that could be adversely affected by contaminants from the site." Therefore, the SERA will focus on the endpoints that will tend to yield the highest risks, which should then account for endpoints that will have lower risks (see below).

Upper-level carnivorous birds and mammals were not chosen as assessment endpoints because the greatest exposure to site contaminants is expected to occur to small mammals and birds that ingest invertebrates, fish, or plants. Additionally, the known or potentially contaminated areas at SWMUs 8 and 15 represent only a fraction of these large carnivores' home ranges, and they are only expected to obtain a small portion of their food from the SWMUs. SWMU 8 covers approximately 3.5 acres; SWMU 15 covers approximately 20 acres; however, approximately 3.5 acres are covered by buildings, indicating that the potential feeding area for upper-level species at SWMU 15 is approximately 16.5 acres. The home ranges of the red fox and red-tailed hawk are 193 acres and 370 acres, respectively (U.S. EPA, 1993), so the SWMUs represent only a fraction (i.e., 2 and 9 percent, for the fox and 1 and 4.5 percent for

the hawk at SWMUs 8 and 15, respectively) of these species' feeding areas. Also, because of the industrialized nature of both SWMUs, there are not likely to be large numbers of small mammals at the SWMUs that could be consumed by upper-level carnivorous birds and mammals. Therefore, by protecting the small herbivorous and insectivorous mammals and birds that may obtain all of their food from the SWMUs, large carnivorous mammals and birds will also be protected.

Omnivores were not selected as assessment endpoints because exposure to contaminants in plants is greatest for herbivores and exposure to contaminants in invertebrates is greatest for insectivores. Therefore, omnivores will be protected by protecting herbivores and invertivores.

D.2.4.2 Measurement Endpoints

Measurement endpoints are estimates of measurable 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 the SERA, where applicable:

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

- Wildlife toxicity reference values (TRVs) - Mortality, reproductive, and/or developmental effects of birds and mammals will be evaluated by comparing the estimated dose incurred (based on conservative and average assumptions) from ingestion of contaminants in surface water, sediment, surface soil, plants, invertebrates, and potentially fish to wildlife TRVs.

- 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 of chemicals in 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 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 environments at the SWMUs are typically grouped into general categories such as soil invertebrates and vegetation. This is a reflection of the nature of the threshold values, affects values, or criteria typically used to characterize risk for such organisms. However, for vertebrate receptors selection of a representative species is required so that risks incurred by intake through eating and drinking can be estimated to these upper-level species.

Ingestion is the primary route of exposure for most mammals and birds. The selection of species used to represent the receptor groups identified in Section D.2.4.1 was based on considerations of their preferred habitat, body size, sensitivity to contaminants, home range, abundance, commercial or sport utilization, legal status, and functional role (e.g., predators). To be conservative, chosen representative species have small home ranges. The availability of exposure parameters such as body mass, feeding rate, and drinking rate may also be a factor in selecting surrogate species. The following surrogate species are proposed for use in food-chain modeling:

- Herbivorous mammal - meadow vole
- Herbivorous bird - bobwhite quail
- Insectivorous bird - American robin
- Insectivorous mammals - short tail shrew
- Piscivorous mammal - raccoon
- Piscivorous bird - belted kingfisher

Piscivorous receptor species will only be evaluated if it is determined by visual observation during the field investigation that the Building 106 pond and/or the intermittent stream adjacent to SWMU 15 support fish. Receptor profiles for each of these species are presented in Attachment D-1.

D.2.4.4 <u>Conceptual Model</u>

A conceptual model in problem formulation is a written description and visual representation of predicted relationships between ecological entities and the stressors to which they may be exposed. The conceptual model consists of two primary components: predicted relationships among stressor, exposure, and assessment endpoint response and a diagram that illustrates the relationships (U.S. EPA, 1998).

The primary sources of known or potential contamination at the sites were identified based on past operational practices and the physical characteristics of the sites. The primary stressors are contaminants in surface soil, surface water, sediment, and ground water. Because ecological receptors are not directly exposed to contaminants in ground water, secondary stressors are contaminants in the surface water and sediment. The primary receptors for contaminants in surface soil are plants and invertebrates, and secondary receptors are birds and mammals. The primary receptors for contaminants in surface water and sediment are fish and aquatic/benthic invertebrates, and secondary receptors are birds and mammals. Figures D-7 and D-8 present the conceptual site models for SWMUs 8 and 15, respectively.

D.3 ECOLOGICAL EFFECTS EVALUATION/SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN

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 toxicological evaluation, it may also include descriptions of apparent effects seen during the site visit (i.e., stressed vegetation). 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 aquatic 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 contaminant concentrations in surface water, sediment, and surface soil samples to Region 5 ecological screening levels (ESLs) (U.S. EPA, 1999). U.S. EPA has developed Ecological Soil Screening Levels (Eco SSLs) for a few chemicals. These values will be used instead of the Region 5 ESLs because they are based on more recent data. Also, the Region 5 ESLs for surface water are the lowest water quality criteria for the various states in U.S. EPA Region 5. State of Indiana Water Quality Standards (WQSs) or U.S. EPA Water Quality Criteria (WQCs) will be used in place of the Region 5 ESLs for surface water because the Region 5 ESLs may not be appropriate for Indiana. The following bullets present the rules for selecting chemicals as COPCs:

- A contaminant will be retained as a COPC if the maximum detected concentration exceeds the associated ESL (or substituted screening level as described above) in surface soil, surface water, or sediment.

- 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 ESLs will be retained as COPCs, but they may only be evaluated qualitatively. Contaminants retained as COPCs will be further evaluated as part of Step 3a of the eight-step ERA process.

D.4 STEP 3A -REFINEMENT OF CONSERVATIVE EXPOSURE ASSUMPTIONS

Step 3a consists of refining the conservative exposure assumptions/concentrations when evaluating potential risks to ecological receptors (i.e., plants, invertebrates, and wildlife receptors) and re-evaluating the analytical data using benchmarks that may be more appropriate for the assessment endpoints. The objective of the Step 3a evaluation is to further reduce the number of chemicals retained as chemicals of concern (COCs), if possible, to focus any additional efforts on those chemicals causing ecological concern. The Step 3a evaluation is designed to eliminate chemicals from further evaluation for certain groups of receptors. For example, a chemical may not be retained as a COC in soil based on risks to soil invertebrates but may be retained for evaluating risks to plants or wildlife. Therefore, chemicals are evaluated during the Step 3a evaluation in order from plants/invertebrates, aquatic receptors, and ending with wildlife.

As presented in Section D.1, Figures D-2, D-3, and D-4 are flow charts that present the ERA process that will be used to evaluate risks to ecological receptors from chemicals in the soil, sediment, and surface water, respectively. As shown in the flow charts, the very first step in the process is comparing the maximum contaminant concentration to a screening level to determine if the chemical is selected as a COPC. The following sections describe the process for further evaluating chemicals that are retained as COPCs in soil, sediment, and surface water.

Surface soil: If the chemical is selected as a COPC in surface soil, the chemical is carried through three independent flow paths: 1) to further evaluate risks to plants, 2) to further evaluate risks to invertebrates, and 3) to further evaluate risks to wildlife (i.e., mammals and birds). This further evaluation is conducted to determine if there are potential risks from that chemical to all three receptor groups (i.e., plants, invertebrates, and wildlife), or to only one or two of the receptor groups. This is important because if the site proceeds further in a BERA, the studies in the BERA should only focus on the receptors that are at potential risk. Because most of the Region 5 soil screening levels are based on risks to mammals or birds, potential risks to plants and invertebrates are not known. Therefore, the first step in the Step 3a evaluation will be to compare the maximum chemical concentration in the soil to no-effects benchmarks

for plants and invertebrates (if benchmarks are available). The following bullets outline decisions that will be made based on this comparison:

- If the concentration is less than the no-effects benchmark, it will be concluded that the chemical is not causing an unacceptable risk to that receptor group and the chemical will not be evaluated further in Step 3a.

- If the chemical concentration is greater than the no-effects benchmark (or the chemical does not have a no-effects benchmark) and greater than background, the chemical will be further evaluated in Step 3a to determine if the risks are great enough to warrant additional evaluations [i.e., proceed to a BERA, develop cleanup levels, proceed to a corrective measures study (CMS), etc.].

- If the concentration is greater than the no-effects benchmark (or the chemical does not have a no-effects benchmark) but is less than background, it will be concluded that the chemical is not causing an unacceptable site-related risk to that receptor group and the chemical will not be evaluated further in Step 3a.

Concurrent with the evaluation of risks to plants and invertebrates, chemicals that are retained as COPCs are further evaluated to determine if there are unacceptable risks to wildlife. Even though the screening level may have been based on risks to wildlife, risks to wildlife are further evaluated in Step 3a because the screening levels are very conservative. The first step in the process is to determine if the COPC is bioaccumulative. A chemical is considered to be bioaccumulative if it is included in the list of important bioaccumulative chemicals in USEPA (2000). If the chemical is not bioaccumulative, it will not be carried through the food chain model and it will be concluded that the chemical is not causing an unacceptable risk to wildlife. If the chemical is bioaccumulative, it will be carried through the food chain model. The following bullets outline decisions that will be made based on the results of the food chain model:

- If the ecological effects quotient (EEQ) (see Section D.5) is less than 1.0 using average contaminant concentrations and exposure factors and the No Observable Adverse Effects Level (NOAEL) as the TRV, it will be concluded that the chemical is not causing an unacceptable risk to wildlife and the chemical will not be evaluated further in Step 3a.

- If the EEQ is greater than 1.0 using average contaminant concentrations and exposure factors and the NOAEL) as the TRV, and the concentration of the chemical is greater than background, the chemical will be further evaluated in Step 3a to determine if the risks are great enough to warrant

additional evaluations [i.e., proceed to a BERA, develop cleanup levels, proceed to a corrective measures study (CMS), etc.].

- If the EEQ is greater than 1.0 using average contaminant concentrations and exposure factors and the NOAEL) as the TRV, but the concentration of the chemical is less than background, it will be concluded that the chemical is not causing an unacceptable site-related risk to wildlife and the chemical will not be evaluated further in Step 3a.

For chemicals that are further evaluated in Step 3a, the factors described in Section D.4.1 will be used to determine if the risks are great enough to warrant additional evaluations [i.e., proceed to a BERA, develop cleanup levels, proceed to a corrective measures study (CMS), etc.].

Sediment: If the chemical is selected as a COPC in sediment, the chemical is carried through two independent flow paths: 1) to further evaluate risks to invertebrates, and 2) to further evaluate risks to wildlife (i.e., mammals and birds). This further evaluation is conducted to determine if there are potential risks from that chemical to both receptor groups (i.e., invertebrates and wildlife), or to only one of the receptor groups. This is important because if the site proceeds further in a BERA, the studies in the BERA should only focus on the receptors that are at potential risk. Because many of the Region 5 sediment screening levels are based on equilibrium partitioning, if the screening level is not based on the consensus-based freshwater sediment quality guideline, threshold effects concentration (TEC) (MacDonald, 2000), the maximum contaminant concentration will be compared to an alternate lower effects level following the order of preference in Figure D-5. The following bullets outline decisions that will be made based on this comparison:

- If the concentration is less than the lower-effects benchmark, it will be concluded that the chemical is not causing an unacceptable risk to invertebrates and the chemical will not be evaluated further in Step 3a.

- If the concentration is greater than the lower-effects benchmark, or if the TEC was used as the Region 5 ESL, and the chemical concentration is greater than background (or upgradient concentrations), the chemical will be further evaluated in Step 3a to determine if the risks are great enough to warrant additional evaluations [i.e., proceed to a BERA, develop cleanup levels, proceed to a corrective measures study (CMS), etc.].

- If the concentration is greater than the lower-effects benchmark, or if the TEC was used as the Region 5 ESL, but the chemical concentration is less than background (or upgradient concentrations), it will be concluded that the chemical is not causing an unacceptable site-related risk to invertebrates and the chemical will not be evaluated further in Step 3a.

Concurrent with the evaluation of risks to invertebrates, chemicals that are retained as site-related COPCs are further evaluated to determine if there are unacceptable risks to wildlife. The first step in the process is to determine if the COPC is bioaccumulative. A chemical is considered to be bioaccumulative if it is included in the list of important bioaccumulative chemicals in USEPA (2000). If the chemical is not bioaccumulative, it will not be carried through the food chain model and it will be concluded that the chemical is not causing an unacceptable risk to wildlife. If the chemical is bioaccumulative, it will be carried through the food chain model. The following bullets outline decisions that will be made based on the results of the food chain model:

- If the EEQ (see Section D.5) is less than 1.0 using average contaminant concentrations and exposure factors and the NOAEL as the TRV, it will be concluded that the chemical is not causing an unacceptable risk to wildlife.

- If the EEQ is greater than 1.0 using average contaminant concentrations and exposure factors and the NOAEL) as the TRV, and the chemical concentration is greater than background (or upgradient concentrations) the chemical will be further evaluated in Step 3a to determine if the risks are great enough to warrant additional evaluations [i.e., proceed to a BERA, develop cleanup levels, proceed to a corrective measures study (CMS), etc.]

- If the EEQ is greater than 1.0 using average contaminant concentrations and exposure factors and the NOAEL) as the TRV, but the chemical concentration is less than background (or upgradient concentrations), it will be concluded that the chemical is not causing an unacceptable site-related risk to wildlife.

For chemicals that are further evaluated in Step 3a, the factors described in Section D.4.1 will be used to determine if the risks are great enough to warrant additional evaluations [i.e., proceed to a BERA, develop cleanup levels, proceed to a corrective measures study (CMS), etc.].

Surface Water: If the chemical is selected as a COPC in surface water, the chemical is carried through two independent flow paths: 1) to further evaluate risks to aquatic organisms, and 2) to further evaluate

risks to wildlife (i.e., mammals and birds). This further evaluation is conducted to determine if there are potential risks from that chemical to both receptor groups (i.e., invertebrates and wildlife), or to only one of the receptor groups. This is important because if the site proceeds further in a BERA, the studies in the BERA should only focus on the receptors that are at potential risk. Organic chemicals that are retained as COPCs will be evaluated directly in Step 3a. However, for metals, the following decisions will be made:

- If the metal was either not detected in the filtered samples, or was detected at a concentration less than the screening level in the filtered samples, it will be concluded that the chemical is not causing an unacceptable risk to aquatic organisms and the chemical will not be evaluated further in Step 3a.

- If the metal was detected in the filtered samples at a concentration greater than the screening level, and the chemical concentration is greater than background (or upgradient concentrations), it will be concluded that the chemical is not causing an unacceptable risk to aquatic organisms and the chemical will not be evaluated further in Step 3a.

- If the metal was detected in the filtered samples at a concentration greater than the screening level, but the chemical concentration is less than background (or upgradient concentrations), it will be concluded that the chemical is not causing an unacceptable risk to aquatic organisms and the chemical will not be evaluated further in Step 3a.

Concurrent with the evaluation of risks to aquatic organisms, chemicals that are retained as site-related COPCs are further evaluated to determine if there are unacceptable risks to wildlife. The first step in the process is to determine if the COPC is bioaccumulative. A chemical is considered to be bioaccumulative if it is included in the list of important bioaccumulative chemicals in USEPA (2000). If the chemical is not bioaccumulative, it will not be carried through the food chain model and it will be concluded that the chemical is not causing an unacceptable risk to wildlife. If the chemical is bioaccumulative, it will be carried through the food chain model. The following bullets outline decisions that will be made based on the results of the food chain model:

- If the EEQ (see Section D.5) is less than 1.0 (based on the surface water portion of the food chain model) using average contaminant concentrations and exposure factors and the NOAEL as the TRV, it will be concluded that the chemical is not causing an unacceptable risk to wildlife.

- If the EEQ is greater than 1.0 (based on the surface water portion of the food chain model) using average contaminant concentrations and exposure factors and the NOAEL) as the TRV, and the chemical concentration is greater than background (or upgradient concentrations) the chemical will be further evaluated in Step 3a to determine if the risks are great enough to warrant additional evaluations [i.e., proceed to a BERA, develop cleanup levels, proceed to a corrective measures study (CMS), etc.]

- If the EEQ is greater than 1.0 (based on the surface water portion of the food chain model) using average contaminant concentrations and exposure factors and the NOAEL) as the TRV, but the chemical concentration is less than background (or upgradient concentrations), it will be concluded that the chemical is not causing an unacceptable site-related risk to wildlife.

For chemicals that are further evaluated in Step 3a, the factors described in Section D.4.1 will be used to determine if the risks are great enough to warrant additional evaluations [i.e., proceed to a BERA, develop cleanup levels, proceed to a corrective measures study (CMS), etc.].

D.4.1 Other Step 3a Factors

For chemicals that are evaluated further in Step 3a, the following factors will be evaluated, as appropriate, to determine if the risks are great enough to warrant additional evaluations [i.e., proceed to a BERA, develop cleanup levels, proceed to a corrective measures study (CMS)].

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

- Frequency of chemical detection and spatial distribution: A chemical detected at a low frequency typically will be of less concern than a chemical detected at higher frequency if 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. In addition, the spatial distribution of a chemical may be evaluated to determine the area that a sample represents.

- 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 additional evaluation.

- Alternate benchmarks: These benchmarks are used to further evaluate risks to specific groups of ecological receptors (e.g., plants, invertebrates) because the ESLs are the most conservative values available for soil, sediment, and surface water and will ensure that more realistic exposure assumptions are evaluated. However, some of the alternate benchmarks are overly protective for some receptors and may not be applicable in some cases. For example, the ESLs for soil may be based on risks to small mammals. Therefore, an exceedance of that ESL does not necessarily indicate potential risks to plants or invertebrates, so other more appropriate benchmarks will be used to evaluate potential risks to those receptors. Some of these alternate benchmarks were used in the fist part of Step 3a to refine the list of chemicals that need further evaluated in Step 3a, as described above and in Figures D-2 and D-3.

In addition to the general Step 3a factors above, other factors may be evaluated in Step 3a for each receptor group. The following sections discuss the other factors than may be used, including the specific alternate benchmarks that may be used in Step 3a.

D.4.1.1 Terrestrial Plants and Invertebrates

The alternate benchmarks that will be used to further evaluate risks to plants and invertebrates are listed below. The ecological endpoint for the each benchmark that is used in this step will be provided in the ERA. For example, if a benchmark is based on a 25% reduction in growth to a lettuce plant, that information will be presented in the ERA.

- Canadian Soil Quality Guidelines (CCME, 1997).

- Oak Ridge National Laboratory (ORNL) Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision (Efroymson, et al., 1997a).

- ORNL Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision (Efroymson, et al., 1997b).

Additional sources of toxicity data from the literature may be used to evaluate potential risks to terrestrial vegetation and invertebrates from contaminants in the surface soil not evaluated in the above documents.

D.4.1.2 Sediment

In addition to the Step 3a factors presented above, additional evaluations for sediment will include comparing the chemical concentrations in the sediment to higher effects levels to show the probability a range of possible effects. The higher effects levels that will be used to further evaluate risks to benthic invertebrates will be from the same sources listed in order of preference in Figure D-3 with one exception. The Probable Effects Concentration (PEC) from MacDonald et al., (2000) will be the first higher effects level that will be selected. A description of what the higher effects level represent used in this step will be provided in the ERA. For example, the PECs were intended to identify contaminant concentrations above which harmful effects on sediment-dwelling organisms were expected to occur frequently (MacDonald, et al., 2000).

Also, emphasis will be placed on average sediment concentrations because the aquatic organisms will be exposed to average chemical concentrations as they swim in the water or as the sediment is transported downstream. Contaminants that exceed the SDSLs also will be compared to background contaminant levels developed in 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 factor to be considered in the lines-of-evidence approach for evaluating sediments.

This background comparison will be in addition to the site-specific background/upgradient comparison that is presented in the decision diamond on Figure D-5.

D.4.1.3 Surface Water

In addition to the Step 3a factors presented above, additional evaluations for surface water will include comparing the chemical concentrations in the surface water to acute water quality standards/criteria to show a range of possible effects. Also, emphasis will be placed on average surface water concentrations because the aquatic organisms will be exposed to average chemical concentrations as they swim in the water or the water flow over them (for organisms that are relatively sessile). Finally, more emphasis will be placed on the dissolved metals concentrations (compared to total metals concentrations) because dissolved metals are a better indicator of potential bioavailability that are total recoverable metals.

D.4.2 Food-Chain Modeling

Most of the above-mentioned standards and benchmark values are not designed to evaluate risks to terrestrial wildlife via the ingestion of the soil, sediment, surface water, plants, invertebrates, and fish. Therefore, a terrestrial intake model will be used to estimate exposure of terrestrial receptors to COPCs. As presented in Figures D-2, D-3, and D-4, food chain modeling will only be conducted on chemicals that are considered to be bioaccumulative [i.e., included in the list of important bioaccumulative chemicals in USEPA (2000)]. If the chemical is not bioaccumulative, it will not be carried through the food chain model and it will be concluded that the chemical is not causing an unacceptable risk to wildlife.

Risk to terrestrial receptors as a result of exposure to 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 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. 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 (ATSDR) toxicity profiles and Integrate Risk Information System (IRIS) printouts will be utilized, when necessary.

Table D-1 presents the TRVs that will be used for food-chain modeling. 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. If a LOAEL study is used to develop the NOAEL TRV, the LOAEL will be multiplied by a factor of 0.1 to obtain the NOAEL. No body weight scaling or other uncertainty factors will be used to adjust the NOAELs and LOAELs from literature studies.

D.4.3 Characterization of Exposure

This section describes the potential or actual contact or co-occurrence of contaminants with receptors to determine their exposure dose.

Terrestrial soil invertebrates and plants are exposed to contaminants in surface soil through direct contact and/or ingestion. Aquatic organisms are exposed to contaminants in surface water and sediment through direct contact and/or ingestion.

COPC intake for wildlife exposed to the COPCs in surface soil, sediment, and surface water will be estimated as a daily dose (mg/kg-day) using exposure equations. The contaminant concentrations in

surface soil, sediment, and surface water will be used to calculate CDI doses. The following equation presents a generic food-chain model for CDI that will be used for the surrogate species selected for modeling:

$$\text{CDI Dose (mg/kg - day)} = \frac{(FI * FC) + (WI * SW) + (SI * SC)}{BW}$$

Where:

	FI	= Food ingestion rate (kg/day)
	FC	= Food concentration (mg/kg)
	WI	= Surface water ingestion rate (L/day)
	SW	= Surface water concentration (mg/L)
	BW	= Body weight (kg)
	SI	= Incidental soil/sediment ingestion rate (kg/day)
	SC	= Soil/Sediment concentration (mg/kg)

For inorganic constituents in surface soil and sediment and organic constituents in surface soil, the contaminant concentrations of prey items (e.g., earthworms, fish) is calculated using the following equation:

$$FC = SC * BAF$$

Where:

	FC	= Contaminant concentration in food (kg/day)
	SC	= Contaminant concentration in surface soil or sediment (µg/kg for organics and mg/kg for inorganics)
	BAF	= Bioaccumulation factor (unitless)

For organic constituents in sediment, the contaminant concentration of prey items is calculated using the following equation:

$$FC = \frac{SC * \%L * BSAF}{\%TOC}$$

Where:

	FC	= Contaminant concentration in food (kg/day)
	SC	= Contaminant concentration in sediment (µg/kg)

%L = Percentage of lipids in fish [3.6% = the average of various species of sunfish. Attachment D-3 presents the calculation used to derive this value (U.S. EPA, 1997b)]

BSAF = Biota-sediment accumulation factor (chemical-specific, unitless)

%TOC = Percentage of total organic carbon in sediment (site-specific)

The lower bound of the threshold effects is based on consistently conservative assumptions and NOAEL toxicity values (U.S. EPA, 1997a). 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 assumptions consistent with those used in the lower bound, site-specific data, LOAEL toxicity values, or an impact evaluation (U.S. EPA, 1997a). This bound will present the average potential risk. Both the lower and upper bounds will be evaluated in the SERA, as conservative and average exposure scenarios, respectively, to provide the overall range of potential risks, as presented in the following table:

Conservative Scenario	Average Scenario
95-percent Upper Confidence Level (UCL) soil, surface water, or sediment concentration.	Average soil, surface water, or sediment concentration.
90-percent BAF/BSAF value from the literature (when available).	Median BAF/BSAF value 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 as the TRVs.	Use LOAELs as the TRVs.
Receptors spend 100 percent of their time at the site.	Receptor's home range taken into account.

The exposure assumptions (e.g., 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-2 presents the exposure parameters that will be used in the SERA. 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 (i.e., concentration of medium or intake) to the ecological effects (i.e., screening levels or dose benchmarks). 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 indicative of 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 aquatic receptors will be calculated as follows:

$$EEQ = \frac{C_{sw}}{SWSL} \text{ or } \frac{C_{sd}}{SDSL}$$

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)
- SDSL = 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 = Surface soil screening level for plants or invertebrates (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 = Toxicity reference value (NOAEL or LOAEL) (mg/kg-day)

D.6 ECOLOGICAL RISK UNCERTAINTY ANALYSIS

This section discusses 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 selected for the SERA. For the 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 underprotect or overprotect the small mammal population based on 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, BAFs, and other exposure factors. These exposure factors are obtained from literature studies or predicted using various equations. Ingestion rates and body weights vary among species, especially among species inhabiting different areas. For example, food ingestion rates for the robin were reported as 0.89 gram per gram-day (g/g-day) in California and 1.52 g/g-day in Kansas (U.S. EPA, 1993).

Bioaccumulation of contaminants into various biological media (e.g., plants, invertebrates, small mammals) depends on characteristics of the media such as pH, organic carbon, etc. Therefore, actual BAFs at the sites may be different than those used in the SERA and obtained from the literature. Also, the bioavailability of the chemicals is not taken into account in the SERA.

There is uncertainty in the chemical data 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.

Surface soil will be collected from the 0- to 2-foot below ground surface (bgs) depth interval. There is uncertainty in this approach depending on the source of contamination and how it was disposed at the site (i.e., deposited on the surface as a result of burning activities, buried, etc.).

Finally, under the conservative exposure scenario, terrestrial wildlife are assumed to live and feed only at the sites. 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 U.S. EPA in theory protect 95 percent of the exposed species. Therefore, some sensitive species may be present at the SWMUs that are not protected by the use of these criteria. There also are situations where the 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 sediment are evaluated by comparing COPC concentrations to SDSLs. The SDSLs have more uncertainty associated with them than do the SWSLs because the procedures for developing them are not as well established. Screening levels have been developed using different methodologies because less sediment toxicity data are available than surface water toxicity data. Also, sediment characteristics (e.g., pH, acid volatile sulfides, total organic carbon) may 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 COPC concentrations to SSSLs. The SSSLs are similar to the SDSLs in that they are less established than the SWSLs. Fewer studies and fewer data are available for establishing SSSLs than SWSLs 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 and LOAELs selected for the wildlife endpoint species were based on species other than the endpoint species (e.g., 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 of 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 are not available. 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 1.0 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 a site translate into risk to the population in the area as a whole.

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TABLE D-1

TOXICITY REFERENCE VALUES
SWMUS 8 AND 15
NSWC CRANE, INDIANA

PARAMETER	Mammal		Bird	
	NOAEL	LOAEL	NOAEL	LOAEL
SEMIVOLATILES (mg/kg)				
2,2'-Oxybis(1-chloropropane)	NV	NV	NV	NV
2,4,5-Trichlorophenol	10	30	NV	NV
2,4,6-Trichlorophenol	0.42	4.2	NV	NV
2-Methylnaphthalene	41	410	2	20
2-Methylphenol	5	15	NV	NV
4-Chloro-3-methylphenol	NV	NV	NV	NV
4-Nitroaniline	NV	NV	NV	NV
4-Nitrophenol	NV	NV	NV	NV
Acenaphthene	17.5	35	2	20
Acenaphthylene	70	700	2	20
Anthracene	100	1000	2	20
Benzo(a)anthracene	0.17	1.7	2	20
Benzo(a)pyrene	1	10	2	20
Benzo(b)fluoranthene	4	40	2	20
Benzo(g,h,i)perylene	7.2	72	2	20
Benzo(k)fluoranthene	7.2	72	2	20
bis(2-Ethylhexyl) phthalate	18.3	183	NV	NV
Butylbenzyl Phthalate	15.9	47	NV	NV
Carbazole	1	10	2	20
Chrysene	0.17	1.7	2	20
Dibenzo(a,h)anthracene	1.33	13.3	2	20
Dibenzofuran	NV	NV	2	20
Diethylphthalate	4583	45830	NV	NV
Di-n-butyl phthalate	550	1833	NV	NV
Di-n-octyl phthalate	NV	NV	NV	NV
Fluoranthene	12.5	25	2	20
Fluorene	12.5	25	2	20
Hexachloroethane	0.1	1.5	NV	NV
Indeno(1,2,3-cd)pyrene	7.2	72	2	20
Isophorone	15	179	NV	NV
Naphthalene	7.1	14.2	2	20
Pentachlorophenol	0.24	2.4	NV	NV
Phenanthrene	1	10	2	20
Phenol	6	12	NV	NV
Pyrene	7.5	12.5	2	20
Perylene	1	10	2	20
HERBICIDES (mg/kg)				
Dinoseb	0.1	1	NV	NV
2,4-D	1	5	NV	NV
2,4,5-T	3	10	NV	NV

TABLE D-1

TOXICITY REFERENCE VALUES
SWMUS 8 AND 15
NSWC CRANE, INDIANA

PARAMETER	Mammal		Bird	
	NOAEL	LOAEL	NOAEL	LOAEL
PESTICIDES/POLYCHLORINATED BIPHENYLS (PCBs) (mg/kg)				
2,4'-DDD	0.8	4	0.009	0.052
2,4'-DDE	0.8	4	0.009	0.052
2,4'-DDT	0.8	4	0.009	0.052
4,4'-DDD	0.8	4	0.009	0.052
4,4'-DDE	0.8	4	0.009	0.052
4,4'-DDT	0.8	4	0.009	0.052
Aldrin	0.2	1	NV	NV
alpha-BHC	0.014	0.14	0.56	2.25
alpha-Chlordane	4.58	9.16	2.14	10.7
Aroclor-1232	0.068	0.68	0.18	1.8
Aroclor-1242	0.069	0.69	0.41	4.1
Aroclor-1248	0.01	0.1	NV	NV
Aroclor-1254	0.068	0.68	0.18	1.8
Aroclor-1260	0.068	0.68	0.18	1.8
PCB-28	0.068	0.68	0.18	1.8
PCB-44	0.068	0.68	0.18	1.8
PCB-52	0.068	0.68	0.18	1.8
PCB-66	0.068	0.68	0.18	1.8
PCB-101	0.068	0.68	0.18	1.8
PCB-105	0.068	0.68	0.18	1.8
PCB-118	0.068	0.68	0.18	1.8
PCB-128	0.068	0.68	0.18	1.8
PCB-138	0.068	0.68	0.18	1.8
PCB-153	0.068	0.68	0.18	1.8
PCB-170	0.068	0.68	0.18	1.8
PCB-180	0.068	0.68	0.18	1.8
PCB-187	0.068	0.68	0.18	1.8
PCB-195	0.068	0.68	0.18	1.8
PCB-206	0.068	0.68	0.18	1.8
PCB-209	0.068	0.68	0.18	1.8
beta-BHC	0.4	2	0.56	2.25
delta-BHC	0.014	0.14	0.56	2.25
Dieldrin	0.02	0.2	0.077	0.77
Endosulfan I	0.15	1.5	10	100
Endosulfan II	0.15	1.5	10	100
Endosulfan Sulfate	0.15	1.5	10	100
Endrin	0.092	0.92	0.01035	0.1035
Endrin Aldehyde	0.092	0.92	0.01	0.1
Endrin Ketone	0.092	0.92	0.01	0.1
gamma-BHC (Lindane)	8	80	2	20
gamma-Chlordane	4.58	9.16	2.14	10.7
Heptachlor	0.1	1	NV	NV

TABLE D-1

TOXICITY REFERENCE VALUES
SWMUS 8 AND 15
NSWC CRANE, INDIANA

PARAMETER	Mammal		Bird	
	NOAEL	LOAEL	NOAEL	LOAEL
PESTICIDES/POLYCHLORINATED BIPHENYLS (PCBs) (mg/kg) (Continued)				
Heptachlor Epoxide	0.1	1	NV	NV
Methoxychlor	4	8	NV	NV
Toxaphene	8	80	NV	NV
DIOXINS AND FURANS (mg/kg)				
1,2,3,4,6,7,8-HpCDD	0.0001	0.001	0.014	0.14
1,2,3,4,6,7,8-HpCDF	0.0001	0.001	0.0014	0.014
1,2,3,4,7,8,9-HPCDF	0.0001	0.001	0.0014	0.014
1,2,3,4,7,8-HXCDD	0.00001	0.0001	0.00028	0.0028
1,2,3,4,7,8-HxCDF	0.00001	0.0001	0.00014	0.0014
1,2,3,6,7,8-HxCDD	0.00001	0.0001	0.0014	0.014
1,2,3,6,7,8-HxCDF	0.00016	0.0016	0.00014	0.0014
1,2,3,7,8,9-HxCDD	0.00001	0.0001	0.00014	0.0014
1,2,3,7,8,9-HxCDF	0.00001	0.0001	0.00014	0.0014
2,3,4,6,7,8-HxCDF	0.00001	0.0001	0.00014	0.0014
1,2,3,7,8-PECDD	0.000001	0.00001	0.000014	0.00014
1,2,3,7,8-PECDF	0.00016	0.0016	0.00014	0.0014
2,3,4,7,8-PECDF	0.000016	0.00016	0.000014	0.00014
2,3,7,8-TCDD	0.000001	0.00001	0.000014	0.00014
2,3,7,8-TCDF	0.00001	0.0001	0.000014	0.00014
OCDD	0.01	0.1	0.14	1.4
OCDF	0.01	0.1	0.14	1.4
TOTAL HpCDD	0.0001	0.001	0.014	0.14
TOTAL HxCDD	0.00001	0.0001	0.00014	0.0014
TOTAL PeCDD	0.000001	0.00001	0.000014	0.00014
Total HpCDF	0.0001	0.001	0.0014	0.014
Total HxCDF	0.00001	0.0001	0.00014	0.0014
Total PeCDF	0.000002	0.00002	0.000014	0.00014
Total TCDD	0.000001	0.00001	0.000014	0.00014
Total TCDF	0.00001	0.0001	0.000014	0.00014
EXPLOSIVES (mg/kg)				
1,3 Dinitrobenzene	0.113	0.264	NV	NV
1,3,5-Trinitrobenzene	2.64	13.44	NV	NV
2,4-Dinitrotoluene	0.2	1.5	NV	NV
2,4,6-Trinitrotoluene	1.6	16	NV	NV
2-Amino-4,6-dinitrotoluene	NV	NV	NV	NV
2-Nitrotoluene	20	200	NV	NV
3-Nitrotoluene	20	200	NV	NV
4-Amino-2,6-dinitrotoluene	NV	NV	NV	NV
4-Nitrotoluene	20	200	NV	NV
Ammonia	NV	NV	NV	NV
HMX	3	7.5	NV	NV
Nitrobenzene (exp)	NV	NV	NV	NV
RDX	7	35	NV	NV
Tetryl	1.3	13	NV	NV

TABLE D-1

TOXICITY REFERENCE VALUES
SWMUS 8 AND 15
NSWC CRANE, INDIANA

PARAMETER	Mammal		Bird	
	NOAEL	LOAEL	NOAEL	LOAEL
INORGANICS (mg/kg)				
Aluminum	1.93	19.3	109.7	1097
Antimony	0.125	1.25	NV	NV
Arsenic	0.126	1.26	2.46	7.38
Barium	5.1	19.8	20.8	41.7
Beryllium	0.66	6.6	NV	NV
Cadmium	1	10	1.45	20
Chromium	3.28	13.14	1	5
Hexavalent Chromium	3.28	13.14	1	5
Cobalt	1.2	12	NV	NV
Copper	11.71	15.14	46.97	61.72
Cyanide	68.7	687	NV	NV
Iron	50	500	100	1000
Lead	8	80	1.13	11.3
Manganese	88	284	977	9770
Mercury	0.032	0.16	0.0064	0.064
Nickel	40	80	77.4	107
Selenium	0.2	0.33	0.4	0.8
Silver	2.38	23.8	5.44	54.4
Thallium	0.0074	0.074	NV	NV
Vanadium	0.21	2.1	11.38	113.8
Zinc	160	320	14.49	130.9

The sources of these NOAELs and LOAELs are presented in Table D.1-2 in Attachment D-1.

The NOAELs and LOAELs in the source table were divided by 10 if a subchronic study was the basis for the value. Also, if only a NOAEL was available, the value was multiplied by 10 to estimate the LOAEL. If only a LOAEL was available, the value was divided by 10 to estimate the NOAEL.

NV - No value available.

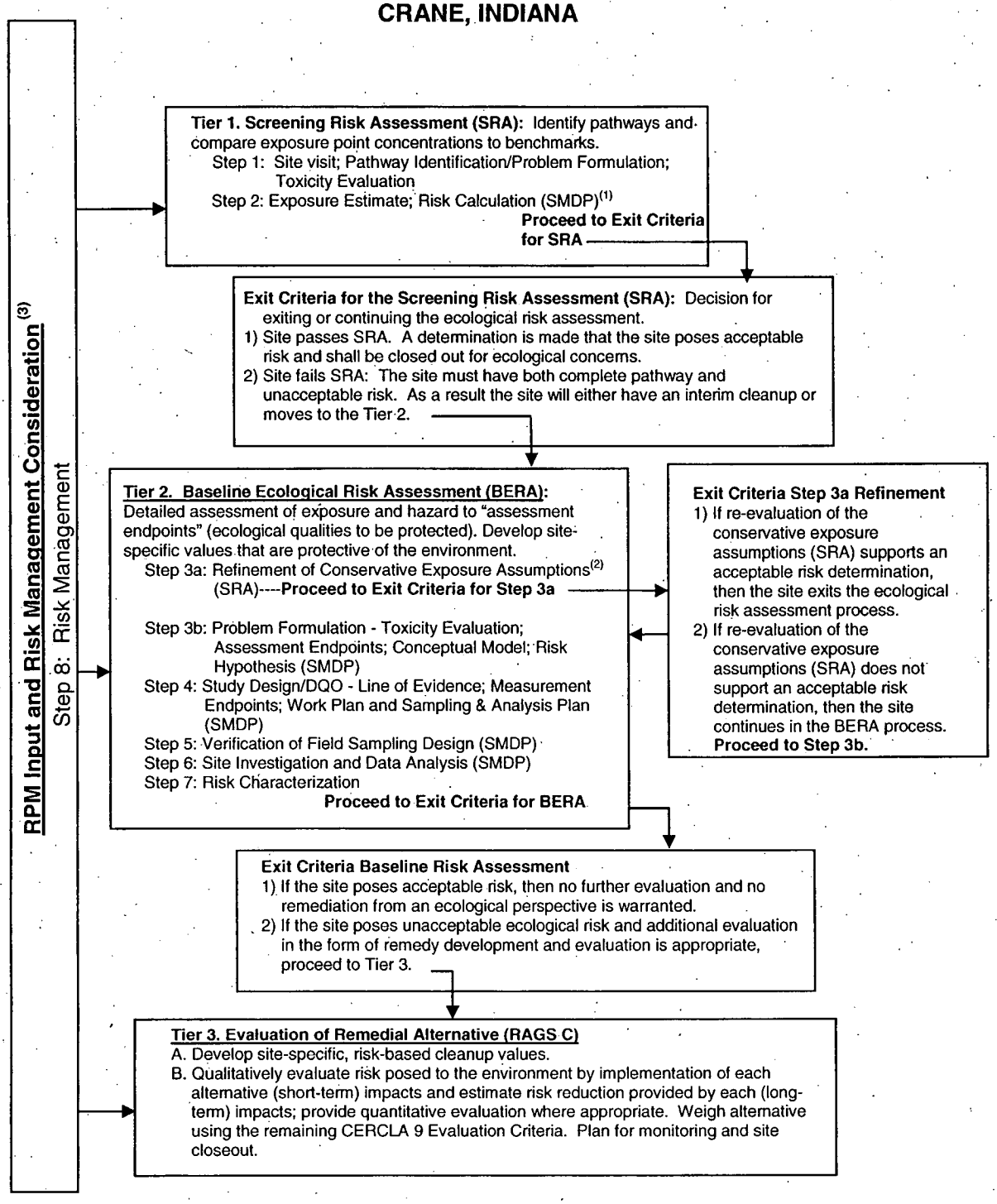
TABLE D-2

EXPOSURE PARAMETERS FOR THE TERRESTRIAL WILDLIFE MODEL
NSWC CRANE, INDIANA

Exposure Inputs	Conservative Input		Average Input		Source
	Value	Unit	Value	Unit	
Short-Tailed Shrew					
Body Weight = BW	1.525E-02	kg	1.687E-02	kg	U.S. EPA, 1993
Food Ingestion Rate = If	1.620E-02	kg/day	1.030E-02	kg/day	U.S. EPA, 1993
Water Ingestion Rate = Iw	4.300E-03	L/day	3.800E-03	L/day	U.S. EPA, 1993
Soil Ingestion Rate = Is	4.860E-04	kg/day	1.545E-04	kg/day	U.S. EPA, 2000
Home Range = HR	Assume 100% on site		9.700E-01	acres	U.S. EPA, 1993
Meadow Vole					
Body Weight = BW	3.290E-02	kg	3.660E-02	kg	U.S. EPA, 1993
Food Ingestion Rate = If	1.300E-02	kg/day	1.200E-02	kg/day	U.S. EPA, 1993
Water Ingestion Rate = Iw	7.700E-03	L/day	6.400E-03	L/day	U.S. EPA, 1993
Soil Ingestion Rate = Is	3.120E-04	kg/day	2.880E-04	kg/day	Beyer, et al., 1994
Home Range = HR	Assume 100% on site		1.640E-01	acres	U.S. EPA, 1993
American Robin					
Body Weight = BW	7.730E-02	kg	8.100E-02	kg	U.S. EPA, 1993
Food Ingestion Rate = If	1.231E-01	kg/day	9.760E-02	kg/day	U.S. EPA, 1993
Water Ingestion Rate = Iw	1.210E-02	L/day	1.130E-02	L/day	U.S. EPA, 1993
Soil Ingestion Rate = Is	1.280E-02	kg/day	1.015E-02	kg/day	Beyer, et al., 1994
Home Range = HR	Assume 100% on site		1.190E+00	acres	U.S. EPA, 1993
Bobwhite Quail					
Body Weight = BW	1.620E-01	kg	1.770E-01	kg	U.S. EPA, 1993
Food Ingestion Rate = If	1.640E-02	kg/day	1.440E-02	kg/day	U.S. EPA, 1993
Water Ingestion Rate = Iw	2.310E-02	L/day	1.840E-02	L/day	U.S. EPA, 1993
Soil Ingestion Rate = Is	1.345E-03	kg/day	1.181E-03	kg/day	Beyer, et al., 1994
Home Range = HR	Assume 100% on site		2.860E+01	acres	U.S. EPA, 1993
Raccoon					
Body Weight = BW	5.340E+00	kg	6.864E+00	kg	U.S. EPA, 1993
Food Ingestion Rate = If	1.651E+00	kg/day	1.339E+00	kg/day	U.S. EPA, 1993
Water Ingestion Rate = Iw	5.698E-01	L/day	5.664E-01	L/day	U.S. EPA, 1993
Sediment Ingestion Rate = Is	1.552E-01	kg/day	1.258E-01	kg/day	Beyer, et al., 1994
Home Range = HR	Assume 100% on site		3.855E+02	acres	U.S. EPA, 1993
Belted Kingfisher					
Body Weight = BW	1.360E-01	kg	1.520E-01	kg	U.S. EPA, 1993
Food Ingestion Rate = If	7.580E-02	kg/day	6.890E-02	kg/day	U.S. EPA, 1993
Water Ingestion Rate = Iw	1.870E-02	L/day	1.670E-02	L/day	U.S. EPA, 1993
Sediment Ingestion Rate = Is	2.501E-03	kg/day	2.274E-03	kg/day	Beyer, et al., 1994
Home Range = HR	Assume 100% on site		2.185E+00	km	U.S. EPA, 1993

Notes:
- The food ingestion rates presented in this table are on a wet weight basis; they will be converted to dry weight values for use in the SERA as discussed in Attachment D-1.
- The sources of these values are listed in Table D.1-1 in Attachment D-1.
- The soil/sediment ingestion rates were calculated by multiplying the food ingestion rates by the incidental ingestion percentage discussed in Attachment D-1 for each surrogate receptor.

FIGURE D-1
NAVY ECOLOGICAL RISK ASSESSMENT TIERED APPROACH
SWMUs 8 and 15
NSWC CRANE
CRANE, INDIANA



Notes:
1 See U.S. 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.

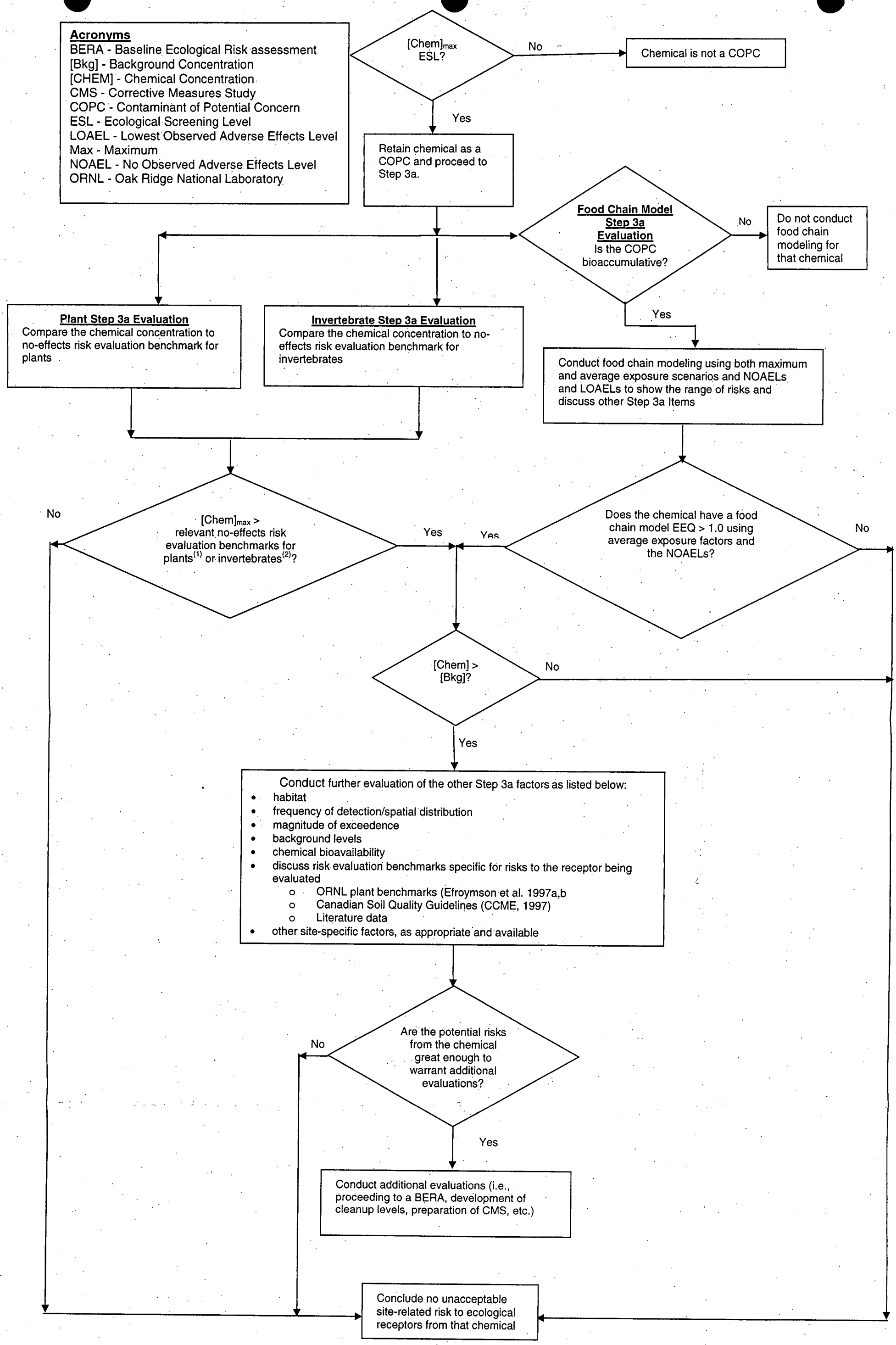


FIGURE D-2

GENERAL ERA PROCESS FOR EVALUATION OF RISKS TO CHEMICALS IN SURFACE SOIL AT NSWC CRANE, INDIANA
SWMUs 8 AND 15
NSWC CRANE, CRANE, INDIANA

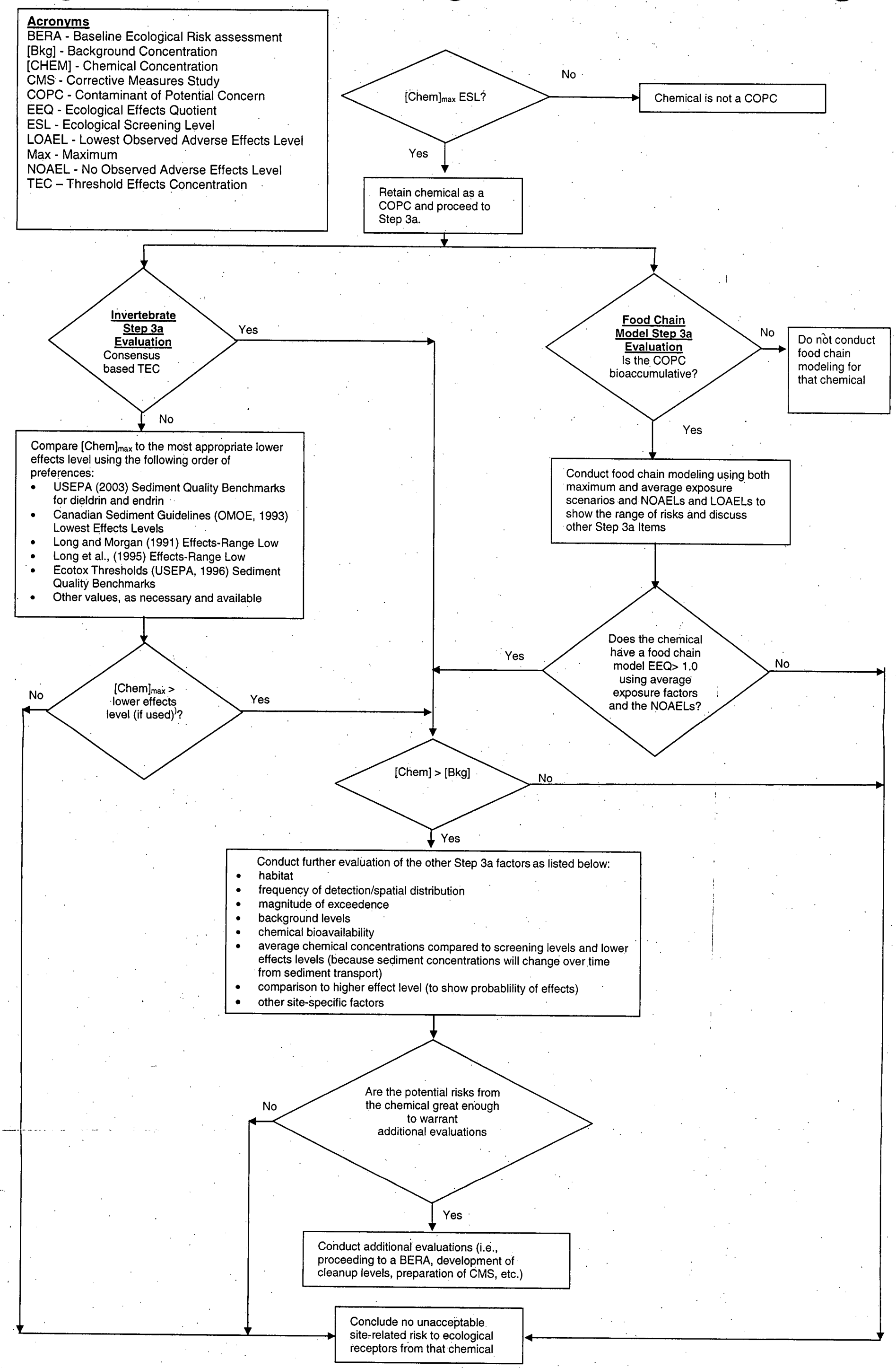
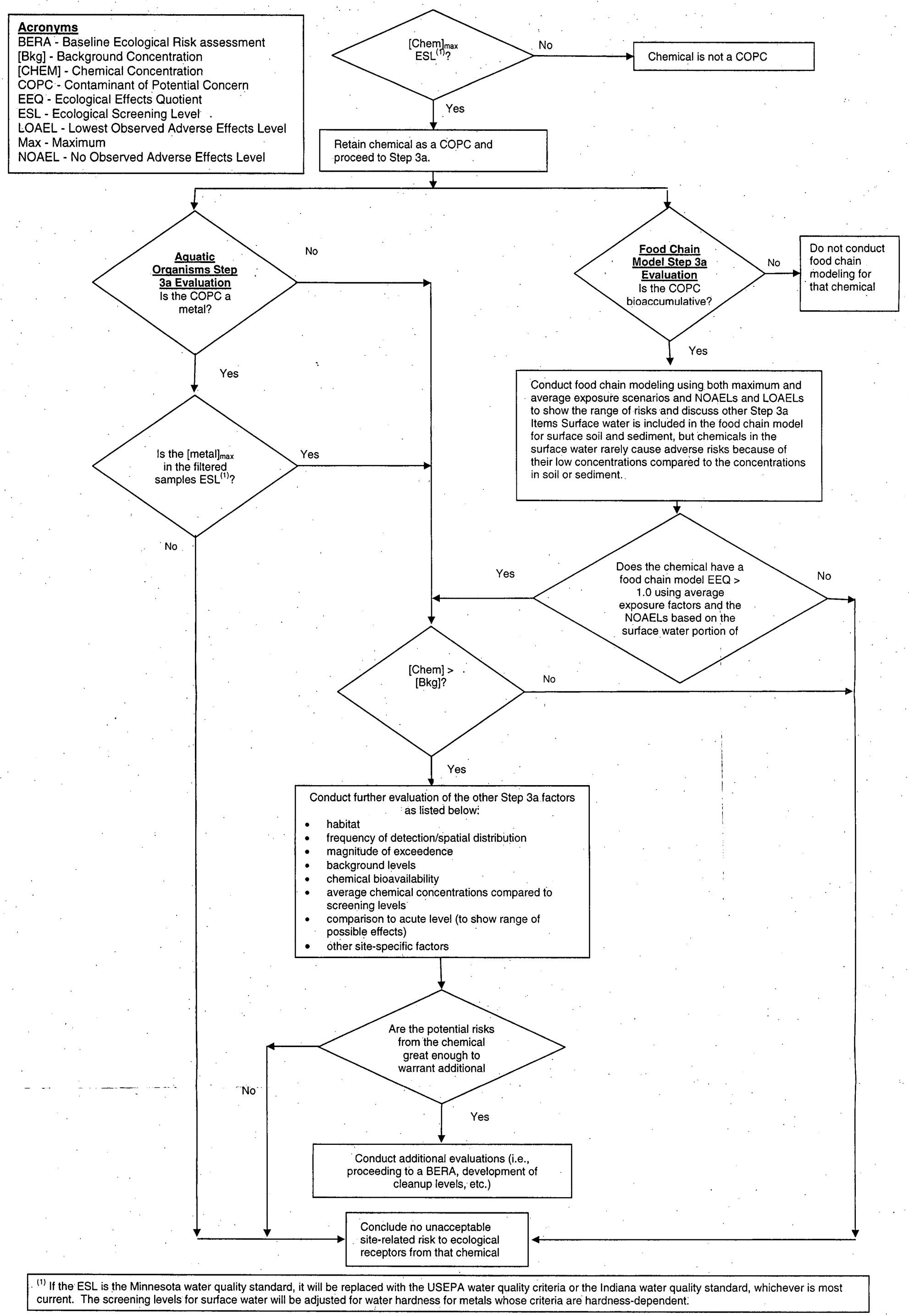


FIGURE D-3

GENERAL ERA PROCESS FOR EVALUATION OF RISKS TO CHEMICALS IN SEDIMENT AT NSWC CRANE, INDIANA
SWMUs 8 AND 15
NSWC CRANE, CRANE, INDIANA



(1) If the ESL is the Minnesota water quality standard, it will be replaced with the USEPA water quality criteria or the Indiana water quality standard, whichever is most current. The screening levels for surface water will be adjusted for water hardness for metals whose criteria are hardness-dependent.

FIGURE D-4

GENERAL ERA PROCESS FOR EVALUATION OF RISKS TO CHEMICALS IN SURFACE WATER AT NSWC CRANE, INDIANA
SWMUs 8 AND 15
NSWC CRANE, CRANE, INDIANA

P:/GIS/NSWC_CRANE/APR/SITEMAPS.APR SWMU 08 AERIAL LAYOUT 8/04/04 AJ

This aerial figure is for relative reference only. The actual SWMU boundaries and site features may vary due to the inaccuracy of aerial photography.

CONTRACT NO. N1245

APPROVED BY	DATE
APPROVED BY	DATE

DRAWING NO. FIGURE D - 5

REV 0

AERIAL PHOTO MAP
SWMU 8 - LOAD AND FILL AREA BUILDING 106 POND
NSWC CRANE
CRANE, INDIANA

DRAWN BY	DATE
A. JANOCHA	6/16/04
CHECKED BY	DATE
V. PLACHY	8/04/04

COST/SCHED-AREA

SCALE AS NOTED

P:/GIS/NSWC_CRANE/APR/SITEMAPS.APR SWMU 15 AERIAL LAYOUT 8/04/04 AJ

This aerial figure is for relative reference only. The actual SWMU boundaries and site features may vary due to the inaccuracy of aerial photography.

CONTRACT NO.
N1245

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE D - 6

REV 0

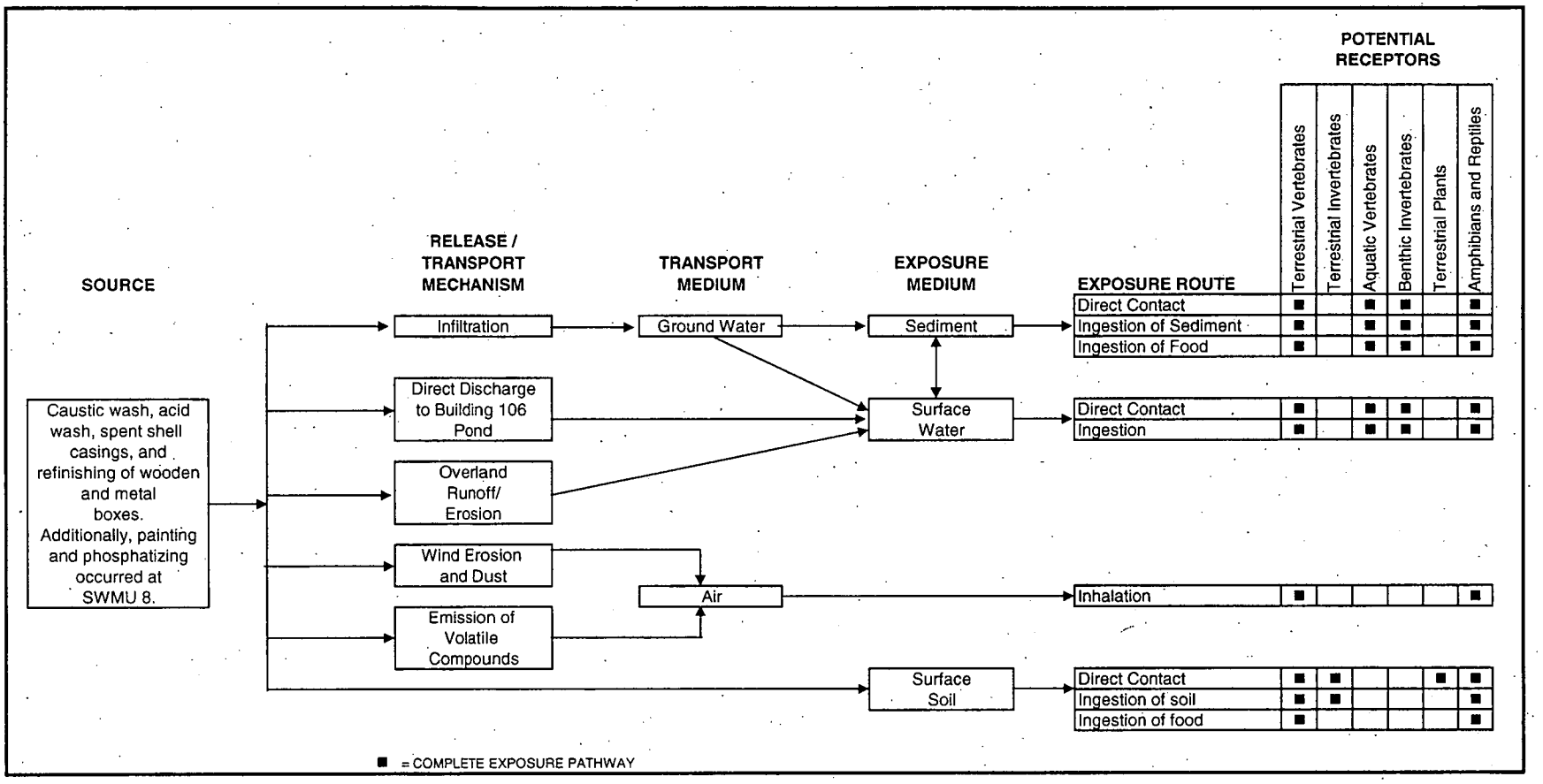
AERIAL PHOTO MAP
SWMU 15 - ROADS AND GROUNDS AREA
NSWC CRANE
CRANE, INDIANA

DEPARTMENT OF THE NAVY * SOUTHERN DIV FACILITIES ENGINEERING COMD *

DRAWN BY	DATE
A. JANOCHA	6/16/04
CHECKED BY	DATE
V. PLACHY	8/04/04
COST/SCHED-AREA	
SCALE	
AS NOTED	

FIGURE D-7

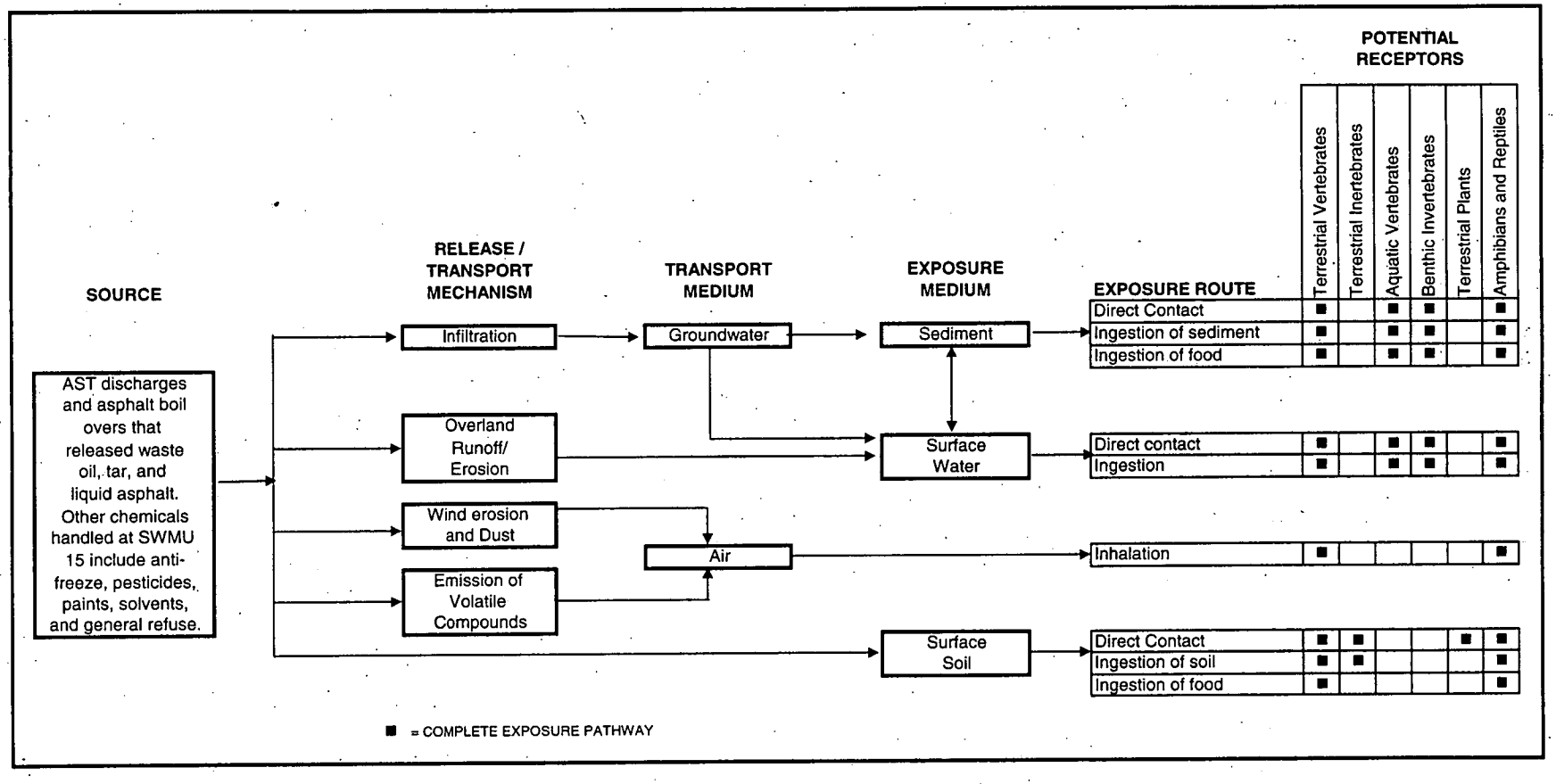
ECOLOGICAL CONCEPTUAL SITE MODEL
SWMU 8
NSWC CRANE, INDIANA



Blank space indicates incomplete exposure pathway or relatively insignificant or not applicable potential exposure.

FIGURE D-8

ECOLOGICAL CONCEPTUAL SITE MODEL
SWMU 15
NSWC CRANE, INDIANA



Blank space indicates incomplete exposure pathway or relatively insignificant, or not applicable potential exposure.

ATTACHMENT D-1

SURROGATE RECEPTOR PROFILES

ATTACHMENT D-1

The following sections present the receptor profiles for the meadow vole, American robin, 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 (U.S. EPA, 1993). Incidental soil ingestion rates were obtained from the Estimates of Soil Ingestion by Wildlife (Beyer, et al., 1994), except for the shrew data, which were in U.S. EPA, 2000. The exposure parameters selected for this SERA work plan are based on animals collected in or near southern Indiana, when available.

The food and water ingestion rates are presented in grams per gram (grams ingested per body weight)-day (g/g-day) on a wet weight basis but will be converted to dry weight for the SERA. Also note that the estimated percentages of soil in the diets are listed in dry weight, while the other exposure factors are in wet weight. The home ranges for all species are presented in hectares in U.S. 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 kilometers of shoreline.

The attached table (Table D.1-1) presents the calculation of the exposure parameters. In this table, the ingestion rates in kg/day (or L/day) for the conservative scenario were calculated by multiplying 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 were 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 for these receptors, 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 32.9 to 39.1 g with an average of 36.6 g. The only listed food ingestion rates were for voles in Russia, which ranged from 0.3 to 0.35 g/g-day, with an average of 0.325 g/g-day. The food ingestion rates were then multiplied by 0.30, the percent solids of young grass (Sample, et al., 1997), to convert the ingestion rate from a wet-weight value to a dry-weight value. 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 is calculated by multiplying the ingestion rate by the percentage of soil that is incidentally ingested (2.4 percent) from Beyer, et al. (1994).

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 acre.

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 weight for the short-tailed shrew in various Pennsylvania habitats ranged from 15.25 to 19.21 g with an average of 16.87 g. 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 food ingestion rates are then multiplied by 0.16, the percent solids of worms (Sample, et al., 1997), to convert the ingestion rate from a wet-weight value to a dry-weight value. 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 (assumed 3 percent for conservative food-chain model and 1.5 percent for the average food-chain model) from U.S. EPA, 2000. Three percent is the 90th-percentile value and 1.5 percent is the 50th-percentile value from U.S. EPA, 2000.

The home range for the shrew was calculated using data from a tamarak bog in Manitoba (only value available). The value was 0.97 acre.

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 77.3 to 86.2 g with an average of 81 g. 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 food ingestion rates were then multiplied by 0.23, the percent solids of fruit (Sample, et al., 1997), to convert the ingestion rate from a wet-weight value to a dry-weight value. However, because it is assumed that 100 percent of the robin's diet consists of worms for the food-chain models, the ingestion rate for the robin was calculated using field metabolism scaling as presented on the attached table (Nagy, et al., 1999). The water ingestion rate was estimated as 0.14 g/g-day. The incidental soil ingestion rate was calculated by multiplying the food ingestion rate by the percentage of soil that is incidentally ingested (10.4 percent for a woodcock) from Beyer, et al. (1994).

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 162 to 185.5 g with an average of 177 g. 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 food ingestion rates were then multiplied by 0.30, the percent solids of young grass (Sample, et al., 1997), to convert the ingestion rate from a wet-weight value to a dry-weight value. The water ingestion rate was estimated as 0.10 and 0.11 g/g-day, based on measurements in a Texas lab (0.086 to 0.131 g/g-day), with 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 (8.2 percent). The 8.2 percent is based on the incidental sediment ingestion rate of a Canada goose (Beyer, et al., 1994), which also consumes terrestrial vegetation, because an incidental soil ingestion rate was not available for the quail.

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.

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 were based on data from Illinois and range from 5,340 to 8,860 g, with an average of 6865 g. The average food ingestion rate of 1.3388 kg/day was calculated using the average body weight and the following equation from U.S. EPA, 1993:

$$FI = (0.0687)\ (BW^{0.822})/0.25$$

Where: FI = Food ingestion rate (kg/day)
BW = Body weight in kg

To convert the food ingestion rate into a dry weight value, the mean percent solids content of bony fish (0.25) was incorporated into the equation (Sample, et al., 1997). 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 the food ingestion rate by the percentage of soil that is incidentally ingested (9.4 percent), as presented in Beyer, et al., 1994.

Based on data from Michigan, home range sizes for the raccoon range from 266.9 to 504.1 acres, with 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.

The adult body weights were based on data from Michigan, Pennsylvania, Ohio, and Minnesota and range from 136 to 170 g, with an average of 152 g. The listed food ingestion rates are based on data from Michigan and range from 0.41 to 0.5 g/g-day. The food ingestion rates were then multiplied by 0.25, the percent solids of fish (Sample, et al., 1997), to convert the ingestion rate from a wet-weight value to a dry-weight value. The water ingestion rate is estimated as 0.11 g/g-day. The incidental sediment ingestion rate of was calculated by multiplying the ingestion rate by the percentage of sediment that is incidentally ingested (3.3 percent). The 3.3 percent is based on the incidental sediment ingestion rate of a mallard (Beyer, et al., 1994), which also consumes aquatic organisms, because an incidental sediment ingestion rate was not available for the kingfisher.

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.

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TABLE D.1-1

CALCULATION OF EXPOSURE PARAMETERS FOR WILDLIFE RECEPTORS
NAVAL SURFACE WARFARE CENTER, CRANE, INDIANA

Exposure Parameters	Meadow Vole		Short-Tailed Shrew		American Robin	Bobwhite Quail		Raccoon		Belted Kingfisher
Body Weights (g)	32.9	35.5	17.61	16.87	77.3	180	181	7090	6160	150
	39.1	39	17.33	15.58	80.8	168	183	7140	6440	136
			19.21	15.7	86.2	162	179	7600	5340	158
			17.4	15.25	83.6	175	175	6000	5620	147
					77.4	178	183.2	6400	8860	148
					80.6	179	185.5	7740	7560	170
						180	173	6560	7600	
						162.8	180.4			
Minimum (Conservative Scenario)	***32.9***		***15.25***		***77.3***	***162***		***5340***		***136***
Maximum	***39.1***		***19.21***		***86.2***	***186***		***8860***		***170***
Average (Average Scenario)	***36.63***		***16.87***		***81***	***177***		***6865***		***152***
Food Ingestion Rate (g/g-day) (1)(2)	0.3	0.35	0.49	0.77	0.89	0.067	0.079			0.5
			0.62	0.55	1.52	0.072	0.093			0.41
			0.43	0.96		0.09	0.089			
			0.52	0.54						
Minimum	***0.3***		***0.43***		***0.89***	***0.067***				***0.41***
Maximum	***0.35***		***0.96***		***1.52***	***0.093***				***0.5***
Average	***0.325***		***0.61***		***1.205***	***0.082***				***0.455***
Food Ingestion Rate (kg/day)										
Conservative Scenario	***0.013***		***0.016***		***0.123***	***0.016***		***1.65***		***0.076***
Average Scenario	***0.012***		***0.01***		***0.098***	***0.014***		***1.34***		***0.069***
Water Ingestion Rate (g/g-day)	0.14	0.21	0.223		0.14	0.115	0.1	0.082	0.083	0.11
						0.106	0.131			
						0.093	0.101			
						0.086	0.102			
						0.11	0.1			
Minimum	***0.14***		***0.223***		***0.14***	***0.086***		***0.082***		***0.11***
Maximum	***0.21***		***0.223***		***0.14***	***0.131***		***0.083***		***0.11***
Average	***0.175***		***0.223***		***0.14***	***0.104***		***0.083***		***0.110***
Water Ingestion Rate (L/day)										
Conservative Scenario	***0.0077***		***0.0043***		***0.0121***	***0.0231***		***0.5698***		***0.0187***
Average Scenario	***0.0064***		***0.0038***		***0.0113***	***0.0184***		***0.5664***		***0.0167***
Home Range (Ha) (3)	0.43	0.097	0.3925		0.15	7.6	6.4	204	108	2.185
	0.019	0.041			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) (3)	***0.0297***		***0.97***		***0.37***	***15.8***		***267***		***0.39***
Maximum (acres) (3)	***1.06***		***0.97***		***2***	***41.3***		***504***		***2.19***
Average (acres) (3)	***0.164***		***0.97***		***1.19***	***28.6***		***385***		***1.16***

Notes:
Source of data is US EPA, 1993.
1 - Food Ingestion Rate (kg/day) for the raccoon was calculated using the following equation:
$FI = (0.0687)(BW^{0.822})/0.25$, where FI = Food Ingestion Rate (kg/day) and BW = Body Weight (kg).
2 - Values presented are wet weight but will be converted to dry weight in the SERA as discussed in Attachment D-1.
3 - Home range for the kingfisher is presented in km of shoreline.
Ingestion Rates (kg/day or L/day) (if more than one 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 one ingestion rate is available)
- Conservative value = Ingestion Rate (g/g-day)* Max. Body Weight
- Average value = Ingestion Rate (g/g-day)*Avg. Body Weight

ATTACHMENT D-2

WILDLIFE TOXICITY DATA

TABLE D.2-1

SOURCES AND ENDPOINTS FOR NOAELS AND LOAELS FOR TERRESTRIAL WILDLIFE
NSWC CRANE, INDIANA

Parameter	Concentration (mg/kg-day)	Endpoint	Effect	Chronic/ Subchronic	Species	Primary Reference	Source of Reference
Semivolatiles Organics							
Acenaphthene	175	NOAEL	systemic	subchronic	mouse	USEPA, 1989a	IRIS, 2002
Acenaphthene	350	LOAEL	systemic	subchronic	mouse	USEPA, 1989a	IRIS, 2002
Acenaphthylene	700	NOAEL	mortality/BW	subchronic	mouse	USEPA, 1989a	PRC, 1996
Anthracene	1000	NOAEL	systemic	subchronic	mouse	USEPA, 1989b	IRIS, 2002
Anthracene	1000	NOAEL	reproductive	Subchronic	mouse	USEPA, 1989b	IT Corp, 1997
Benzo(a)anthracene	17.1	NOAEL	carcinogenic	acute	mouse	Clayson et al., 1968	PRC, 1996
Benzo(a)pyrene	10	LOAEL	reproductive	chronic	mouse	Mackenzie and Angevine, 1981	Sample et.al., 1996
Benzo(b)fluoranthene	40	LOAEL	carcinogenic	chronic	rodent	Lo and Sandi, 1978	PRC, 1996
Benzo(g,h,l)perylene	72	LOAEL	carcinogenic	chronic	rodent	Simms and Overcash, 1983	PRC, 1996
Benzo(k)fluoranthene	72	LOAEL	carcinogenic	chronic	rodent	Lo and Sandi, 1978	PRC, 1996
Bis(2-ethylhexyl)phthalate	18.33	NOAEL	reproductive	chronic	mouse	Lamb et al., 1987	Sample et.al., 1996
Bis(2-ethylhexyl)phthalate	183.3	LOAEL	reproductive	chronic	mouse	Lamb et al., 1987	Sample et.al., 1996
Butylbenzylphthalate	159	NOAEL	systemic	subchronic	rat	NTP, 1985a	IRIS, 2002
Butylbenzylphthalate	470	LOAEL	systemic	subchronic	rat	NTP, 1985a	IRIS, 2002
Chrysene	17.1	NOAEL	carcinogenic	acute	mouse	Clayson et al., 1968	PRC, 1996
Dibenzo(a,h)anthracene	13.3	LOAEL	carcinogenic	chronic	mouse	Lorenz and Stewart, 1948	PRC, 1996
1,2-Dichlorobenzene	120	NOAEL	systemic	chronic	rat	NTP, 1985b	IRIS, 2002
1,4-Dichlorobenzene	300	LOAEL	mortality	chronic	rat	NTP, 1987	ATSDR, 1998
Diethyl phthalate	4583	NOAEL	reproductive	chronic	mouse	Lamb et al., 1987	Sample et.al., 1996
Di-n-butylphthalate	550	NOAEL	reproductive	chronic	mouse	Lamb et al., 1987	Sample et.al., 1996
Di-n-butylphthalate	1833	LOAEL	reproductive	chronic	mouse	Lamb et al., 1987	Sample et.al., 1996
7,12-Dimethylbenz(a)anthracene	2	NOAEL	systemic	chronic	nestling/starlings	Trust et al., 1994	
7,12-Dimethylbenz(a)anthracene	20	LOAEL	systemic	chronic	nestling/starlings	Trust et al., 1994	
Fluoranthene	125	NOAEL	systemic	subchronic	mouse	USEPA, 1988	IRIS, 2002
Fluoranthene	250	LOAEL	systemic	subchronic	mouse	USEPA, 1988	IRIS, 2002
Fluorene	125	NOAEL	systemic	subchronic	mouse	USEPA, 1989c	IRIS, 2002
Fluorene	250	LOAEL	systemic	subchronic	mouse	USEPA, 1989c	IRIS, 2002
Hexachloroethane	1	NOAEL	systemic	subchronic	rat	Gorzinski et al., 1985	IRIS, 2002
Hexachloroethane	15	LOAEL	systemic	subchronic	rat	Gorzinski et al., 1985	IRIS, 2002
Indeno(1,2,3-cd)pyrene	72	LOAEL	carcinogenic	chronic	rodent	Simms and Overcash, 1983	PRC, 1996
Isophorone	150	NOAEL	systemic	subchronic	dog	Nor-Am Agric. Products, 1972	IRIS, 2002
Isophorone	179	LOAEL	systemic	chronic	rat	NTP, 1984	IRIS, 2002
2-Methylnaphthalene	41	NOAEL	mortality	chronic	rat	Schmahl, 1955	ATSDR, 1989
2-Methylphenol	50	NOAEL	neurotoxicity	subchronic	rat	USEPA, 1996 and 1997	IRIS, 2002
2-Methylphenol	150	LOAEL	neurotoxicity	Subchronic	rat	USEPA, 1996 and 1997	IRIS, 2002
Naphthalene	71	NOAEL	systemic	subchronic	rat	BCL, 1980	IRIS, 2002
Naphthalene	142	LOAEL	systemic	subchronic	rat	BCL, 1980	IRIS, 2002
Pentachlorophenol	0.24	NOAEL	reproductive	chronic	rat	Schwetz et al., 1978	Sample et.al., 1996
Pentachlorophenol	2.4	LOAEL	reproductive	chronic	rat	Schwetz et al., 1978	Sample et.al., 1996
Phenol	60	NOAEL	body weight	subchronic	rat	NTP, 1983	IRIS, 2002
Phenol	120	LOAEL	body weight	subchronic	rat	NTP, 1983	IRIS, 2002
Pyrene	75	NOAEL	systemic	subchronic	mouse	USEPA, 1989c	IRIS, 2002
Pyrene	125	LOAEL	systemic	subchronic	mouse	USEPA, 1989c	IRIS, 2002
2,4,5-Trichlorophenol	100	NOAEL	systemic	subchronic	rat	McCollister, et al., 1961	IRIS, 2002
2,4,5-Trichlorophenol	300	LOAEL	systemic	subchronic	rat	McCollister, et al., 1961	IRIS, 2002
2,4,6-Trichlorophenol	4.2	NOAEL	reproductive	subchronic	rat	Exon and Koller, 1985	ASTDR, 1999
2,4,6-Trichlorophenol	42	LOAEL	reproductive	subchronic	rat	Exon and Koller, 1985	ASTDR, 1999
Herbicides							
Dinoseb	1	LOAEL	reproductive	chronic	rat	Dow Chemical, 1981	IRIS, 2002
2,4-D	1	NOAEL	systemic	chronic	rat	Dow Chemical, 1983	IRIS, 2002
2,4-D	5	LOAEL	systemic	chronic	rat	Dow Chemical, 1983	IRIS, 2002
2,4,5-T	3	NOAEL	reproductive	chronic	rat	Kociba et al, 1979	IRIS, 2002
2,4,5-T	10	LOAEL	reproductive	chronic	rat	Kociba et al, 1979	IRIS, 2002
Pesticides							
Aldrin	0.2	NOAEL	reproductive	chronic	rat	Treon and Cleveland, 1955	Sample et.al., 1996
Aldrin	1	LOAEL	reproductive	chronic	rat	Treon and Cleveland, 1955	Sample et.al., 1996
BHC (mixed isomers)	0.137	LOAEL	reproductive	chronic	mink	Bleavins et al., 1984	Sample et.al., 1996
BHC (mixed isomers)	0.563	NOAEL	reproductive	chronic	Japanese quail	Vos et al., 1971	Sample et.al., 1996
BHC (mixed isomers)	2.25	LOAEL	reproductive	chronic	Japanese quail	Vos et al., 1971	Sample et.al., 1996
beta-BHC	4	NOAEL	systemic	subchronic	rat	Van Velsen et al., 1986	Sample et.al., 1996
beta-BHC	20	LOAEL	systemic	subchronic	rat	Van Velsen et al., 1986	Sample et.al., 1996
gamma-BHC (lindane)	8	NOAEL	reproductive	chronic	rat	Palmer et al., 1978	Sample et.al., 1996

TABLE D.2-1

SOURCES AND ENDPOINTS FOR NOAELS AND LOAELS FOR TERRESTRIAL WILDLIFE
NSWC CRANE, INDIANA

Parameter	Concentration (mg/kg-day)	Endpoint	Effect	Chronic/ Subchronic	Species	Primary Reference	Source of Reference
gamma-BHC (lindane)	20	LOAEL	reproductive	chronic	mallard duck	Chakravarty and Lahiri, 1986	Sample et.al., 1996
Chlordane	2.14	NOAEL	mortality	chronic	red-winged blackbird	Stickel et al., 1983	Sample et.al., 1996
Chlordane	10.7	LOAEL	mortality	chronic	red-winged blackbird	Stickel et al., 1983	Sample et.al., 1996
Chlordane	4.58	NOAEL	reproduction	chronic	mouse	WHO, 1984	Sample et.al., 1996
Pesticides contd.							
Chlordane	9.16	LOAEL	reproduction	chronic	mouse	WHO, 1984	Sample et.al., 1996
4,4'-DDT	0.8	NOAEL	reproductive	chronic	rat	Fitzhugh, 1948	Sample et.al., 1996
4,4'-DDT	4	LOAEL	reproductive	chronic	rat	Fitzhugh, 1948	Sample et.al., 1996
4,4'-DDT	0.052(1)	LOAEL	reproduction	chronic	brown pelican	Anderson et al., 1975	USEPA, 1995
4,4'-DDT	0.009(1)	NOAEL	reproduction	chronic	brown pelican	Anderson et al., 1975	USEPA, 1995
Dieldrin	0.077	NOAEL	reproduction	chronic	barn owl	Mendenhall et al., 1983	Sample et.al., 1996
Dieldrin	0.2	LOAEL	reproduction	chronic	rat	Treon and Cleveland, 1955	Sample et.al., 1996
Endosulfan	1.5	NOAEL	reproduction	subchronic	rat	Dikshith et al., 1984	ATSDR, 1993
Endosulfan	10	NOAEL	reproduction	chronic	gray partridge	Abiola, 1992	Sample et.al., 1996
Endrin	0.92	LOAEL	reproduction	chronic	mouse	Good and Ware, 1969	Sample et.al., 1996
Endrin	0.1035	LOAEL	reproduction	chronic	screech owl	Fleming et al., 1982	Sample et.al., 1996
Heptachlor	1	LOAEL	reproduction	chronic	mink	Crum et al., 1993	Sample et.al., 1996
Methoxychlor	4	NOAEL	reproduction	chronic	rat	Gray et al., 1988	Sample et.al., 1996
Methoxychlor	8	LOAEL	reproduction	chronic	rat	Gray et al., 1988	Sample et.al., 1996
Toxaphene	8	NOAEL	reproduction	chronic	rat	Kennedy et al., 1973	Sample et.al., 1996
Aroclor-1242	0.685	LOAEL	reproduction	chronic	mink	Bleavins et al., 1980	Sample et.al., 1996
Aroclor-1242	0.41	NOAEL	reproduction	chronic	screech owl	McLane and Hughes, 1980	Sample et.al., 1996
Aroclor-1248	0.1	LOAEL	reproductive	chronic	rhesus monkey	Barsotti et al., 1976	Sample et.al., 1996
Aroclor-1254	1.8	LOAEL	reproductive	chronic	pheasant	Dahlgren et al., 1972	Sample et.al., 1996
Aroclor-1254	0.68	LOAEL	reproduction	chronic	mouse	McCoy et al., 1995	Sample et.al., 1996
Explosives							
1,3-Dinitrobenzene	0.4	NOAEL	reproduction	subchronic	rat	Cody et al., 1981	IRIS, 2002
1,3-Dinitrobenzene	1.07	NOAEL	reproductive	subchronic	rat	Cody et al., 1981	IRIS, 2002
2,4-Dinitrotoluene	0.2	NOAEL	neurotoxicity	chronic	dog	Ellis et al., 1985	IRIS, 2002
2,4-Dinitrotoluene	1.5	LOAEL	neurotoxicity	chronic	dog	Ellis et al., 1985	IRIS, 2002
m, o, and p-Nitrotoluene	200	LOAEL	systemic	chronic	rat	Ciss et al., 1980	HEAST, 1997
HMX	30	NOAEL	mortality	subchronic	mouse	Everett and Maddock, 1985	Talmage et al., 1999
HMX	75	LOAEL	mortality	subchronic	mouse	Everett and Maddock, 1985	Talmage et al., 1999
RDX	7	NOAEL	reproduction	chronic	mouse	Lish et al., 1984	Talmage et al., 1999
RDX	35	LOAEL	reproduction	chronic	mouse	Lish et al., 1984	Talmage et al., 1999
Tetryl	13	NOAEL	reproduction	subchronic	rat	Reddy et al, 1994	Talmage et al., 1999
Tetryl	62	LOAEL	reproduction	subchronic	rat	Reddy et al, 1994	Talmage et al., 1999
1,3,5-Trinitrobenzene	2.68	NOAEL	systemic	chronic	rat	Reddy et al, 1996	IRIS, 2002
1,3,5-Trinitrobenzene	13.31	LOAEL	systemic	chronic	rat	Reddy et al, 1996	IRIS, 2002
2,4,6-Trinitrotoluene	160	LOAEL	reproductive	subchronic	rat	Dilley et al., 1982	Talmage et al., 1999
Inorganics							
Aluminum	109.7	NOAEL	reproductive	chronic	ringed dove	Carriere et al., 1986	Sample et.al., 1996
Aluminum	19.3	LOAEL	reproductive	chronic	mouse	Ondreicka et al., 1966	Sample et.al., 1996
Antimony	1.25	LOAEL	lifespan	chronic	mouse	Schroeder et al., 1968	Sample et.al., 1996
Arsenic	1.261	LOAEL	reproductive	chronic	mouse	Schroeder and Mitchner, 1971	Sample et.al., 1996
Arsenic	2.46	NOAEL	mortality	chronic	brown-headed cowbird	USFWS, 1969	Sample et.al., 1996
Arsenic	7.38	LOAEL	mortality	chronic	brown-headed cowbird	USFWS, 1969	Sample et.al., 1996
Barium	5.1	NOAEL	growth	chronic	rat	Perry et al., 1983	Sample et.al., 1996
Barium	198	LOAEL	mortality	subchronic	rat	Borzelleca et al., 1988	Sample et.al., 1996
Barium	208.26	NOAEL	mortality	subchronic	chicks	Johnson et al., 1960	Sample et.al., 1996
Barium	416.53	LOAEL	mortality	subchronic	chicks	Johnson et al., 1960	Sample et.al., 1996
Beryllium	0.66	NOAEL	systemic	chronic	rat	Schroeder and Mitchner, 1975b	Sample et.al., 1996
Cadmium	1	NOAEL	reproductive	chronic	rat	Sutou et al., 1980	Sample et.al., 1996
Cadmium	10	LOAEL	reproductive	chronic	rat	Sutou et al., 1980	Sample et.al., 1996
Cadmium	1.45	NOAEL	reproductive	chronic	mallard duck	White and Finely, 1978	Sample et.al., 1996
Cadmium	20	LOAEL	reproductive	chronic	mallard duck	White and Finely, 1978	Sample et.al., 1996
Chromium(III)	1	NOAEL	reproductive	chronic	black duck	Haseltine et al., unpubl.	Sample et.al., 1996
Chromium(III)	5	LOAEL	reproductive	chronic	black duck	Haseltine et al., unpubl.	Sample et.al., 1996
Chromium(VI)	3.28	NOAEL	BW/food cons.	chronic	rat	Mackenzie et al., 1958	Sample et.al., 1996
Chromium(VI)	131.4	LOAEL	mortality	subchronic	rat	Steven et al., 1976	Sample et.al., 1996
Cobalt	12	LOAEL	growth	chronic	rat	Domingo et al., 1985	Eng. Field Activity,1998
Copper	11.71	NOAEL	reproductive	chronic	mink	Aulerich et al., 1982	ATSDR, 1989
Copper	15.14	LOAEL	reproductive	chronic	mink	Aulerich et al., 1982	ATSDR, 1989

TABLE D.2-1

SOURCES AND ENDPOINTS FOR NOAELS AND LOAELS FOR TERRESTRIAL WILDLIFE
NSWC CRANE, INDIANA

Parameter	Concentration (mg/kg-day)	Endpoint	Effect	Chronic/ Subchronic	Species	Primary Reference	Source of Reference
Copper	46.97	NOAEL	mortality	chronic	chicks	Mehring et al., 1960	Sample et.al., 1996
Copper	61.72	LOAEL	mortality	chronic	chicks	Mehring et al., 1960	Sample et.al., 1996
Cyanide	68.7	NOAEL	reproductive	chronic	rat	Tewe and Maner, 1981	Sample et.al., 1996
Iron	500	LOAEL	unknown	chronic	rabbit	NAS, 1980	
Iron	1000	LOAEL	unknown	chronic	poultry	NAS, 1980	
Lead	8	NOAEL	reproductive	chronic	rat	Azar et al., 1973	Sample et.al., 1996
Lead	80	LOAEL	reproductive	chronic	rat	Azar et al., 1973	Sample et.al., 1996
Lead	1.13	NOAEL	reproductive	chronic	Japanese quail	Edens et al., 1976	Sample et.al., 1996
Inorganics contd.							
Lead	11.3	LOAEL	reproductive	chronic	Japanese quail	Edens et al., 1976	Sample et.al., 1996
Manganese	977	NOAEL	growth	chronic	Japanese quail	Laskey and Edens, 1985	Sample et.al., 1996
Manganese	88	NOAEL	reproductive	chronic	rat	Laskey et al., 1982	Sample et.al., 1996
Manganese	284	LOAEL	reproductive	chronic	rat	Laskey et al., 1982	Sample et.al., 1996
Mercury	0.064	LOAEL	reproductive	chronic	mallard duck	Heinz, 1979	Sample et.al., 1996
Mercury	0.032	NOAEL	reproductive	chronic	rat	Verschuuren et al., 1976	Sample et.al., 1996
Mercury	0.16	LOAEL	reproductive	chronic	rat	Verschuuren et al., 1976	Sample et.al., 1996
Nickel	40	NOAEL	reproductive	chronic	rat	Ambrose et al., 1976	Sample et.al., 1996
Nickel	80	LOAEL	reproductive	chronic	rat	Ambrose et al., 1976	Sample et.al., 1996
Nickel	77.4	NOAEL	mortality	chronic	mallard duck	Cain and Pafford, 1981	Sample et.al., 1996
Nickel	107	LOAEL	mortality	chronic	mallard duck	Cain and Pafford, 1981	Sample et.al., 1996
Selenium	0.4	NOAEL	reproductive	chronic	mallard duck	Heinz et al., 1989	Sample et.al., 1996
Selenium	0.8	LOAEL	reproductive	chronic	mallard duck	Heinz et al., 1989	Sample et.al., 1996
Selenium	0.2	NOAEL	reproductive	chronic	rat	Rosenfeld and Beath, 1954	Sample et.al., 1996
Selenium	0.33	LOAEL	reproductive	chronic	rat	Rosenfeld and Beath, 1954	Sample et.al., 1996
Silver	54.4	LOAEL	survival	chronic	chicks	Petersen and Jensen, 1975	
Silver	23.81	LOAEL	weight loss	chronic	mouse	Rungby and Danscher, 1984	
Thallium	0.74	LOAEL	reproductive	subchronic	rat	Formigli et al., 1986	Sample et.al., 1996
Tin	23.4	NOAEL	reproductive	chronic	mouse	Davis et al., 1987	Sample et.al., 1996
Tin	35	LOAEL	reproductive	chronic	mouse	Davis et al., 1987	Sample et.al., 1996
Tin	6.76	NOAEL	reproductive	chronic	Japanese quail	Schlatterer et al., 1993	Sample et.al., 1996
Tin	16.9	LOAEL	reproductive	chronic	Japanese quail	Schlatterer et al., 1993	Sample et.al., 1996
Vanadium	2.1	LOAEL	reproductive	chronic	rat	Domingo et al., 1986	Sample et.al., 1996
Vanadium	11.38	NOAEL	mortality,BW	chronic	mallard duck	White and Dieter, 1978	Sample et.al., 1996
Zinc	160	NOAEL	reproductive	chronic	rat	Schlicker and Cox, 1968	Sample et.al., 1996
Zinc	320	LOAEL	reproductive	chronic	rat	Schlicker and Cox, 1968	Sample et.al., 1996
Zinc	14.49	NOAEL	reproductive	chronic	white leghorn hen	Stahl et al., 1990	Sample et.al., 1996
Zinc	130.9	LOAEL	reproductive	chronic	white leghorn hen	Stahl et al., 1990	Sample et.al., 1996

Notes: The NOAELS and LOAELS for the PAHs that do not have values are based on the benzo(a)pyrene values.
The NOAELS and LOAELS for the PAHs for birds are based on 7,12-dimethylbenz(a)anthracene.

1 - The LOAEL of 0.052 mg/kg-day was the recalculated LOAEL for the referenced study by assumming a lag time for the reduction of DDT (see USEPA, 1995)
The NOAEL of 0.009 was calculated by dividing the original LOAEL of the referenced study (0.027 mg/kg-day) by an uncertainty factor of 3.

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ATTACHMENT D-3

FISH PERCENT LIPIDS CALCULATION

TETRA TECH NUS, INC. **CALCULATION WORKSHEET** PAGE 1 OF 1

CLIENT NSWC Crane, SWMUs 8 & 15	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. EPA 823-R-97-006.	DRAWING NUMBER
BY R. Haynie / CHECKED BY A. Bernhardt	APPROVED BY / DATE 5-9-02

Percent lipid content in fish

Species	Whole fish % lipid content *
Redbreast Sunfish	3.6
Green Sunfish	3.2
Pumpkinseed	3.9
Longear Sunfish	2.8
Bluegill Sunfish	3.5
Bluegill Sunfish	4.4

$3.56\bar{6} \approx 3.6\%$ 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

FIELD STANDARD OPERATING PROCEDURES

APPENDIX E

SOP TABLE OF CONTENTS

CTO331-01	Sample Labeling
CTO331-02	Sample Identification Nomenclature
CTO331-03	Sample Custody and Documentation of Field Activities
CTO331-04	Borehole Advancement and Soil Coring Using Direct-Push Technology
CTO331-05	Monitoring Well Sampling
CTO331-06	Calibration and Use of Photoionization Detector
CTO331-07	Borehole and Soil Sample Logging
CTO331-08	Surface and Subsurface Soil Sampling
CTO331-09	Inspection of Existing Monitoring Wells
CTO331-10	Monitoring Well Development
CTO331-11	Drilling and Geologic Logging of Boreholes in Rock
CTO331-12	Monitoring Well Installation
CTO331-13	Packer Testing of Uncased Boreholes
CTO331-14	Calibration and Care of Water Quality Meter
CTO331-15	Management of Investigation-Derived Waste
CTO331-16	Low-Flow Well Purging and Stabilization
CTO331-17	Decontamination of Field Sampling Equipment
CTO331-18	Measurement of Water Levels in Monitoring Wells
CTO331-19	Surface Water Sampling
CTO331-20	Sediment Sampling - Shallow Streams
CTO331-21	Estimating Flow in Small Streams
CTO331-22	Hydraulic Conductivity Testing
CTO331-23	Tracer Tests
CTO331-24	Sample Preservation, Packaging, and Shipping
CTO331-25	Sediment Sampling - Building 106 Pond

STANDARD OPERATING PROCEDURE
NUMBER CTO331-01

SAMPLE LABELING

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the procedures to be used for labeling sample containers. Sample labels are used to document the sample ID, date, time, analysis to be performed, preservative, matrix, sampler, and the analytical laboratory. A sample label will be attached to each sample container. The label 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

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 prior to field activities.

- Project number (CTO 331)
- Project location (NSWC Crane)
- Sample ID
- Preservative
- Analysis to be performed

- Matrix type
- Laboratory name

3.2 Preprinted sample labels will be prepared before the team mobilizes to the field. Check to determine if

- One sample label exists for each sample container that is to be collected for all media during the field activities.
- The information printed on each label is correct.
- Extra blank labels 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 should also be brought to the site in case a sample container is broken or some of the preprinted labels are accidentally lost before they are 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 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

ATTACHMENT 1

SAMPLE LABEL

Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090	Project: Location: CTO:	
Sample No:		Matrix:
Date:	Time:	Preserve:
Analysis:		
Sampled by:	Laboratory	

STANDARD OPERATING PROCEDURE
NUMBER CTO331-02

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:

A or NN 2 to 5-Characters	**AA**	**A or N 2 to 5-Characters**	**NN and/or A Aqueous only**	**NNNN Soils and Sediment only**
SWMU,Site Name, or Site Number	Sample Type	Location	Round Identifier and/or Filtered	Depth Interval

Character Type:

A = Alpha
N = Numeric

SWMU, Site Name, or Site Number:

08 = Building 106 Pond
15 = Roads and Grounds Area
18 = Load and Fill Area Buildings
19 = Pyrotechnic Test Area
20 = Crane Army Ammunition Activity
OGTSL = Old Gun Tub Storage Lot

Sample Type:

GW - Groundwater 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
ST - Storm Sewer Water 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. For 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) 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:

This code section will be used for soil and sediment samples 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 interval in feet bgs (soil) or 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, logbook, 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 groundwater sample collected from existing monitoring well 01 at the Building 106 Pond Fill/B146 Incinerator (SWMU 08) for a filtered sample would be designated as 08GW0101F.

The unfiltered groundwater sample collected from new monitoring well MWT01 at SWMU 08 would be designated as 08GWT0101.

A surface soil sample collected from soil boring 03 at SWMU 19 at the 0- to 2-foot interval would be designated as 19SS030002.

A subsurface soil sample from the same soil boring 03 at an interval of 4 to 5 feet bgs would be designated as 19SB030405.

A sediment sample collected at SWMU 19 from 0 to 6 inches at location 14 would be designated as 19SD140006.

A surface soil sample collected from soil boring 03 at the OGTSL at the 0- to 2-foot interval would be designated as OGTSLSS030002.

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 CTO331-03

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 will be crossed out with a single strike mark, initialed, and dated.

3.1 Site Logbook

The site logbook is a hard-bound, paginated, controlled-distribution record book in which all major on-site activities are documented. At a minimum, the following activities and events will 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 COC 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 will 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 CTO331-09.

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 CTO331-18.

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 in accordance with SOP CTO331-16.

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 CTO331-05.

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 CTO331-19.

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 CTO331-08 and SOP CTO331-20.

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

DATE YEAR ___	TIME	SAMPLE ID	MATRIX	GRAB (G) COMP (C)	No. OF CONTAINERS	CONTAINER TYPE PLASTIC (P) or GLASS (G)								COMMENTS
						PRESERVATIVE USED								
						TYPE OF ANALYSIS								

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. TtNUS-001

STANDARD OPERATING PROCEDURE
NUMBER CTO331-04

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) at the NSWC Crane facility.

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 SOP CTO331-07
Photoionization detector (PID) (see SOP CTO331-06)
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 CTO331-17)
Bentonite pellets

3.0 BOREHOLE ADVANCEMENT AND SOIL SAMPLING USING A GEOPROBE®

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.

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 the coring device to the Geoprobe® rig.

3.3 Drive the macrocore sampler (lined with acetate) into the ground to a depth of 2 feet using hydraulic pressure. The 0- to 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 tailgate 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., 1-foot depth). Details for collecting a VOC sample using the Encore sampler are included in SOP CTO331-08.

3.9 Log the soil core on the Boring Log Sheet (see SOP CTO331-07).

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 CTO331-8.

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 will 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 will 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 locations and depths from where the soils came from and the date. The bag will then be placed in a 55-gallon drum and stored on site until laboratory analyses of the soil are completed and classification of the soil waste materials can be determined (see SOP CTO331-15).

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 CTO331-17 before collecting the next sample.

STANDARD OPERATING PROCEDURE
NUMBER CTO331-05

GROUND WATER SAMPLING

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedure for collecting ground water samples from permanent and temporary monitoring wells. Low-flow sampling techniques will be used for ground water sampling 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:

Writing utensil (preferably black ink)

Stainless steel Geoprobe Screen Point Groundwater Sampler (or equivalent)

Ground Water Sample Log Form: A copy of this form is attached at the end of this SOP

Low Flow Purge Data Sheet: A copy of this form is attached at the end of this SOP

Bound field log book

Chain-of-Custody Form

Bladder pump

Photoionization Detector (PID)

Peristaltic pump

Silicon tubing

Teflon tubing

Required sample containers with appropriate preservative: All sample containers for analysis by fixed-base laboratories will be supplied and deemed certified clean by the laboratory.

Surgical gloves

Water-level indicator

0.45-micron filter cartridge

Bucket: to collect development/purge water

Calculator, wristwatch, and timer

Stainless steel clamps

Plastic storage bags

Shipping containers with ice

3.0 SAMPLING PROCEDURES FOR PERMANENT MONITORING WELLS

3.1 Ground water sampling may be initiated when the monitoring well has been purged and stabilized in accordance with SOP CTO331-16.

3.2 Record the sample start time (using military time) on the Ground Water Sample Log Sheet. Record the field measurements for pH, oxidation-reduction potential (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 will 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 label, and the sample label.

3.7 Place the tagged sample container into a plastic storage bag and then into a cooler containing ice.

3.8 Enter the proper information on the Chain-of-Custody Form for each sample container (see SOP CTO331-03).

3.9 Repeat steps 3.3 through 3.9 for each sample container collected.

3.10 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.

3.11 All samples will be collected into pre-preserved bottles (if required) supplied by an approved laboratory. All samples will be collected in the following sequence (where applicable):

- Volatile organic compounds (VOCs)
- Other organics
- Metals
- Other Inorganics
- Filtered Metals (only if turbidity reading > 10 NTU, see section 3.13 below)

3.12 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.

3.13 Repeat steps 3.5 through 3.9 for the filtered sample containers.

3.14 After completion of sample collection, remove the bladder pump (if bladder pump is used for sampling) from the well and decontaminate the pump following the procedures in SOP CTO331-17. Leave dedicated tubing inside the well for possible future sampling events.

3.15 Replace the outer protective well cap and lock the well.

3.16 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 CTO331-15).

4.0 SAMPLING PROCEDURES FOR TEMPORARY WELL POINTS

4.1 Ground water samples may be collected from temporary well screens inserted into auger holes or DPT soil borings. The temporary well screens can be constructed of PVC or stainless steel.

4.2 Once the water table has been encountered, and the Geoprobe hole or auger hole has been completed, insert a 0.75- to 1.0-inch diameter slotted PVC well screen and riser to the bottom of the hole.

4.3 Field screening of volatile organic vapors (VOCs) in the borehole shall be done using a PID.

4.4 The temporary well screen will be allowed to equilibrate for at least 15 minutes. Measure water level in well every 5 minutes and record on the Low Flow Purge Data Sheet.

4.5 Development of the screen point will be accomplished using a peristaltic pump and Teflon tubing.

4.6 Insert the intake end of a length of Teflon tubing to the bottom of the screen point and attach a length of silicon tubing (approximately 1 foot) to the discharge end of the Teflon tubing. The silicon tubing will be threaded around the rotor of the pump and out of the pump.

4.7 The Teflon tubing will be lifted and lowered slightly while the pump is operating. The maximum pump rate will be approximately 2 liters per minute during development. However, the yield of the formation will dictate the pumping rate. Measure water level in well every 5 minutes and record on the Low Flow Purge Data Sheet.

4.8 Measurement of pH, specific conductance, turbidity, dissolved oxygen, ORP, and temperature shall be recorded every 5 to 10 minutes during the development process using a water quality meter and flow-through cell.

4.9 The screen point will be pumped until discharge water is visibly clear, the turbidity readings do not improve over time, or the well screen goes dry.

4.10 Once the water has cleared or will clear no further, the pumping rate will be lowered to 50 to 100 mL per minute. Stabilization is achieved after two consecutive readings taken at 5 to 10 minutes intervals of the following field parameters has occurred:

- pH +/- 0.1 standard units
- Turbidity +/- 10% for values greater than 1 NTU
- Specific conductance +/- 3%
- Temperature +/- 3%
- ORP +/- 10 millivolts
- Dissolved oxygen +/- 10%

If the above condition(s) have not been met after three well point volumes have been removed, this will be recorded on the field sample form and the ground water sample collection can commence.

4.11 Samples will be collected using the peristaltic pump set at a flow rate of 100 mL per minute or less, depending on the yield of the formation. Samples will be collected directly from the pump discharge tubing. The pump shall operate continuously between development, purging, and sampling.

4.12 Record the sample date and time (using military time) on a TtNUS Ground Water Sample Log Sheet and on a chain of custody form.

4.13 Record the sample date and time (using military time) on an adhesive-backed sample label and affix the sample label securely to the sample container.

4.14 With the pump continuing to run, allow the pump discharge to flow gently down the inside of the sample container with minimal turbulence when filling sample containers. Avoid immersing the discharge tube into the sample as the sample container is being filled.

4.15 Cap each container immediately after filling.

4.16 Place the sample container into a ziplock bag and then into a cooler containing ice.

4.17 Repeat steps 4.14 through 4.17 for each sample container collected.

4.18 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 TtNUS Ground Water Sample Log Sheet.

4.19 All samples will be collected into pre-preserved bottles (if required) supplied by an approved laboratory. Table 1-3 of the FSP includes information on preservation requirements and types of sample containers. The hierarchy of filling sample containers is as follows:

- Volatile organics
- Other Organics
- Total metals
- Other Inorganics
- Filtered metals (only if turbidity reading > 10 NTU, see section 4.20 below)

This hierarchy takes into consideration the volatilization sensitivity of groundwater samples.

4.20 If the turbidity of a ground water sample is greater than 10 NTU and a total metals sample aliquot is collected, then a dissolved metals aliquot will also be collected. A single-use, disposable, in-line 0.45-micron filter cartridge shall be used to collect dissolved metals samples. Attach the

filter cartridge to the discharge end of the pump tubing. Prior to filling containers with filtered sample, rinse the filter cartridge with approximately 100-ml of water from the boring to be sampled. Direct the discharge from the filter cartridge into the sample bottle and collect the filtered sample. Types of sample containers, sample volume, preservation requirements, and holding times are summarized in Table 1-3 of the FSP. The laboratory will supply all sample containers, and the laboratory will pre-preserve sample containers where appropriate.

4.21 Once all of the sample containers have been filled, the pump shall be shut off. Record the sample date and time (in military time) on an adhesive-backed sample label and affix the sample label securely to the sample container. Record the end time for sampling on a TtNUS Groundwater Sample Log Sheet.

4.22 Once collection of samples is complete, remove tubing from temporary well screen and discard as investigation-derived waste (IDW, see SOP CTO311-15). The screen point shall be removed from the boring and decontaminated in accordance with the procedures outlined in SOP CTO331-17.

4.23 Proceed to abandon the borehole with bentonite chips and excess soil core material.

5.0 ATTACHMENTS

1. Ground Water Sample Log Sheet
2. Low Flow Purge Data 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: / Time: / Method:	Color (Visual)	pH (S.U.)	S.C. (mS/cm)	Temp. (°C)	Turbidity (NTU)	DO (mg/l)	Salinity (%)	Other

PURGE DATA:

Date:	Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
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:

MS/MSD	Duplicate ID No.:	Signature(s):

STANDARD OPERATING PROCEDURE
NUMBER CTO331-06

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 NSWC Crane facility 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. Any of these results can be viewed, but only one mode may be viewed at a time.

The 2020 has six keys for alphanumeric entry and for accessing multiple functions. The keys are used to set up and calibrate 2020. They allow the user 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 four 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 two 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 two- line by 16-character display. The top line is used to display status information and prompts the user for inputs. The bottom line is used for soft key names. Up to three names can be displayed for the three 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 the user to advance and the EXIT key provides a way to go back. If the user is at the initial entry of the menu, EXIT will return you to the default display.

The ENTER key has a context sensitive function. When the user is operating or navigating through the function map, the ENTER key is used to exit the functions and return 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 is entered, 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 eight-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 1-minute averaging interval.

Once every minute, the oldest of the 15 samples is replaced with a new 1-minute average. This moving average provides a 15-minute average of the last 15 minutes with a 1-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. The user 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 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. The user 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 the MAX reading is displayed, and "Clr" is pressed, 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 166, the instrument should be operated in this mode. Operation within the other specialized modes is the responsibility of the SSO.

4.5 Set Functions

Set functions are used to set up the 2020. Three functions 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 the pump is turned 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 they are not needed, the lives of the battery and ultraviolet (UV) lamp will be conserved.

To set the pump:

1. Press the ENTER key. The top line of the status display changes to "Select?" The bottom line displays three 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 three devices that 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 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 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. Wait for the display to timeout or press ENTER to return to the default display.

4.5.3 Calibration (Cal)

"Cal" allows the user to set up 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 the user 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 the user 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 three soft key selections, "Set," "Log," and "Display."

5. Press "Set." From this option, three 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 inch 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.

- PIDs 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 that 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, rainfall 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 was 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 if 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 CTO331-07

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 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 CTO331-06)
Writing utensil

3.0 RESPONSIBILITIES

A field geologist or 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 will 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" will be used to indicate angular granular materials resulting from the breakup of rock. The sharp edges that are 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 will 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 will 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 will 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" will 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 will 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 will 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 consist 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 will 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 will 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

Unified Soil Classification System

Coarse Grained Soils (more than half of soil > No. 200 sieve)	Gravels (More than half of coarse fraction > no. 4 sieve size)	GW	Well graded gravels or gravel-sand mixtures, little or no fines
		GP	Poorly graded gravels or gravel-sand mixtures, little or no fines
		GM	Sandy gravels, gravel-sand-silt mixtures
		GC	Clayey gravels, gravel-sand-silt mixtures
	Sands (More than half of coarse fraction < no. 4 sieve size)	SW	Well graded sands or gravelly sands, little or no fines
		SP	Poorly graded sands or gravelly sands, little or no fines
		SM	Silty sands, sand-silt mixtures
		SC	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
Fine Grained Soils (more than half of soil < No. 200 sieve)	Silts and Clays LL = < 50	ML	Inorganic silts and very fine sands, rock flour, silty fine sands or clayey silts with slight plasticity
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, lean clays
		OL	Organic silts and organic silty clays of low plasticity
	Silts and Clays LL = > 50	MH	Inorganic silts, micaceous or diatomaceous fine sand or silty soils, elastic silts
		CH	Inorganic silts of high plasticity, fat clays
		OH	Organic clays of high plasticity, organic silty clays, organic silts
Highly Organic Soils		Pt	Peat and other highly organic soils

Grain Size Chart

Classification	Range of Grain Sizes	
	U.S. Standard Sieve Size	Grain Size In Millimeters
Boulders	Above 12"	Above 305
Cobbles	12" to 3"	305 to 76.2
Gravel	3" to No. 4	76.2 to 7.76
coarse	3" to 3/4"	76.2 to 4.76
fine	3/4" to No.4	19.1 to 4.76
Sand	No. 4 to No. 200	4.76 to 0.074
coarse	No.4 to No. 10	4.76 to 2.00
medium	No. 10 to No. 40	2.00 to 0.420
fine	No. 40 to No. 200	0.420 to 0.074
Silt and Clay	Below No. 200	Below 0.074

Relative Density (SPT)

SANDS AND GRAVELS	BLOWS/FOOT
VERY LOOSE	0 – 4
LOOSE	4 – 10
MEDIUM DENSE	10 – 30
DENSE	32 – 50
VERY DENSE	OVER 50

Consistency (SPT)

SILTS AND CLAYS	BLOWS/FOOT
VERY SOFT	0 – 2
SOFT	2 – 4
MEDIUM STIFF	4 – 8
STIFF	8 – 16
VERY STIFF	16 – 22
HARD	OVER 32

ATTACHMENT 2

BORING LOG

Tetra Tech NUS, Inc.

BORING LOG

Page ___ of ___

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	RQD/Ft Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**

* When rock coring, enter rock hardness.
** 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 CTO331-08

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 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 certified clean by the laboratory.

Required decontamination materials

Chain-of-custody records

Required personnel protective equipment (PPE)

Photoionization detector (PID) (see SOP CTO331-06)

Wooden stakes or pin flags

Sealable polyethylene bags

Heavy-duty cooler

Ice

Razor knife

Geoprobe® and sampling equipment

Sample labels

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 CTO331-04) 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 CTO331-04).

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 the range of PID readings that 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 indicates potential contamination, then collect the VOC sample from near the center of a core.

3.3 The 0- to 2-foot 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 identification 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 identification, 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 identification and other necessary information (see SOP CTO331-01).

3.5 Once the samples are properly labeled and bagged, place the sample into the cooler containing ice and a trip blank. The cooler 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, after 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- to 2-foot 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 will 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

4.3 Complete all required information on the sample labels (see SOP CTO331-01).

4.4 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.

4.5 Record the required information on the Soil Sample Log Sheet and the COC Record form.

5.0 PACKAGING AND SHIPPING OF SAMPLES

Samples will be packaged and shipped according to SOP CTO331-24.

6.0 ATTACHMENTS

1. Soil and Sediment Sample Log Sheet
2. Chain of Custody Record

ATTACHMENT 1

SOIL AND SEDIMENT SAMPLE LOG SHEET

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:

Date:	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)
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):

ATTACHMENT 2
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

DATE YEAR	TIME	SAMPLE ID	MATRIX	GRAB (G) COMP (C)	No. OF CONTAINERS	CONTAINER TYPE PLASTIC (P) or GLASS (G) / PRESERVATIVE USED / TYPE OF ANALYSIS								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 CTO331-09

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 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 logbook
Well keys
Disposable medical-grade gloves (e.g., latex, nitrile)
Photoionization detector (PID)
Electronic water-level indicator
Steel rod (about 1 inch in 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 polyvinyl chloride (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 0.01foot.

3.10 Check the existing well log 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 Health & Safety Plan (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 foot (see SOP CTO331-18) 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 the bottom of the 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 CTO331-17.

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. Before the riser is cut, a clean rag will be inserted into the riser to just below the cut to 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 and 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

NSB-NLON
Field Form
Revision: 1
January: 1999

STANDARD OPERATING PROCEDURE
NUMBER CTO331-10

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 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 developing monitoring wells. The drilling contractor personnel must have all the health and safety training required to perform the work, as specified in the health and safety plan (HASP).

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 will 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 that 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 because 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 percent 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 Task Order Manager 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: _____
Site: _____
Date Installed: _____
Date Developed: _____
Dev. Method: _____
Pump Type: _____

Depth to Bottom (ft.): _____
Static Water Level Before (ft.): _____
Static Water Level After (ft.): _____
Screen Length (ft.): _____
One Well Volume (gal/L): _____
Casing ID (in.): _____

Responsible Personnel: _____
Drilling Company: _____
Project Name: _____
Project Number: _____
PID Readings: Bore Hole____ppm
PID Readings: Breathing Zone____ppm

Time	Cumulative Water Volume (Gal.)	Flow Rate (mL/min.)	Water Level Readings (Ft. below TOC)	Temperature (Degrees C)	pH	Specific Conductance (Units _____)	Turbidity (NTU)	Remarks (odor, color, etc.)

STANDARD OPERATING PROCEDURE
NUMBER CTO331-11

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 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. 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 before the desired well boring depth is reached.

- Rotary drilling with a roller bit and water wash may be used to complete well borings in the event that bedrock is encountered before the desired well boring depth is reached.

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 and equipment. The FOL is responsible for the completion of all field activities and field and chain-of-custody documentation. The

FOL 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 Task Order Manager (TOM). Specific FOL responsibilities include the following:

- Function as a communications link among field staff members, the site quality assurance/quality control 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 recordkeeping.
- 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 will 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 - The subcontractor operates under the supervision of the FOL. He or she is 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 will 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 that underlie the site.
- 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 CTO331-17. 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 because 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 that 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 the drill rods. This variation is practical only if fewer 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 can yield 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), may be used.

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 and 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: cement the hole , ream and case, or case and advance with the next smaller size core barrel, as conditions warrant.

3.3 Rock Core Management and Labeling

When the core barrel has been recovered, the rock core will 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 will be described, classified, and logged using a uniform system (Section 3.5 of this SOP).

Rock cores will 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 will not be placed in the same core box. The core boxes will be constructed to accommodate at least 20 linear feet of core in rows of approximately 5 feet each. Wood partitions will 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 will 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 will be the same in all core boxes. Rock core will 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 their true depths will 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 will 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 will be marked by indelible ink to show all pertinent data about the box's contents. At a minimum, the following information will 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 will also be labeled and will include project number, boring number, top and bottom depths of core, and box number.

Before final closing of the core box, a photograph will be taken of the recovered core and the labeling on the inside cover will 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 that 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 will 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 or 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 or engineer. To maintain a consistent flow of information, it is imperative that the field geologist or 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 will 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 "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 modifying descriptions 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 USGS 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 will be classified while wet, when possible, and air-cored samples will be scraped clean of cuttings prior to color classifications. Soil colors will 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

(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 that 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 will 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), and a gouge is much deeper.

4.2.5 Fracturing

Method of Calculating RQD
(After Deere, 1966)

Fractures should also be noted.

$$RQD\ \% = r/l \times 100$$

r = Total length of all pieces of the lithologic unit being measured that 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 - The rock shows little or no weathering effect. Fractures or joints have little or no staining and rock has a bright appearance.

Slight - The rock has some staining that may penetrate several centimeters into the rock. Clay filling of joints may occur. Feldspar grains may show some alteration. Oxidation and weathering may affect the degree of fracturing or brokenness of a rock. After eliminating drilling breaks, the average spacing of natural breaks 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 a 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 will 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 will be neat so it can be reproduced on a copy machine for report presentation. The data will 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 will 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 will be used to complete the logs. A sample boring log is attached at the end of this SOP.

The field geologist or engineer will use this example as a guide in completing each boring log. Each boring log will be fully described by the geologist or 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 will 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 will be entered under the "Remarks" column and will 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 should 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 the 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 will be drawn if there is a change in lithology, then vertical lines will be 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 is to be scraped clean before the color is described.

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 Section 5.3.

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 and as noted on the back of the boring log.

The following information will be entered under the remarks column. Items will 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 will include

- Type and size of core obtained
- Depth casing was set
- Type of rig used

As a final check, the boring log will include the following:

- Vertical lines will 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 will be followed when logging cuttings are as follows:

- 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 ziplock bag for future reference, and label the jar or bag (i.e., hole number, depth, date, etc.). Cuttings will 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 and mud rotary methods.

5.4 Review

Upon completion of the borings logs, copies will 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 will be retained in the project files.

7.0 ATTACHMENTS

1. Boring Log

ATTACHMENT 1

BORING LOG

Tetra Tech NUS, Inc.

BORING LOG

Page ___ of ___

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 response read.

Remarks: _____

Drilling Area Background (ppm): _____

Converted to Well: Yes _____ No _____ Well I.D. #: _____

References

Deere, D.U. and Miller, R.P., (1966). Engineering Classification and Index Properties for Intact Rock, Air Force Weapons Lab. Tech. Report AFWL-TR-65-116, Kirtland Base, New Mexico.

Wentworth, C.K., 1922. A Scale of Grade and Class Terms for Caustic Sediments: Jour. Geology, v. 30, p. 377-392.

Ingram, R.L., 1954. Terminology for the Thickness of Stratification and Parting Units in Sedimentary Rocks: Geological Society of America Bulletin, v. 65. p. 937-938.

STANDARD OPERATING PROCEDURE
NUMBER CTO331-12

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 NSWC Crane facility. Guidelines by South Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM, 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 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 ensures 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

Overburden 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 comprising aquifer material is encountered before the desired well depth is reached. 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.

Bedrock monitoring well borings will be drilled using hollow-stem auger or rotary drilling techniques until the bedrock is reached. A 6-inch-diameter steel casing will be installed to the top of the bedrock 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 in those borings where coring is planned. For each well, the coring will proceed from the bottom of the casing to the full depth of the boring. Once the coring has been completed and the core has been logged (see SOP CTO331-11), then the hole will be reamed out with a minimum 5-inch-diameter air rotary bit. Air rotary drilling will be performed through the casing immediately after the grout has cured in those cases where coring is not anticipated. These borings will be logged using the rock chips and dust blown up the boring by the return air of the drill bit (see SOP CTO331-11). The borehole will then be cleaned out using compressed air from the drill 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 CTO331-13). 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.

All monitoring wells will be constructed of Schedule 40, flush-joint-threaded, 2-inch inside diameter polyvinyl chloride (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 will be National Sanitation Foundation (NSF) approved. Well screens will be 10 feet long but may be longer or shorter based on the subsurface conditions that are 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 will 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 foot 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 will 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 do not 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 will 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 will l 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 that 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 in a field logbook. Details of borehole logging are contained in SOP CTO331-11.

6.0 ATTACHMENTS

1. Bedrock Monitoring Well Sheet
2. Overburden Monitoring Well Sheet

ATTACHMENT 1

BEDROCK MONITORING WELL SHEET

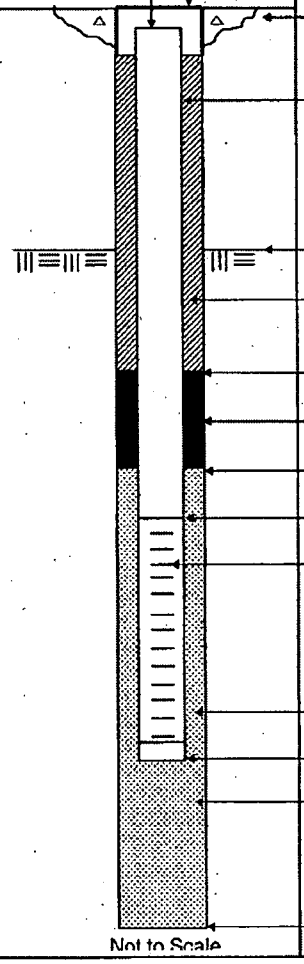
Tetra Tech NUS, Inc.

WELL No.: _____

MONITORING WELL SHEET

PROJECT:		DRILLING Co.:		BORING No.:	
PROJECT No.:		DRILLER:		DATE COMPLETED:	
SITE:		DRILLING METHOD:		NORTHING:	
GEOLOGIST:		DEV. METHOD:		EASTING:	

Ground Elevation =
Datum:



Elevation / Depth of Top of Riser: ____ / ____

Elevation / Height of Top of Surface Casing: ____ / ____

I.D. of Surface Casing: _____

Type of Surface Casing: _____

Type of Surface Seal: _____

I.D. of Riser: _____

Type of Riser: _____

Borehole Diameter: _____

Elevation / Depth Top of Rock: ____ / ____

Type of Backfill: _____

Elevation / Depth of Seal: ____ / ____

Type of Seal: _____

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: _____

Elevation / Depth of Bottom of Screen: ____ / ____

Elevation / Depth of Bottom of Filter Pack: ____ / ____

Type of Backfill Below Well: _____

Elevation / Total Depth of Borehole: ____ / ____

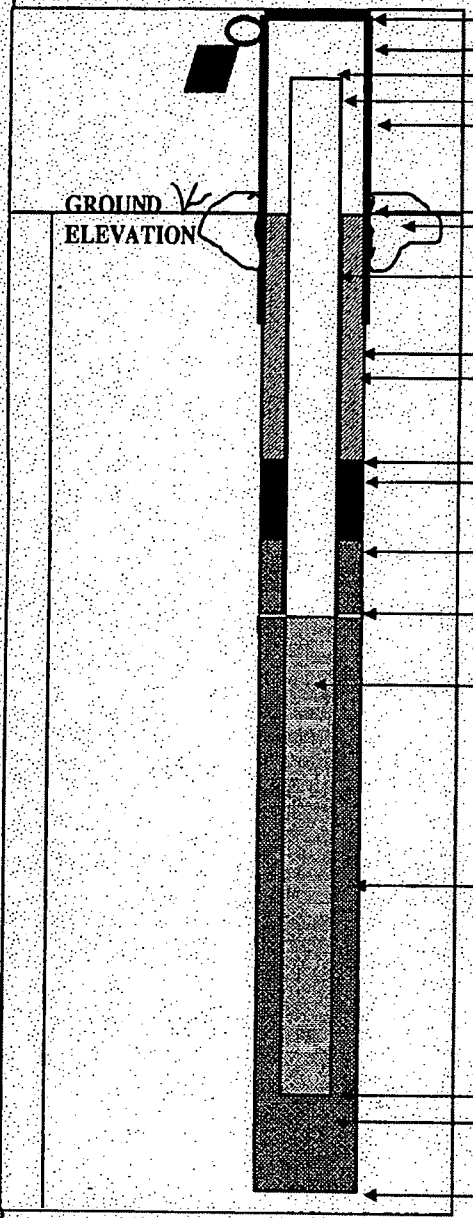
ATTACHMENT 2

OVERBURDEN MONITORING WELL SHEET

BORING NO.:

Tetra Tech NUS, Inc. **OVERBURDEN MONITORING WELL SHEET**

PROJECT:	NIROP FRIDLEY	DRILLING Co.:		BORING No.:	
PROJECT No.:	7842 CTO 0057	DRILLER:		DATE COMPLETED:	
SITE:	ANOKA PARK	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.: 2"
TYPE OF RISER PIPE: CARBON STEEL

BOREHOLE DIAMETER:
TYPE OF SEAL:

ELEVATION / DEPTH OF SEAL: /
TYPE OF SEAL: BENTONITE CHIPS

ELEVATION / DEPTH TOP OF FILTER PACK: /

ELEVATION / DEPTH TOP OF SCREEN: /

TYPE OF SCREEN: CARBON STEEL

SLOT SIZE X LENGTH: .10 SLOT x

I.D. OF SCREEN: 2"

TYPE OF FILTER PACK: SILICA SAND
(No. 10-20 U.S. STANDARD SEIVE SIZE)

ELEVATION / DEPTH BOTTOM OF SCREEN: /
ELEVATION / DEPTH BOTTOM OF FILTER PACK: /
TYPE OF BACKFILL BELOW WELL:
ELEVATION / DEPTH OF BOREHOLE: /

STANDARD OPERATING PROCEDURE
NUMBER CTO331-13

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 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 to 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 that 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 the data logger.

3.5 Once the pressure has reached steady state, turn on the pump, which will produce water at a rate of about 1 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 CTO331-16 in-line in the pump discharge line during the test. Record values every 2 to 3 minutes.

3.9 Monitor the flow rates during the test and record every 2 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 CTO331-17.

3.17 Contain all water produced during testing. Transport the IDW water to the central storage area in accordance with SOP CTO331-15.

STANDARD OPERATING PROCEDURE
NUMBER CTO331-14

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 that 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 logbooks, forms, equipment, and supplies are required:

Site logbook
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 will be 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 before the ground water comes in contact with the atmosphere. The parameters measured by the YSI for this field effort are as follows:

- DO
- SC
- Temperature
- pH
- 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-specification 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 will be charged. One-half inch of tap or distilled water will 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 the calibration cup will remain at 100 percent 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 Material Safety Data Sheets (MSDSs), 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 CTO331-15

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 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
Wastewater 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 following:

- The location and type of each water that has been placed in the tank (e.g., purge water from wells)
- The quantity of water from each source
- The date the wastewater was generated
- The date and time the wastewater 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 show 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 on site 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 on site. If the levels of contamination of any of the samples from a borehole exceed Toxicity Characteristic Leaching Procedure (TCLP) limits (using the total soil concentrations), then all

excess soil from the borehole will be considered as RCRA-hazardous and disposed off site in accordance with RCRA waste disposal regulations. Alternatively, the toxicity characteristic leaching procedure may be conducted for any constituent that 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, Direct-Push Technology (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 CTO331-16

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 CTO331-05.
Bound field logbook
Writing utensil
Photoionization detector (PID): The procedures for the operation of the PID are found in the health and safety plan and SOP CTO331-06.
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 foot (see SOP CTO331-18).
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 CTO331-14).
Flow-through cell adapter for water-quality meter
LaMotte Turbidity Meter: Used to measure turbidity (see SOP CTO331-14).
Purge water containers
Graduated cylinder and stopwatch: Used to calculate flow rate.

Decontamination supplies: SOP CTO331-17 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 above equipment in accordance with manufacturer requirements as necessary.

3.2 Follow the steps outlined in SOP CTO331-18 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 by measurement.

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 that 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 it is 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 it is 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 per minute. Use the graduated cylinder and stopwatch to measure the pumping rate. Adjust pumping rates as necessary to prevent drawdown from exceeding 0.3 foot during purging. If no drawdown is noted, the pump rate may be increased (to a max of 0.4 liters per 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:

- Stabilization of parameters
- Possible drawdown
- 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 5 minutes. Record the well water level on the Low-Flow Purge Data Form (attached at the end of this SOP).

3.11 Every 5 to 10 minutes, record on the Low-Flow Purge Data Form 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 4 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 from a distance until he or she 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 the sampler departs.

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

ATTACHMENT 1
LOW-FLOW PURGE DATA SHEET

Tetra Tech NUS, Inc.

LOW FLOW PURGE DATA SHEET

PROJECT :
PROJECT NUMBER:
PROJECT SITE NAME:

WELL ID.:
DATE:
WEATHER:

Time (Hrs.)	Water Level (Ft. below TOC)	Volume (gal/L)	Flowrate (mL/min)	pH (S.U.)	Cond. (mS/cm)	Turb. (NTU)	DO (mg/L)	Temp. (Celsius)	ORP (mV)	Comments

Water Quality Meter (S/N)
Control Box Type (S/N)
Turbidity Meter (S/N)

Pump Intake Depth

SIGNATURE(S):

PAGE___OF___

STANDARD OPERATING PROCEDURE
NUMBER CTO331-17

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 NSWC Crane facility.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Waterproof pens
Non-latex rubber or plastic gloves
Cotton gloves
Field logbook
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 CTO331-15 and the QAPP.

STANDARD OPERATING PROCEDURE
NUMBER CTO331-18

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 logbook
Photoionization detector (PID): Operation and calibration of the PID is discussed in SOP CTO331-06.
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 foot.
Decontamination supplies: SOP CTO331-17 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 polyvinyl chloride (PVC) riser pipe as follows:

1. Calibration of the PID shall be done in accordance with the calibration procedures described in SOP CTO331-06. Calibration of the PID shall be done at the field office prior to entering the field.

2 Insert the PID sample inlet straw approximately 3 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 10 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 CTO331-17.

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 CTO331-17.

3.13 Containerize any decontamination fluids and PPE in accordance with the procedures described in SOP CTO331-15.

4.0 ATTACHMENTS

1. Ground Water Level Measurement Sheet

ATTACHMENT 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 From TOC (feet)*	Water Level Indicator Reading (feet)*	Groundwater Elevation (feet)*	Comments

* All measurements to the nearest 0.01 foot

Page ____ of ____

STANDARD OPERATING PROCEDURE
NUMBER CTO331-19

SURFACE WATER SAMPLING

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedure for collecting surface water samples 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 CTO331-14).

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.

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.

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. Sample containers for volatile constituents (VOCs) must be completely filled so 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, and the Chain-of-Custody Form.

3.6 After the sample label is 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. 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 CTO331-14). 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 in accordance with SOP CTO331-21. 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

ATTACHMENT 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	ORP
Date:	Visual	Standard	mS/cm	Degrees C	NTU	mg/l	%	mV
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 CTO331-20

SEDIMENT SAMPLING - SHALLOW STREAMS

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedure for sediment sampling 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 logbook
Disposable plastic trowels
Survey stakes and flagging: Used to mark sampling locations after completion of sampling.
Labeled sample containers: See SOP CTO331-01 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

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.

4.0 SEDIMENT SAMPLING PROCEDURES

4.1 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 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.

4.2 Use the same trowel to scoop the homogenized sediment into the requisite labeled sample containers. 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

4.3 Record the sample time (using military time) on the Sediment Sample Log Form and sample container labels. Record all other information required on the labels as specified by SOP CTO331-01.

4.4 Place the labeled sample container into a plastic storage bag and then place the plastic storage bag by holding the sample container into a cooler containing ice.

4.5 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 in accordance with SOP CTO331-03.

4.6 Using an indelible marker, write the sample identification on a survey stake, and drive the stake into the ground at the sample location. Tack 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.

5.0 ATTACHMENTS

1. Soil and Sediment Sample Log Sheet

ATTACHMENT 1

SOIL AND SEDIMENT SAMPLE LOG SHEET

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:

Date:	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)
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 CTO331-21

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. Stream flow rates will be measured at the same time as 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 logbook
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 visible 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 CTO331-22

HYDRAULIC CONDUCTIVITY TESTING

1.0 PURPOSE

This Standard Operating Procedure (SOP) provides technical guidance for the performance and evaluation of an in-situ hydraulic conductivity testing (slug testing) in monitoring wells 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 logbook
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, because 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 or 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 will be placed in the well approximately 1 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, and rising head slug tests can be performed in wells with either partially or fully submerged screens or 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 when 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 that 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 will be taken from the top of the well casing.

3.8 Stop the test when 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, in accordance SOP CTO331-17.

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 are usable for the intended analysis prior to leaving the field. Time and 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, with 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 1

HYDRAULIC CONDUCTIVITY TESTING DATA SHEET

Tetra Tech NUS, Inc.

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: .....

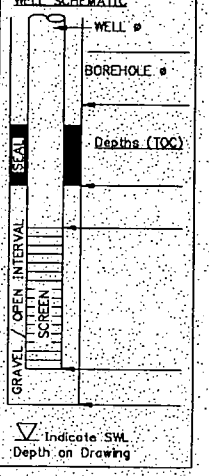
TEST TYPE (Rising/Falling/Constant Head): ..... CHECKED: .....

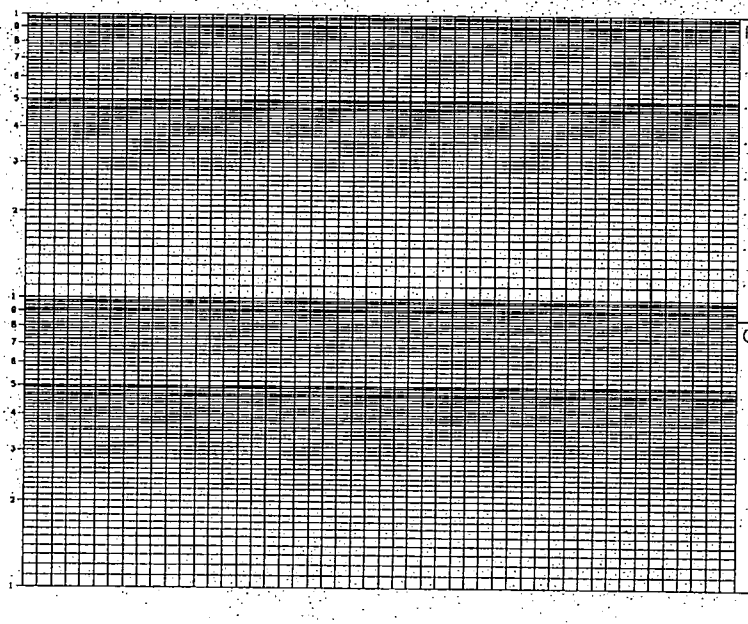
METHOD OF INDUCING WATER LEVEL CHANGE: ..... PAGE ..... OF .....

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





REMARKS:

CALCS, SKETCH MAPS, ETC.:

ACAD:FORM_HYDCONTST.dwg 07/08/99 INL

STANDARD OPERATING PROCEDURE
NUMBER CTO331-23

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
23.5 kilograms reagent grade sodium bromide
Ion-selective electrode (ISE) probe for bromide (with calibration fluids)
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.

STANDARD OPERATING PROCEDURE
NUMBER CTO331-24

SAMPLE PRESERVATION, PACKAGING, AND SHIPPING

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the procedures for sample preservation, packaging, and shipping to be used in handling ground water, surface water (including seeps), soils, and sediments collected at the NSWC Crane.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Shipping labels
Custody seals
Chain-of-custody (COC) form(s)
Sample containers with preservatives: All sample containers for analysis by fixed-base laboratories will be supplied, with preservatives added (if required) and deemed certified clean by the laboratory.
Sample shipping containers (coolers): All sample shipping containers are supplied by the laboratory.
Packaging material: Bubble wrap, ZipLoc® bags, strapping tape, etc.

3.0 PROCEDURES FOR SAMPLE PRESERVATION, PACKAGING, AND SHIPPING

3.1 The laboratory provides sample containers with preservative already included (as required) for the analytical parameter for which the sample is to be analyzed. All samples will be held, stored, and shipped at 4°C. This will be accomplished through refrigeration (used to hold samples prior to shipment) and/or ice.

3.2 The sampler shall maintain custody of the samples until the samples are relinquished to another custodian or to the common carrier.

3.3 Check that each sample container is properly labeled, the container lid is securely fastened, and the container is sealed in a ZipLoc® bag.

3.4 If the container is glass, place the sample container into a bubble-out shipping bag and seal the bag using the self-sealing, pressure sensitive tape supplied with the bag.

3.5 Inspect the insulated shipping cooler. Check for any cracks, holes, broken handles, etc. If the cooler has a drain plug, make certain it is sealed shut, both inside and outside of the cooler. If the cooler is questionable for shipping, the cooler must be discarded.

3.6 Put ice into ZipLoc® bags and place a layer of the sealed bags on the bottom of the cooler. Place the sample containers into the shipping cooler on top of the ice in an upright position (containers will be upright, with the exception of the 40-ml vials). Place ZipLoc® bags of ice flat against the sides of the cooler. Continue filling the cooler with samples until the cooler is nearly full and the movement of the sample containers is limited.

3.7 Place a temperature blank in the cooler. Make sure that all samples identified for VOC analysis and their associated trip blank are packed in the same cooler (i.e., VOC samples and trip blank that were stored together during sampling activities can not be separated into different coolers for shipping purposes).

3.8 Add a final layer of ice sealed in ZipLoc® bags to the top of the samples just before the cooler is closed and sealed.

3.9 Place the original (top) signed copy of the COC form inside a large ZipLoc® bag. Tape the bag to the inside of the lid of the shipping cooler that contains the samples for VOC analysis.

3.10 Close the cooler and seal the cooler with approximately four wraps of strapping tape at each end of the cooler. Prior to wrapping the last wrap of strapping tape, apply a signed, numbered, and dated custody seal to each side of the cooler (one per side). Cover the custody seal with the last wrap of tape. This will provide a tamper evident custody seal system for the sample shipment.

3.11 Affix a shipping label to the top of the cooler containing samples for VOC analysis, ensuring all of the shipping information is filled in properly. Overnight (e.g., FedEx Priority Overnight) courier services will be used for all sample shipments.

3.12 All samples will be shipped to the laboratory no more than 72 hours after collection. Under no circumstances will sample hold times be exceeded.

STANDARD OPERATING PROCEDURE
NUMBER CTO331-25

SEDIMENT SAMPLING — BUILDING 106 POND

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedure for multiple depth sediment sampling at the NSWC Crane facility in the Building 106 Pond.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following field forms and equipment are required for sediment sampling.

Bound field logbook
Core sampler (e.g., Wildco® Hand Corer Sampler with disposable liners and catch baskets or equivalent)
Chain-of-Custody Form
Indelible marker
Labeled sample containers: See SOP CTO331-01 for sample identification procedures. Sample containers are certified clean by the laboratory supplying the containers.
Plastic storage bags
Sediment Sample Log Forms: A copy of this form is attached at the end of this SOP.
Shipping containers (containing ice)
Surgical gloves
Labels for each sample container
Skiff

3.0 SEDIMENT SAMPLING PROCEDURES

3.1. Decontaminate the sampling equipment.

3.2. Determine the water depth to the top of the pond sediment by using a weighted measuring line.

3.3. Assemble the coring device by inserting the acetate core into the sampling tube.

3.4. Insert the eggshell check valve into the lower end of the sampling tube with the convex surface positioned inside the acetate core.

3.5. Screw the nosecone onto the lower end of the sampling tube, securing the acetate tube and eggshell check valve.

3.6. Screw the handle onto the upper end of the sampling tube and add extension rods as needed.

3.7. Place the sampler in a perpendicular position on the sediment to be sampled.

3.8. If the "T" handle is used, place downward pressure on the device until the desired depth is reached. After the desired depth is reached, rotate the sampler to shear off the core at the bottom. Slowly withdraw the sampler to a point approximately 2 inches above the sediment.

3.9. If the drive hammer is selected, insert the tapered handle (drive head) of the drive hammer through the drive head.

3.10. Drive the sampler into the sediment to the desired depth. [Note: three sediment depth ranges (0 to 6, 6 to 12, and 12 to 18 inches) will be collected at each sampling location.

3.11. Record the length of the tube that penetrated the sample material, and the number of blows required to obtain this depth.

3.12. Remove the drive hammer and fit the keyhole-like opening on the flat side of the hammer onto the drive head. In this position, the hammer serves as a handle for the sampler.

3.13. Rotate the sampler to shear off the core at the bottom.

3.14. Lower the sampler handle (hammer) until it just clears the two ear-like protrusions on the drive head, and rotate about 90 degrees.

3.15. Slowly withdraw the sampler from the sediment. If the drivehead was used, pull the hammer upwards and dislodge the sampler from the sediment.

3.16. Carefully remove the coring device from the water.

3.17. Unscrew the nosecone and remove the eggshell check valve.

3.18. Slide the acetate core out of the sampler tube. Decant surface water, using care to retain the fine sediment fraction. If head space is present in the upper end, a hacksaw may be used to shear the acetate tube off at the sediment surface. The acetate core may then be capped at both ends. Indicate on the acetate tube the appropriate orientation of the sediment core using a waterproof marker. The sample may be used in this fashion, or the contents transferred to a sample or homogenization container.

3.19. Slowly open the acetate tube and transfer the bottom 6 inches of sediment to a stainless steel, plastic or other appropriate composition (e.g., Teflon) container. Ensure that non-dedicated containers have been adequately decontaminated. If necessary, continue to collect additional sediment until sufficient material has been secured to fulfill analytical requirements. Thoroughly homogenize and then transfer sediment to sample containers appropriate for the analyses requested. Samples for volatile organic analysis must be collected directly from the bucket before homogenization to minimize volatilization of contaminants.

3.20. Use the same sample device (core or dredge sampler) to place the homogenized sediment into the requisite labeled sample containers. All sample jars will be filled in the following sequence:

- Volatile organics
- Other organics
- TAL metals plus and tin (total)
- Nitrate
- Nitrite
- TOC
- pH

3.21. Record the sample time (using military time) on the Sediment Sample Log Form and sample container labels. Record all other information required on the labels as specified by SOP CTO331-01.

3.22. Place the plastic storage bag holding the sample container into a cooler containing ice.

3.23. 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 in accordance with SOP CTO331-03.

3.24. Where possible, using an indelible marker, write the sample identification on a survey stake, and drive the stake into the ground at the sample location. Tack 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.

3.25. Repeat Steps 3.1 through 3.24 for each depth range of sediment to be sampled.

4.0 ATTACHMENTS

1. Soil and Sediment Sample Log Sheet

ATTACHMENT 1

SOIL AND SEDIMENT SAMPLE LOG SHEET

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:

	Time	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date:				
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):