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Conceptual Site Model and Fieldwork Report

for

Ammunition Burning Grounds (SWMU 3)

Volume I of II - Text

Naval Surface Warfare Center Crane

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ACRONYM LIST

µg/L	microgram per liter
ABG	Ammunition Burning Ground
ADNT	amino-dinitrotoluene
amsl	above mean sea level
BC/BC	Big Clifty and Beech Creek
bgs	below ground surface
Ca	Calcium
CAAA	Crane Army Ammunition Activity
CEC	Cation Exchange Capacity
CFR	Code of Federal Regulations
Cl	Chlorine
CLEAN	Comprehensive Long-Term Environmental Action Navy
cm	centimeters
cm/sec	centimeter per second
CMS	Corrective Measures Study
COC	Chain of custody
COC	Chemical of concern
CSM	Conceptual Site Model
CTO	Contract Task Order
DBG	Dye Burial Grounds
DCE	dichloroethene
DI	Deionized
DNT	dinitrotoluene
DO	Dissolved Oxygen
DPT	Direct Push Technology
FOL	Field Operations Leader
ft^3/s	cubic feet per second
FTMR	Field Task Modification Request
G-H	Golconda Haney
gpm	gallons per minute
HASP	Health and Safety Plan
HCO_3	Bicarbonate
HMX	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine

ID	Inside Diameter
IDW	Investigation Derived Waste
k	Hydraulic Conductivity
K	Potassium
LSC	Little Sulphur Creek
Mg	Magnesium
mg/kg	milligrams per kilogram
MTA	Main Treatment Area
Na	Sodium
NAD	Naval Ammunition Depot
NAD27	North American Datum 1927
NAVD88	North American Vertical Datum 1988
No.	Unit
NSWC	Naval Surface Warfare Center
NTU	Nephelometric Turbidity Unit
NWSC	Naval Seapons Support Center
OJT	Old Jeep Trail
ORP	oxidation-reduction potential
pH	potential of Hydrogen
PID	Photoionization Detector
PPE	Personnel Protection Equipment
PRG	Preliminary Remediation Goal
PVC	Polyvinyl Chloride
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RDX	Hexahydro-1,3,5-trinitro-1,3,5-triazine
RFI	RCRA Facility Investigation
RQD	Rock Quality Designation
SB	Soil Boring
SCS	Soil Classification System
SOP	Standard Operating Procedure
SSL	Soil Screening Level
SVOC	semi-volatile organic compound
SWMU	Solid Waste Management Unit

TAL	Target analyte list
TCE	trichloroethylene
TNT	2,4,6-Trinitrotoluene
TOC	Total Organic Carbon
TOM	Task Order Manager
TtNUS	Tetra Tech NUS, Inc.
TW	Temporary Well
US EPA	United States Environmental Protection Agency
USACE	United States Army Corp 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

1.0 INTRODUCTION

1.1 INTRODUCTION

The Naval Surface Warfare Center (NSWC) Crane Ammunition Burning Grounds (ABG) solid waste management unit (SWMU) 3 consists of the Main Treatment Area (MTA), the Old Jeep Trail (OJT), and Little Sulphur Creek (LSC). Figure 1-1 depicts the MTA, and Figure 1-2 depicts the OJT and LSC.

Resource Conservation and Recovery Act (RCRA) Facility Investigations (RFI) have been conducted. The RFI Report for the OJT and LSC recommended that a Corrective Measures Study (CMS) be conducted to address explosives, chlorinated solvents, and metals contamination in groundwater and soils at the OJT. RFI studies had been conducted by the United States Army Corps of Engineers (USACE) for groundwater, soils, and surface waters at the MTA. These studies had recommended that corrective measures be considered to address explosives, chlorinated solvents, and metals contamination from the MTA in soils, groundwater, and surface waters. The MTA, which is permitted by United States Environmental Protection Agency (US EPA) Region 5 as a treatment facility for hazardous waste munitions, explosives, and pyrotechnics, is subject to the groundwater monitoring and corrective action requirements of 40 Code of Federal Regulations (CFR) 264 Subpart F. These regulations require corrective actions for any groundwater contamination resulting from the treatment operations.

The Navy is in the process of preparing the CMS to address groundwater and soils contamination at SWMU 3. The initial phase of the CMS consists of development of the conceptual site model, which describes the geology, hydrology, groundwater contamination sources, transport of contamination, and fate. The conceptual site model is the basis for developing, evaluating, and choosing corrective measures. During the development of the CMS, the Navy determined that groundwater contamination sources were not adequately delineated at the MTA and that it was not possible to fully develop the conceptual site model until this data gap was filled. A Quality Assurance Project Plan (QAPP) Addendum No. 1 was developed which described the field investigation designed to fill these data gaps. The field investigation was conducted in April of 2004.

The purpose of this CMS field report is to describe and document the site investigation activities conducted in April 2004 and to present the results and interpretation thereof for SWMU 3 and development of the conceptual site model. This field investigation provides further information regarding concentrations of organic and inorganic chemicals measured in surface soils, subsurface soils, and groundwater at the MTA, OJT, and LSC. Additional data interpretation and reporting is presented as

needed to provide further perspective on current data and to aid in the development of the conceptual site model.

Section 1.0 of this Conceptual Site Model and Field Report presents historical information and describes the results of the April 2004 field investigation. Section 2.0 provides a detailed discussion of field investigation activities which were conducted during April, 2004. Section 3.0 presents the conceptual site model. Appendix A contains analytical results showing positive hits in surface soil, subsurface soil, and groundwater for all field investigations conducted at the ABG and OJT for the period 1993-2004. Appendix B provides surveyed sample locations of SWMU 3 for the April 2004 field investigation. Appendices C through E contain copies of all boring logs, field forms, sample log sheets, records, and field logbooks associated with the April 2004 field investigation. Appendix F shows the concentration versus time graphs for RDX and TCE in groundwater monitoring wells and springs. Appendix G contains the calculations for contaminant quantities and soil volumes.

1.2 PURPOSE OF CONCEPTUAL MODEL

The conceptual site model provides a representation of the environmental system. The conceptual site model is a tool for identifying release pathways of migration, potential receptors and, ultimately, risk. It should provide a basis, in part, for the formulation and evaluation of remedial options for the SWMU 3 watershed. It will provide a guide to:

- the locations where soils, groundwater, surface water, and sediment are contaminated and the relative magnitude of the contamination in each area;
- the directions that contaminants are migrating; and
- the natural attenuation processes that are affecting the persistence and migration rates of the contaminants in the watershed.
- the locations where human or ecological receptors are being or could be exposed to contaminants.

Based on temporal trends of contaminant concentrations in monitoring wells, springs, and surface water, an attempt has also been made to estimate the length of time that the contaminants might be present in the watershed at concentrations above acceptable risk levels. These estimates will affect, to some extent, where the priorities for remediation efforts might be assigned during the formulation and evaluation of remedial alternatives.

Potential exposure and health risks are expected to be confined primarily to aqueous and solid media. Only minimal airborne release pathways (e.g., occasional minor resuspension of dust or release of volatile chemicals) are anticipated. Therefore, this conceptual site model does not discuss or evaluate airborne contaminants or related potential migration pathways.

1.3 GENERAL DESCRIPTION OF STUDY AREAS

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.

The ABG and OJT are located in a remote hilly area in the eastern portion of the installation along LSC. The OJT area is located in the valley of LSC, approximately one-half mile south-southeast of the ABG on Jeep Trail 25. These areas lie within the Sulphur Creek drainage basin, which is one of five main drainage basins that carry surface water off the installation. LSC is a small stream whose headwaters originate in channels on the north, west, and south of the ABG. These ephemeral channels run through the ABG area and converge on the eastern side of the ABG. From the ABG, LSC runs southeastward through the OJT area and then southward to the NSWC Crane property boundary.

1.3.1 Operational History

The NSWC Crane facility was commissioned on December 1, 1941 as the Naval Ammunition Depot (NAD), Burns City. Its initial mission was to prepare, load, renovate, receive, store, and issue all types of ammunition, including pyrotechnics and illuminating projectiles, and act as a principal supply source at a most critical time during the early days of World War II. In May 1943, the depot was renamed the Naval Ammunition Depot, Crane, in honor of Commodore William Montgomery Crane, the Navy's first chief of the Bureau of Ordnance. The name changed again in 1975 to the Naval Weapons Support Center (NWSC) Crane to reflect the facility's growing involvement in high-technology weapons systems. In 1977, the Secretary of Defense combined all conventional ammunition acquisition under the responsibility of a single service. The ammunition production and storage function was given to the Army, and the Crane Army Ammunition Activity (CAAA) was established as a Crane tenant to accomplish this task for Naval ammunition. In 1992, the facility name was changed to NSWC Crane. The Army has assumed ordnance production, storage, and related responsibilities under the single-service management directive. All environmental activities on the installation, including permitting activities, remain the responsibility of the

Navy. Information regarding operations conducted at the ABG MTA and the OJT are described in Sections 1.3.1.1 and 1.3.1.2.

1.3.1.1 MTA Operations

The MTA of the ABG is used extensively to destroy unwanted materials contaminated with explosives and related materials. Several separate burning areas are located within the site (see Figure 1-1). The largest quantities of materials were treated at the ABG MTA from 1956 to 1960, when 15,000 pounds per day of smokeless powder were flashed. In the same period, about 46,000 pounds per day of high explosives were burned. The area was also used to flash the residue from bombs and projectiles after they have been subjected to melt-out or drill-out operations to remove the bulk of the explosive (Murphy, 1994).

Prior to the construction and use of lined and unlined steel pans for open burning operations, explosives and propellants and materials contaminated with explosives and propellants were spread and ignited on pads or in pits at the ABG MTA. Many of these burn pads and pits were reportedly located in the area now occupied by the clay-lined steel burn pans (see Unit No. 3 on Figure 1-1). However, others were located throughout the MTA.

Three unlined surface impoundments (no longer present) were used to remove liquids from otherwise combustible sludges resulting from the blending and loading of munitions. In 1982, each impoundment was modified to include a liner and leachate collection system. Each of the impoundments was approximately 40 feet in diameter. Two impoundments held TNT, RDX, and breakdown compounds in water from a facility munitions plant (Rockeye) and other locations within NSWC Crane. A third impoundment held phosphorus compounds. The three impoundments have been replaced by dewatering units (see Units No. 10 and 11 on Figure 1-1). The impoundments are now empty and are scheduled for closure.

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

The "ash pile" area (see Figure 1-1) was the site of a former stockpile of burn residue. The pile was removed between July 1986 and February 1987, pursuant to a RCRA closure plan. The pile consisted of approximately 12,290 pounds of burn residue.

Prior to approximately 1985, pink water sludge was placed and burned in an unlined pit in the location of the pink water tanks (see Unit No. 14 on Figure 1-1). This flashing process was relocated to the burn pads in approximately 1985. The pink color of the water and sludge is caused by the presence of explosives and related chemicals.

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

No treatment operations have taken place on the ground surface since the 1980s; all current treatment operations take place in containment facilities. The following operations currently occur at the ABG. The locations of many of these ABG activities are shown on Figure 1-1.

- Solid bulk propellant and explosives are open burned in 18 clay-lined steel pans at the ABG Main Burn Pan Grid (Unit No. 3).

- The primer pit operation (Unit No. 12) involves treatment of small explosive components such as hand grenade fuses and cartridge primers.

- Solvents contaminated with propellants, explosives, and pyrotechnics are burned in one unlined steel pan at the ABG (Unit No. 5).

- Waste scrap pyrotechnics, which have been desensitized in No. 2 fuel oil, are burned in a second unlined steel pan at the ABG (Unit No. 7).

- A third pan is used to burn scrap black powder desensitized with water (Unit No.8).

- Two sets of four pans each are used at Unit No. 6 for the treatment of a waste mixture containing red phosphorus and No. 2 fuel oil.

- The incendiary cage (Unit No. 13) at the ABG is set up primarily to allow the open burning of pyrotechnic devices and components.

- The flashing and thermal treatment of suspect explosive-contaminated materials is carried out at three concrete-lined burn pads at the ABG (Unit No. 9).

- Explosive- and pyrotechnic-contaminated sludges from production operations are treated at three sludge burning pans (Units No. 10 and 11). Hexahydro-1,3,5-trinitro-1,3,5-trizine (HMX) contaminated sludge and phosphorus-contaminated sludge are currently burned at this unit.

1.3.1.2 OJT

The OJT is an inactive area that is adjacent to and down-valley (south-southeast) of the ABG. Former operations at the OJT were directly associated with operations at the ABG. The OJT area was used to burn out bombs and flash powder from the mid-1970s through 1983. Materials were reportedly treated at two separate regions of the Jeep Trail Area (also known as the OJT), the burn area and the burn pit. The approximate locations for these two areas are shown on Figure 1-2. At the burn area, bomb casings from which the bulk explosives had been removed were filled with initiating powder, tilted on-end toward a hillside east of the Jeep Trail Area in the direction of the adjacent hillside, and flashed to complete the demilitarization process. Some munitions are thought to have been lashed to a horizontally positioned utility pole (that may have been creosote treated) prior to flashing.

The burn pit was a trench or natural depression, approximately 100 feet long, 30 feet wide, and 10 to 12 feet deep, located just south-southeast of the burn area (Figure 1-2). The term "pit" may be a misnomer because it may have been more of a natural topographic depression than an excavated pit. Powder was flashed and explosives-contaminated materials were burned in this pit. The contaminated material may have included cardboard, paper, wood, and metal packaging that may have come into contact with explosives, solvents-contaminated rags, or any other material that may have been contaminated with explosives. Some of the wooden packaging material may have contained pentachlorophenol. Small munition items and components were also reportedly treated. The area has not been used for any operations since 1983 when it was filled with clean fill material and revegetated. The area is now overgrown with brush, trees, and grasses.

The exact size, shape, and locations of the burn pit and the burn area are not known. Their approximate locations have been indicated on Figure 1-2. However, descriptions of the treatment areas in previous reports (Figure 41 in Dunbar, 1982; Murphy, 1996) and interviews with base personnel during the OJT-LSC RFI (TtNUS, 2002b) indicate that the treatment areas may have covered a larger area than just the burn area and the burn pit, extending from Jeep Trail 25 westward to the LSC stream channel and southward as far as well 03-07. However, sampling along the length of the OJT, in areas where

treatment reportedly took place, did not result in findings of contaminants. Although inactive as a treatment area, Jeep Trail 25 is still actively used as a vehicle route.

1.3.1.3 Groundwater Contamination Sources

Based on the above discussion of operations and the results of previous investigations at the MTA and the OJT which are discussed in Section 1.5, Table 1-1 identifies the key operations and potential sources of groundwater contamination at the MTA and the OJT.

1.3.2 Topography and Physical Features

The LSC watershed, which contains the ABG MTA and OJT, is characterized by rugged relief, with ground surface elevations ranging from about 600 to 800 feet above mean sea level (msl) in the headwaters of LSC. At the OJT, ground surface elevations range from approximately 550 to 800 feet amsl. The surface elevation is approximately 500 feet amsl where LSC exits the southern border of the installation.

The ABG MTA is relatively flat and is within the northern headwater area of LSC. The ABG treatment area was formerly kept devoid of vegetation in order to minimize the potential for fires during open burning treatments. However, since the early 1990s, areas along LSC within the ABG have been seeded with grass to minimize erosion of soil into LSC. The OJT site is located in a gravel-covered area on the western side of the gravel access road (Jeep Trail 25), where the road widens in excess of 50 feet. The OJT and the remainder of the LSC valley are surrounded by wooded areas along the hillsides to the east and west, with miscellaneous natural ground vegetation under the tree canopy and along the creek banks.

1.3.3 Geology

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 (see Figure 1-3). Due to erosion and the moderate relief in the area, the Lower Pennsylvanian and Upper Mississippian rock units crop out on the ridgetops and along the stream valleys. A map showing the uppermost bedrock units in the LSC watershed is provided in Figure 1-4.

The USACE, the Indiana Geological Survey, and Indiana University have been investigating the geology and hydrogeology of the LSC watershed since the early 1980s. Based on boring logs drilled to various depths throughout the LSC watershed, the USACE has developed a detailed understanding of the

geologic units in the watershed. Several existing USACE geologic cross-sections are reproduced in this report. The lines of section for these Figures are presented in Figure 1-5. Cross-section A-A' (Figure 1-6) is the shortest cross-section and traverses in a northeast-southwest direction directly through the OJT area. This cross-section is most pertinent to the discussions of the OJT area. Cross-section P-P' (Figure 1-7) also traverses in a northeast-southwest direction, but covers a greater distance. It extends from the Dye Burial Ground (DBG) area (SWMU 02) in the northeast, through the southeastern corner of the MTA, and southwestward to well 03C25, located on the western side of the watershed. The cross-section C-C'/D-D' (Figure 1-8) lies in a semicircle around the northern and eastern edges of the MTA. The cross-section AA-AA' (Figure 1-9) traverses from the northwestern to the southeastern portions of the watershed. The cross-section K'-K" (Figure 1-10), the longest cross-section, traverses from north of MTA to the southern end of the study area near the NSWC Crane property line.

The uppermost (youngest) bedrock units in the LSC watershed belong to the Lower Pennsylvanian Mansfield Formation of the Raccoon Creek Group (Figure 1-3). This formation 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 (Murphy and Wade, 1998a). For example, over 120 feet of Pennsylvanian strata occur in well 03C29 on the western side of the watershed (see Figure 1-9), in well 03C31 located about 800 feet south of MTA and 2,400 feet west of OJT (see Figure 1-7), and in well 03C16 located on the northwestern side of MTA (see Figure 1-8). In the area near the DBG (Murphy and Wade, 1998a; TtNUS, 2002) and throughout much of the LSC watershed, thick sandstone units are the predominant component of the Mansfield Formation. The Pennsylvanian age sedimentary rocks are absent where LSC and its tributaries have eroded into the Mississippian strata. As a result, the Mansfield sandstones and coal units crop out in the uppermost portions of the ridges (Figures 1-7 through 1-10). The Pennsylvanian sedimentary rocks were also deposited on an erosional surface that developed on the Mississippian rock units, so the basal elevation of the Pennsylvanian rocks is spatially variable (Barnhill, 1993; Kvale and Barnhill, 1994). The base of the Pennsylvanian age strata has the highest elevation (about 670 to 680 feet amsl) near the DBG in the northeastern portion of the watershed (Figure 1-7). The paleoerosion surface generally lies between 640 to 660 feet amsl in the central and southeastern portions of the watershed (Figures 1-7, 1-9, and 1-10). The base of the Pennsylvanian decreases to its lowest elevation (about 615 to 620 feet above msl) on the northwestern side of the MTA near wells 03C16 and 03C19 (Figure 1-8). This agrees with the pre-Pennsylvanian paleosurface that has been mapped to NSWC Crane (Barnhill, 1993; Kvale and Barnhill, 1994).

The Stephensport Group (uppermost Mississippian) lies beneath the Pennsylvanian strata and includes a number of sandstone and limestone formations, including (from top to bottom) the Glen Dean Limestone,

the Hardinsburg Formation, the Haney (also called Golconda) Limestone, the Indian Springs Shale and the Big Clifty Sandstone member of the Big Clifty Formation, and the Beech Creek Limestone (Figure 1-3). The Stephensport Group is generally 120 to 190 feet thick.

A thin layer of Glen Dean Limestone is found directly beneath the Mansfield Formation in isolated areas of the watershed: near well 03C31 south of the ABG (Figures 1-7 and 1-10) and east of the LSC valley near well 03C35 and the NWSC Crane property line (Figure 1-9). This limestone is considered to be a productive aquifer unit in other parts of the NSWC Crane installation, but in this watershed it was extensively eroded prior to Pennsylvanian deposition. The maximum observed thickness was 4 feet in well 03C31. Hence, it is not considered as an aquifer unit in the remainder of this report.

The Hardinsburg Formation is found immediately below the Mississippian-Pennsylvanian unconformity in the northeastern, central, and southern portions of the watershed (Figures 1-7 and 1-9). This unit is up to 50 feet thick and contains primarily shale. Near well 03C31 south and southwest of the MTA, a sandstone lens is present in the middle of the formation (Figure 1-7). The Hardinsburg Formation typically acts as an aquitard between the Mansfield sandstone units above and the underlying Haney Limestone. However, this unit is absent in areas north and northwest of the MTA due to pre-Pennsylvanian erosion (Figure 1-8).

The underlying Haney Limestone (also referred to as Golconda Limestone) is characterized by shaly limestone and limey shales. The thickness ranges from several feet to almost 20 feet. The Golconda/Haney (G-H) Limestone is thinnest northwest of the MTA where it has been partially eroded due to pre-Pennsylvanian erosion.

The Big Clifty Formation underlies the Haney Limestone and includes two distinctly different lithologic members. The upper member is known as the Indian Springs Shale and is approximately 20 feet thick (Figures 1-7 through 1-10). The lower member of the Big Clifty Formation is referred to as the Big Clifty Sandstone and consists of 35 to 45 feet of tan to green-gray, massive to thick-bedded, fine-grained, friable sandstone. Barnhill and Ambers (1994) discuss the lithologic characteristics and sedimentary facies of this sandstone in detail. The Big Clifty Sandstone is the uppermost bedrock unit in the central and southeastern portions of the ABG and along the floodplain of LSC southward to the NSWC Crane property line (Figures 1-4 and 1-6 through 1-10).

The Beech Creek Limestone Formation consists of fossiliferous, hard, and dense limestone, when unweathered. The thickness of this unit ranges from 20 to 25 feet. The lithologic characteristics and sedimentary facies of this limestone are discussed in detail by Barnhill and Ambers (1994). Joints and

bedding-plane fractures in the limestone are sparse to numerous in cores recovered from this formation and surface outcrops (Barnhill and Ambers, 1994). As mentioned in the previous paragraph, erosion has removed the Indian Springs Shale from above the Big Clifty Sandstone in the central and southeastern portions of the MTA area and from the floodplain south of the MTA. In the areas where the Indian Springs Shale is absent, the fractures and joints have been enlarged due to solutioning of the limestone. Fracture widths measured in creek bed exposures range from 2 to 25 centimeters (cm) (1 to 10 inches); these fractures were found to be filled with cobbles, gravel, and sand (Barnhill and Ambers, 1994). Some outcrops show large [up to 30 cm (12 inches)] wide solution channels along the bedding-plane fractures. Drilling logs for wells along the LSC valley show a mass of weathered sandstone and limestone blocks, gravel, silt, and clay that is 10 to 30 feet thick (Figures 1-6, 1-8, and 1-9). This zone along LSC downstream of the MTA has been interpreted by the USACE to represent a zone where the Beech Creek Limestone was intensely fractured and karstified (Hunt, 1988; Murphy and Ciocco, 1990; Murphy, 1994; and Murphy, 1996). The development of solution channels was so intense that the Beech Creek and overlying Big Clifty Sandstone collapsed in the geologic past, and all that remains is the valley filled with weathered rubble and alluvium (Figures 1-6 through 1-10).

The Elwren Formation (uppermost unit of the West Baden Group) lies below the Beech Creek Limestone and below the collapse zone material that lies in the LSC valley (Figures 1-6 through 1-10). It consists of massive to thinly bedded, dark gray to green shale with interbedded red-brown claystone. The formation averages approximately 20 feet in thickness. The Reelsville Formation lies just below the Elwren Shale and is approximately 10 feet thick. It consists of dark gray to gray-green shale, with thin (less than 3 feet thick) beds of fine-grained sandstone. The Sample Formation is just below the Reelsville and it consists of 40 to 45 feet of dark gray to black, thinly bedded, platy to fissile shale with some interbeds of fine-grained sandstone. Together, the Elwren, Reelsville, and Sample Shales form an aquiclude that is approximately 75 feet thick (Figures 1-8 and 1-10). These shales virtually prevent the vertical seepage of shallow groundwater downward into the underlying Beaver Bend Limestone.

The Beaver Bend Limestone is the deepest geologic unit in the MTA/OJT area that is considered a significant aquifer and that has been investigated or monitored in the past. The Beaver Bend ranges from 10 to 12 feet thick and consists of medium gray-brown, medium to coarsely crystalline, very hard and dense limestone. This limestone has numerous intersecting joints.

NSWC Crane is located on the eastern edge of the Illinois Structural Basin, where the Pennsylvanian and Mississippian age bedrock dips to the west-southwest and southwest at approximately 30 to 35 feet per mile (Kvale, 1992). Locally, however, the dip of the Mississippian bedrock can range from 0 to 15 feet per mile to as much as 100 feet per mile to the southwest in the Sulphur Creek watershed (Kvale, 1992). A structure

contour map for the top of the Elwren Shale (i.e., base of the Beech Creek Limestone) is presented in Figure 1-11. It shows that the Beech Creek Limestone is generally dipping to the southwest. Superimposed on the general structural dip to the southwest is an anticlinal structure trending through the OJT area that plunges to the southwest. Parallel to this, two synclinal structures trend through the MTA area and the southern end of the watershed and also plunge to the southwest. These structural features may have had some effect on the orientation and frequency of fracturing in the limestones and the initial development of solution features along the fractures. The regional structure also has a significant effect on the groundwater flow system within the Beech Creek Limestone, as will be discussed in the next subsection.

The unconsolidated overburden deposits at NWSC Crane generally consist of two types: Quaternary and Pleistocene age alluvial and colluvial deposits near the floodplains of primary streams and unconsolidated residual soils and loess on sides and tops of ridges. Residual soils at NSWC Crane were derived from the underlying sedimentary rocks of the Lower Pennsylvanian Raccoon Creek Group and the Upper Mississippian Stephensport and West Baden Groups. These soils consist of clay, silt, sand, and fragmented and/or partially weathered bedrock. The residual soils developed on the ridgetops and upper sideslopes of the ridges were derived from the weathering of Pennsylvanian strata. The residual soils in the lower elevations of the LSC valley were derived from the weathering of the Mississippian sandstones, limestones, and collapse fill materials.

Using the U.S. Department of Agriculture (USDA) Soil Conservation Service (SCS) soil classification system (McElrath, 1988), the soil at NSWC Crane has been classified into 23 different soil series. Each of these soil series is defined by various soil characteristics (e.g., grain size, erosion, slope, drainage, parent material, depositional source, etc.) specific to each series. Within these soil series, various sub-classes or soil map units have been defined.

Chemical characteristics of soils at NSWC Crane were evaluated during a basewide background soils investigation conducted by TtNUS in 2001 (TtNUS, 2001a). The objectives of the investigation were to identify and chemically characterize soils based on three factors: depositional environment, grain size, and depth. A total of 16 soil types were identified and evaluated in the report, based on combinations of these three factors. Four depositional environments were identified at NSWC Crane, based on the mapped geologic parent material: Pennsylvanian bedrock, Mississippian bedrock, alluvium, and loess. Three predominant grain sizes (clay, silt, and sand) and two depths (surface and subsurface) were also identified as factors possibly contributing to soil chemical characteristics. Soil samples were collected to establish representative background metals concentrations for each of the 16 soil types.

The streambed material found in LSC is composed of large boulders, cobbles, and gravel, with small amounts of sand and silt.

1.3.4 Groundwater Hydrology

1.3.4.1 Description of Aquifers and Aquitards

Groundwater in the nonglaciated 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. Groundwater enters the aquifers as infiltration in outcrop areas and flows by gravity down the dip of the strata or locally in directions controlled by the potentiometric gradients, which are in most cases influenced by topography and locations of stream channels (i.e., groundwater discharge areas).

Based on 20 years of drilling and hydrogeological investigations in the LSC watershed (most notably in the MTA area), the hydrostratigraphic units and hydrogeologic conditions in the watershed are well characterized and documented. However, because of the fractured rock units and karstic nature of the limestone formations present in the watershed, the groundwater flow system is very complex and therefore, there are some uncertainties concerning the details of the flow system in localized areas at a small scale.

Four primary aquifers in the LSC watershed have been identified in the Pennsylvanian and Upper Mississippian strata:

- Pennsylvanian sandstones
- the Haney Limestone [also referred to as the Golconda-Haney (G-H) aquifer]
- the Big Clifty Sandstone/Beech Creek Limestone (BC/BC) aquifer
- the Beaver Bend Limestone

The Pennsylvanian sandstone aquifer is the uppermost aquifer and is present only along the tops of ridges at elevations above 615 feet above msl. Typically, the base of the Pennsylvanian Mansfield Formation is even higher (about 650 to 660 feet above msl). The Pennsylvanian rocks are up to 120 feet thick (Figures 1-7 through 1-10). The Pennsylvanian sandstone aquifer actually consists of two or more irregular sandstone units that are commonly separated by shale, siltstone, and clay lenses and some coal beds. The stratigraphy, lithologic characteristics, and hydraulic characteristics of the Pennsylvanian strata of this area are discussed in detail by Barnhill and Hansley (1993), Kvale and Barnhill (1994),

Fisher (1996), and Murphy and Wade (1998a). The hydrogeologic characteristics of the Pennsylvanian aquifer were also presented in the RFI report for SWMU 02 - Dye Burial Grounds (TtNUS, 2002a). This SWMU is located in the far northeastern corner of the LSC watershed (Figure 1-7). The Pennsylvanian sandstone aquifer is not present in the ABG area, OJT area, or the LSC valley floor.

The Glen Dean Limestone is present beneath the Pennsylvanian aquifer in isolated areas of the watershed. Because of its limited presence in the watershed and its complete absence from the ABG, OJT area, and LSC valley, it is not considered a separate aquifer unit and is not discussed further in this report.

The Hardinsburg Shale is up to 50 feet thick and contains mostly shale with some low-permeability sandstone in the middle. This formation forms a nearly continuous, relatively impermeable barrier to groundwater flow between the Pennsylvanian sandstones above and the G-H Limestone below.

The G-H Limestone aquifer crops out on the sides of LSC and Johnson Hollow (Figure 1-4). This limestone aquifer is up to 20 feet thick. A small spring (location 02SWSD07, Figure 1-5) located south-southwest of the Dye Burial Grounds discharges groundwater from the G-H aquifer (Murphy and Wade, 1998a; TtNUS, 2002a).

The Indian Springs Shale aquitard (the 20-foot-thick upper member of the Big Clifty Formation) underlies the G-H Limestone and minimizes vertical movement of groundwater downward into the Big Clifty Sandstone through most of the watershed. In places where the Indian Springs Shale and higher strata have been removed by post-Pennsylvanian erosion, surface recharge into the Big Clifty Sandstone is relatively rapid.

The Big Clifty Sandstone and the underlying Beech Creek Limestone are both permeable rock units and are in direct hydraulic communication with one another. Together, they form the most important aquifer unit in the watershed. The porosity and permeability of the Big Clifty Sandstone are due to intergranular pore spaces and to fractures (i.e., it has both primary and secondary permeability). The Beech Creek Limestone is very dense and well cemented; all of its permeability and porosity are due to vertical fractures, bedding-plane fractures, and solution openings along the fractures. The lithology, fracture patterns, and permeability characteristics of the Big Clifty Sandstone and the Beech Creek Limestone are detailed in reports by the USACE (Hunt, 1988; Murphy and Ciocco, 1990; Murphy, 1994) and the Indiana Geological Survey (Barnhill and Ambers, 1994). The BC/BC aquifer is exposed near the ground surface in the eastern half of the ABG, down along the LSC valley, and in the lower elevation of Johnson Hollow (Figure 1-4). Beneath the ridges, the aquifer is approximately 60 feet thick and fracture flow is dominant

in the limestone. Solution openings and cavities become larger and hydraulically more significant close to the stream valleys where conduit systems in the limestone have developed. Starting in the eastern half of the ABG and continuing down the LSC valley to the facility property line, the solutioning of the Beech Creek Limestone was so extensive that the overlying limestone has collapsed in the geologic past and the Big Clifty Sandstone has collapsed with it. The collapsed zones extend down the centers of the LSC valley and Johnson Hollow, are permeable, and form a hydraulic continuum with the BC/BC aquifer on both sides of the valleys (e.g., Figures 1-5 through 1-10).

The Elwren, Sample, and Reelsville Formations lie beneath the BC/BC aquifer and have a combined thickness of about 75 feet. The permeability of the shales in these formations is so low that a significant hydraulic head difference (about 46 feet) exists between the BC/BC aquifer above and the Beaver Bend Limestone aquifer below (Baedke, 1998). The chemistry of the groundwater in the BC/BC and Beaver Bend aquifers is also significantly different (Baedke, 1998). Based on the geological, hydrogeological, and geochemical evidence mentioned above and on previous reports, the hydrological separation of the BC/BC aquifer from lower strata in the LSC watershed appears to be significant. Groundwater flows laterally through the BC/BC aquifer on top of the Elwren Shale and discharges as springs along the valley bottoms where this aquifer is exposed.

The Beaver Bend Limestone forms an important aquifer below the Elwren-Sample-Reelsville aquiclude. The Beaver Bend aquifer is about 12 feet thick. Five monitoring wells and one groundwater production well have been drilled and screened in the Beaver Bend aquifer, all within the ABG area. Groundwater samples collected from the monitoring wells in 1987 through 1992 have shown minor contamination by TCE and the explosive compound RDX (Murphy, 1994). However, a groundwater sample collected from the ABG "Break Room Water Well" (Figure 1-5) in 1999 showed the groundwater in the Beaver Bend aquifer did not contain detectable concentrations of RDX or TCE or any other organic contaminants (TtNUS, 2000). Because of its depth, hydraulic isolation, and lack of significant contamination, this aquifer unit is not discussed further in this report.

Karst System Monitoring

As indicated earlier in this section, part of the ABG is underlain by a karst system. Several studies of the karst system have been conducted by the USACE Waterways Experiment Station (WES) and the Indiana University Department of Geological Sciences. Additional information regarding the behavior of the karst system was obtained from a thesis that was prepared by Stephen J. Baedke, a graduate student at Indiana University. The presumed locations of the karst system in the LSC watershed are shown in Figure 1-12.

As discussed above, there are three aquifers present at the ABG. One aquifer is a karst system. Karst systems show both temporal and spatial variation between diffuse-type and conduit-type groundwater flow. From highest to lowest, the three aquifer systems present at the ABG are the G-H aquifer, the Beech Creek aquifer, and the Beaver Bend aquifer. Of the three aquifers, the Beech Creek aquifer is the karst system.

Karst parameters, including pH, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, HCO_3^{-}, SO_4^{2-}, and Cl^{-}, are being measured within the Beech Creek aquifer to monitor the behavior of the karst system at the MTA to determine if there are any changes in the behavior of the aquifers present at the ABG. If the behavior of the aquifer system changes, evaluations will be conducted of the necessity for changes in the current monitoring system.

1.3.4.2 Hydraulic Properties of the Aquifers

Most of the bedrock units (including the limestone aquifers) are well cemented and have relatively low values of intergranular porosity and permeability (Barnhill and Ambers, 1994; Fisher, 1996). The Pennsylvanian sandstone and the Big Clifty Sandstone aquifers are exceptions. They do have moderate values of intergranular porosity and permeability. Most of the overall porosity and permeability present in the aquifers are due to vertical fractures, bedding-plane fractures, solution openings in the limestones, and large openings where the BC-BC aquifer has collapsed along the bottom of the LSC valley and Johnson Hollow.

Slug tests and pumping tests have been performed in numerous monitoring wells in the ABG and Dye Burial Ground (DBG) by the USACE (Murphy, 1995) and the Indiana Geological Survey (Fisher, 1996). Low-flow pumping tests were performed in monitoring wells within the OJT area for the OJT-LSC RFI (TtNUS, 2002b). Results of all these tests are summarized in Table 1-2. Based on 11 slug tests performed in the DBG area, the hydraulic conductivities of the Pennsylvanian sandstones are moderate to low; they range from 1.0×10^{-4} up to 0.94 feet/day (Table 1-2). One pumping test performed in the G-H aquifer also yielded a relatively low value of hydraulic conductivity (0.24 feet/day). Pumping tests and low-flow purge tests conducted in the Big Clifty Sandstone, Beech Creek Limestone, and the collapse breccia material have yielded hydraulic conductivity values that are slightly higher than those measured for the upper aquifers. Based on the results of 25 tests, the calculated hydraulic conductivity values for the BC-BC aquifer ranged from 0.06 up to 44.5 feet/day (Table 1-2). The lowest value was determined for well 03C30 which is located in the MTA. The highest value was determined for wells 03C09P2 and 03C15, which are also screened in the Beech Creek Limestone in the MTA. These test results reflect the low to moderate permeabilities that are present in the fractured rock and brecciated collapse materials,

but not in the rock that contains open cavities and solution channels. Well 03-24 is screened in competent limestone and does contain solution cavities.

The solution openings and cavities in the Beech Creek Limestone have formed groundwater conduits that roughly trend north to south on both sides of the LSC valley (Figure 1-12). These conduit systems have been investigated extensively by the USACE (Murphy and Ciocco, 1990; Murphy, 1994; May et al., 2002) and Indiana University (Baedke, 1998; Krothe, 2002). Based on the results of dye tracer studies, groundwater enters these karst conduits, which allow rapid flow of groundwater southward roughly parallel to LSC, but in the valley walls where the BC-BC aquifer has not collapsed. The hydraulic conductivity values of these conduits are extremely large and cannot be measured using standard field methods. These conduits and conduit outlets (i.e., springs) along the valley walls south of the OJT area are discussed below.

During recent investigations in 2004, low-flow purge data collected during the sampling of 23 monitoring wells were used to estimate hydraulic conductivity values throughout the MTA. The estimated hydraulic conductivity values for the BC-BC aquifer are listed in Table 1-2 and are contoured in Figure 1-13. It is already known that monitoring well 03C02P2 intersects a karst conduit which drains directly southward to Springs A and A'. This monitoring well is located on the east side of the MTA. A hydraulic conductivity value could not be calculated for this well. Surprisingly, other wells on the eastern side of the MTA yielded hydraulic conductivity values which ranged from 0.07 to 2.96 feet/day. The highest hydraulic conductivity values determined for the BC-BC aquifer were found on the north side of the MTA in monitoring wells 03C09P2, 03-01, 03-38, and 03-39, and on the west side of the MTA in monitoring well 03C15 (Figure 1-13). Hydraulic conductivities estimated for these five monitoring wells ranged from 23 to 45 feet/day. It is assumed that the areas of higher hydraulic conductivity shown on Figure 1-13 contain fractures and karst conduits and are in some way linked to the main karst conduit located on the east side of the MTA near well 03C02P2.

1.3.4.3 Groundwater Flow Directions

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

A total of four aquifers are present in the LSC watershed, consisting primarily of sandstone and limestone. These aquifers are separated by shale and siltstone aquitards. The upper aquifers, which include the Pennsylvanian sandstones and the G-H Limestone, are exposed in outcrops on the upper hillsides surrounding the MTA, OJT area, and LSC valley bottom. The G-H limestone is underlain by the Indian Springs Shale. Groundwater in the G-H aquifer is prevented from seeping downward into the BC-BC aquifer by the intervening Indian Springs Shale. Instead, perched groundwater in the G-H aquifer flows on top of the shale toward nearby outcrops. In the northeastern portion of the watershed (by the DBG), groundwater in the G-H aquifer is generally flowing southwest toward an unnamed tributary of LSC (TtNUS, 2002). The aquifer also dips to the southwest. A small spring located southwest of the DBG (northeast of the MTA) is a discharge point for the G-H aquifer, where the aquifer crops out on the hillside. In the MTA area, groundwater in the G-H aquifer is generally flowing inward toward the MTA from the northern, western, and southern sides (Hunt, 1988; Murphy, 1994; Duwelius et al., 1995). When the groundwater reaches the cropline of this aquifer (see Figure 1-14), the groundwater is apparently seeping near the ground surface through residual soils and weathered shale until it reaches the cropline of the Big Clifty Sandstone. There, it infiltrates into the Big Clifty Sandstone. No visible surface seeps or springs have been reported emanating from the G-H aquifer in the vicinity of the MTA.

The next lower aquifer, the BC-BC aquifer, has the most monitoring wells screened in it and more effort has gone into characterizing the hydrogeology of this aquifer than any of the other three aquifers. The BC-BC aquifer has been studied the most because:

- It lies directly under the MTA and OJT treatment areas.
- It is the aquifer where the highest concentrations of contaminants have been detected during previous investigations.
- It contains the conduits that feed the majority of springs and baseflow in LSC.

Potentiometric surface maps for the BC-BC aquifer in the LSC watershed have been presented in previous reports (Murphy and Ciocco, 1990; Murphy, 1994). In general, the highest groundwater elevations (560 to 565 feet above msl) in this aquifer were found at the northern end of the LSC watershed (north of the MTA and in the vicinity of the DBG). Groundwater was generally flowing from north to south in the watershed, and flow direction was also inward toward Little Sulphur Creek (i.e., from the perimeter of the watershed in toward the creek and Johnson Hollow). The elevation where groundwater discharges from Spring C was about 530 feet above msl. The lowest groundwater elevations (about 510 to 515 feet above msl) were recorded at the southern end of the watershed at Spring A and well 03B10. A comprehensive set of elevations was measured on June 12 and 13, 2002 and on April 24 and 25, 2004. Table 1-3 lists all the known wells and stream gaging locations in the

watershed, physical characteristics of each well, and the spatial coordinates and reference elevations for each location. Water levels were measured in a total of 120 monitoring wells and at four stream gage locations in June 2002 and 118 monitoring wells and two stream gage locations in April 2004. A total of 64 monitoring wells are screened in the Big Clifty Sandstone, Beech Creek Limestone, or the collapse breccia material along LSC. The water levels measured in these 64 wells, along with the water levels of three stream gage locations, were used to map the potentiometric surface in the BC/BC aquifer. These water levels and potentiometric contours are presented in Figure 1-12. This Figure shows the highest groundwater elevation (577.59 feet amsl) was measured in the DBG (well 02C20) at the northeast end of the watershed. The lowest elevations (511 to 51 feet amsl) were measured at the southern end of the watershed, close to LSC (wells 03B10 and 03C37 and Spring A). The wells in the MTA area had groundwater levels of 543 to 560 feet amsl. Wells in the OJT area had water levels ranging from 535 to 543 feet amsl. The groundwater potentiometric map, based on the June 2002 set of measurements, shows that groundwater flow is from north to south and from the perimeter of the watershed toward the stream (Figure 1-12). These groundwater flow directions are very similar to those observed in previous sets of water-level measurements (e.g., Murphy, 1994). In the smaller area surrounding the OJT study site, however, a localized flow system in the BC-BC/breccia zone aquifer is contrary to the overall flow system for the watershed described above. Measurements of groundwater elevations at OJT in the past (Murphy and Ciocco, 1990; Murphy, 1996) and measurements made during the latest CMS investigation show that a groundwater ridge runs from the northwest to the southeast beneath LSC. The groundwater elevations measured in June and September 2001 and April 2004 are listed in Table 1-4. Figure 1-15 shows the potentiometric contours. Potentiometric contours indicate that groundwater is flowing away from this ridge under the streambed toward the northeast and the southwest.

As stated in previous investigations, LSC is a losing stream between ABG and OJT and probably southward toward Spring C. In this section of the watershed, the streambed is usually dry and groundwater is flowing either through the breccia zone materials parallel to the stream (i.e., underflow) or it is flowing back into the bedrock valley wall, as is suggested by Figure 1-12. These localized flow directions (i.e., away from the Creek toward the northeast and southwest) are in contrast to the overall watershed flow directions, which are toward the stream valley (Figure 1-15). The apparent contradiction in flow directions can be explained, however, by the presence of karst conduits that run in a north-south direction on both sides of the stream valley. The approximate locations of these karst groundwater conduits are shown on Figure 1-12. The majority of groundwater in the OJT area is likely flowing toward the karst conduits. In June 2001, there were relatively large horizontal hydraulic gradients toward the northeast (0.0219 foot/foot between wells 03-07 and 03-24) and southwest (0.0414 foot/foot between wells 03-07 and 03-17). In September 2001, the gradients were much lower (0.0253 foot/foot toward the northeast and 0.00684 foot/foot toward the southwest).

Groundwater in the BC-BC aquifer and the conduits eventually discharge back into the stream at springs A, A', B, C, smaller springs, and diffuse seepage through the streambed. All this discharge occurs at Spring C and south of Spring C, where the top of the Elwren Shale intersects the streambed and LSC becomes a gaining stream (i.e., flow of water is from the ground into the stream). LSC becomes a perennial stream at Spring C, where the flow of groundwater to the stream is sufficient to maintain flow in the stream continuously. More details regarding the conduits and springs are presented below.

The Beaver Bend limestone is 10 to 12 feet thick and comprises the lowest aquifer that has been investigated in this watershed. Five monitoring wells in the MTA area are screened in the Beaver Bend Limestone. Based on data from these five wells, the Beaver Bend is fully saturated and flowing southward at a very gentle gradient (Murphy, 1994). The Beaver Bend is considered to be isolated hydraulically from the BC-BC aquifer above, based on the following:

- The thickness (approximately 70 feet) and low permeability of the intervening Elwren-Reelsville-Sample aquiclude.
- The large hydraulic head difference (approximately 46 feet) that exists between the two aquifers.
- The large difference in basic chemical composition of ground waters that have been found in the two aquifers. The groundwater in the BC-BC aquifer contains mostly calcium, magnesium, bicarbonate, and some sulfate as its primary ions. However, the Beaver Bend groundwater clearly has a sodium and bicarbonate composition (Baedke, 1998).

1.3.4.4 Dye Tracer Studies

During early groundwater investigations in the LSC watershed, the investigators (Hunt, 1988; Murphy and Ciocco, 1990) surmised that springs at the southern end of the watershed were linked to karst conduits originating to the north. Several dye tracer studies have been performed in order to study the pathways in these conduits and the velocity of travel. The first dye tracer investigation was performed by Murphy and Ciocco (1990). They placed one gallon of fluorescein dye solution into well 03C02P2 at 10:35 a.m. on January 20, 1990. Approximately 1,200 gallons of water were added to the well during the next 60 minutes [about 20 gallons per minute (gpm)]. The well accepted the water without overflowing. Two gallons of Direct Yellow 96 dye and Phorwrite AR mixture were added to well 03C03P2 at 12:25 p.m., also on January 20, 1990. About 500 gallons of water were added to this well at a rate of about 7 gpm. The rate of water addition in this well was less in order to prevent overflowing. Light rain occurred on

January 19, preceding the tests, and on January 20, during the tests. Thus, the stream flow and spring flows were above average during the testing. The fluorescein dye appeared in springs A and A' over a period of 5 to 28 hours after injection. The dye persisted in these two springs for at least five days following injection. Based on a mean travel time of 16 hours and assuming a sinuous travel distance of about 8,000 feet, Murphy and Ciocco (1990) estimated a groundwater velocity of approximately 500 feet per hour through the conduit system. They detected a weak but inconclusive presence of dye in Springs B and C and in springs located north of ABG in another watershed. They attributed these weak detections possibly to background coloration of the water. Based on these results, it was clear that the ABG was directly linked to a karst conduit system that transfers water from the ABG south to Springs A and A' through the Beech Creek Limestone. The Direct Yellow 96 dye and Phorwrite AR were not detected in any of wells or springs monitored.

Indiana University initiated a second tracer test on the western side of LSC on May 3, 1997 (Baedke, 1998). Between 12:32 PM and 12:59 PM, 1.6 kg of Rhodamine WT dye and 18.3 kg of bromide ion were added to well 03C02P2. At 1:04 PM, 1.6 kg of eosin dye was injected into well 03C10. The springs and the stream were at relatively high flow rates because 2.5 inches of rain fell the previous day. Rhodamine WT dye was visually detected at springs A and A' at 8:00 PM, 7.5 hours after injection at ABG. The bromide tracer appeared at the same time as the Rhodamine WT. Baedke (1998) calculated a travel velocity of 938 feet per hour between well 03C02P2 and Spring A, which is faster than the velocity calculated by Murphy and Ciocco (1990). Although the Rhodamine WT was detected at these two springs up to four days after injection, the bromide tracer dissipated quickly (within 14 hours), presumably because the bromide ion does not sorb and is therefore flushed from the conduit system more quickly. Rhodamine WT was not detected during the entire test period in any other springs that were monitored. Eosin was not detected at all, even in springs A and A'. Therefore, it does not appear that the portion of the BC-BC aquifer located near well 03C10 is directly connected to the conduit system feeding springs A and A'.

On October 11, 2000, Rhodamine WT dye was again injected into well 03C02P2, but the flow rates in the stream and the springs were relatively low during this test (Krothe, 2002). Monitoring showed that the dye took 18.5 hours to travel from the well to Springs A and A'. The peak of dye arrived 28 hours after injection. Thus, the travel velocity was slower during dry weather conditions.

Previous dye tracer tests all showed that the ABG area does not seem to be hydraulically connected to Spring C, which is a major spring located on the eastern side of the creek, downstream of the OJT area. Groundwater elevations indicate a flow direction from the OJT burn pits to the east-northeast toward well 03-24 (Figure 1-15). The geologic log for well 03-24 (see Figure 1-6) shows solution cavities in the

limestone intercepted by the well screen. It was hypothesized that these solution channels might be linked to a conduit system that leads southward to Spring C, which is separate from but analogous to the conduit system investigated previously on the western side of the creek. Two dye tracer tests have been performed recently on the eastern side of LSC to determine whether there is a link between the OJT area and Spring C (Jock and Krothe, 2002 and Hydrogeology, Inc., 2005). Fluorescein dye was injected into well 03-24 on May 24, 2002. The dye was first detected in Spring C 17 hours after injection. The dye concentration peaked 28 to 38 hours after injection and dissipated 58 hours after injection. A second dye tracer test was conducted on December 2, 2004, using monitoring well 03-24 as the injection point and Springs A and C as monitoring points. This test resulted in 108 percent of the dye being recovered at Spring C. No dye was recovered at Spring A. Thus, the OJT area is linked to the Spring C conduit system in the vicinity of well 03-24. However, this conduit system does not seem to be as well developed, and travel velocities are not as fast as the conduit system on the western side of the creek feeding Springs A and A'.

1.3.4.5 Groundwater Discharge and Springs

As stated in Section 1.3.5.1, the BC-BC aquifer discharges to the ground surface from both sides of the valley via numerous springs and baseflow in LSC downstream of Spring C. These springs and baseflow are forced to the ground surface because, at this point in the watershed, the stream has incised down to the underlying Elwren Shale. Springs A, A', B, and C are the largest in this watershed area. The locations of these springs are shown on Figures 1-2 and 1-12. Springs A, A', and B are located on the western side of the valley, approximately 6,000 to 6,800 feet south of the ABG. Spring C is located on the eastern side of the creek, about 2,000 feet south of the OJT area. Presumably, Springs A, A', and B are draining the portion of the BC-BC aquifer west of the creek, and Spring C is draining the aquifer positioned on the east side of the creek. These springs flow year round; however, flow rates fluctuate rapidly due to rainstorm or large snowmelt events. Flow rates of Springs A and C were measured continuously in March and April 1996 (see Figure 1-16).

As shown in Figure 1-16, the flow rates of the two springs rose rapidly in response to rain events and declined fairly rapidly within a few days. The peak flows in these two springs during the 2-month time period were approximately 10,000 gpm, or 22.3 cubic feet per second (ft^3/s). It has been noted in previous reports (e.g., Hunt, 1988; Murphy and Ciocco, 1990) that the springs become turbid during high flow events and then clear up and return to normal flow within a day or two after a storm event. The flashiness of the spring flows and the fact that the discharge becomes turbid during a storm indicate that the springs are linked to conduit systems that take surface recharge and transfer it through the conduit

systems quickly. The suspended solids contained in the discharge waters likely come from the areas of recharge and gradually move through the conduit system, primarily during storm events.

1.3.5 Surface Hydrology

The surface drainage at NSWC Crane has formed a dense, dendritic pattern throughout the installation. Most of the major streams flow in a general southward or southwestward direction. Seven primary creeks in five drainage basins carry surface water off the installation, where they eventually drain into the East Fork of the White River and then to the Wabash River to the southwest. Figure 1-17 shows the main drainage basins of NSWC Crane. The OJT study area lies within the Sulphur Creek drainage basin. The Sulphur Creek basin drains roughly 30 percent of NWSC Crane.

LSC is a tributary of Sulphur Creek and is approximately 4.6 miles long from its northernmost headwaters to its intersection with Sulphur Creek south of the installation. The creek consists of a north and a south fork from the headwaters to approximately the center of the MTA (Figure 1-12). From the MTA, a single channel meanders south-southeastward a distance of approximately 0.5 mile to the OJT area and then continues another 0.6 mile until it reaches the installation boundary. Several intermittent tributaries discharge into LSC from both sides of the stream, including the Johnson Hollow tributary, which intersects with LSC near the NSWC Crane boundary. The DBG (SWMU 02) are located north of the OJT, and surface drainage from this site enters several ephemeral gullies, which drain into LSC between MTA and OJT.

The LSC channel is usually dry north (upstream) of Spring C. During dry periods of summer and fall the flow rate in the creek between Springs C and A is typically less than about 50 gpm. Downstream of where the discharge from Spring A enters the creek, the dry weather flow in the creek is typically greater than 100 gpm. Flow rates in the creek were visually estimated on June 19, 2001. The flow estimate for 03SG05 was about 20 gpm. Downstream of Spring A at 03SG06, the flow rate in the creek can increase by two to three orders of magnitude, due in large part to the rapid increases in the flow rates of the springs along the creek.

From the installation boundary, LSC flows southward about two miles before it enters Sulphur Creek. Sulphur Creek then flows southward and empties into Indian Creek, which drains into the East Fork of the White River and then southwestward into the Wabash River.

1.4 CONTAMINANT TRANSPORT/MIGRATION

1.4.1 Surface Pathways

Surface water runoff from the MTA and the OJT area enters LSC. During significant rainfall and snowmelt events, these intermittent flows may be transporting some soil and dissolved materials into the stream. However, the land surface near the waterways in the MTA is now revegetated with grasses and the OJT is heavily overgrown with trees, brush, and grass, because it has not been used for waste treatment activities for nearly two decades. All treatment operations now take place on containment facilities of the MTA. Thus, current overland migration of soils and dissolved materials from the MTA and OJT treatment areas is no longer a significant source of contamination.

In the past, treatment operations took place directly on the ground surface directly contaminating the ground. The ground was highly erodable because it was kept devoid of vegetation. Therefore, erosion of contaminated surface soil was a likely contamination transport pathway.

1.4.2 Erosion and Sediment Transport

In the past, the MTA was maintained to be devoid of vegetation to minimize the risk of fires during open burning treatments. In addition, prior to the construction and use of burn pans for open burning operations, explosives and propellants and materials contaminated with explosives and propellants were spread on the ground or pads and ignited. During precipitation events, MTA contaminated surface soil eroded into LSC. However, as noted above, erosion of contaminated soil is no longer a significant source of contamination.

1.4.3 Contaminant Migration via Groundwater Pathway

The western part of the MTA area lies over the G-H aquifer. Contaminated groundwater in the G-H flows eastward until it reaches the area where the Indian Springs Shale is absent. It then moves downward and enters the BC/BC aquifer flow system. Based on several dye tracer studies, there is a significant karst conduit system on the western side of the creek that rapidly conducts groundwater from the MTA southward to Springs A and A' within the Karst system significant dilution of the contaminated groundwater occurs.

Based on the potentiometric surface map for the BC/BC aquifer (Figure 1-12), groundwater within the OJT area is also flowing east-southeastward within the collapse breccia material toward the OJT area. Such a flow pathway could affect groundwater quality along the LSC valley near the OJT. Thus,

contaminants migrating through this second conduit system located on the eastern side of the creek are being greatly diluted with other noncontaminated groundwater, and then discharges from Spring C into LSC .

The watershed potentiometric map for the BC/BC aquifer (Figure 1-12) shows that the regional flow of groundwater is toward the south and inward toward the creek. Springs A, A', B, and C, smaller springs and seeps along the LSC banks, and seepage directly up through the creekbed all contribute groundwater to the creek downstream of Spring C. This is where the creek first becomes a perennial stream. There is strong evidence that none of the contaminated groundwater in the BC/BC aquifer is migrating downward into the Beaver Bend aquifer or is flowing laterally beneath the ridges into another watershed (i.e., cross-valley flow). The Beaver Bend aquifer consists of Beaver Bend limestone. It is a confined aquifer overlaid with 70 feet of Elwren and Sample shales. Hydraulic heads in this aquifer are 50 to 60 feet above the top of the aquifer and 33 to 47 feet below the heads in the overlying Beech Creek aquifer. the extreme differences in hydraulic head and the presence of a thick shale between these two aquifers show that there is no hydrologic connection between these two aquifers. This is supported by the prevalent chemical character of groundwater in this aquifer, which is Na -HCO_3. The chemistry of groundwater from the Beaver Bend aquifer is distinctly different from the other aquifers (TtNUS, 1999b). All surface water, sediments, and groundwater leaving the MTA and OJT areas eventually enter LSC. All soils, sediment, and dissolved materials that do migrate out of the ABG and OJT areas via surface water, sediment, or groundwater also eventually end up in LSC.

A high percentage of the LSC watershed on NSWC Crane property is wooded and relatively pristine (i.e., not contaminated). The fact that numerous tributaries, springs, and seeps drain the "clean" areas causes rapid dilution of contaminants during transit in the stream water, stream sediments, and groundwater within the watershed. Based on previous monitoring of the springs and stream water, the concentrations of contamination in water at the southern end of the watershed are very low, due in part to the amount of dilution that occurs while surface water and groundwater are in transit.

1.5 NATURE AND EXTENT OF CONTAMINATION

1.5.1 Contaminants of Concern

Based on prior field investigations discussed below, the explosives hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), 2,4,6-trinitrotoluene (TNT), and octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) (to a lesser extent), and volatile organic compounds (VOCs) [trichloroethylene (TCE) primarily] have been identified as chemicals of concern (COCs) for the ABG and OJT areas.

1.5.2 Description of Investigations and Characterizations

1.5.2.1 MTA

1.5.2.1.1 Soil

1.5.2.1.1.1 Army Corp Phase III Study

In 1993, the USACE collected 33 surface soil grab samples, and subsurface soil samples collected from 32 soil borings scattered across the ABG (Albertson et al., 1998). Samples were taken from depths of 1 to 30 inches (surface), 30 to 60 inches, and 60 to 90 inches (sample locations are shown on Figure 1-18). The soil samples were analyzed for explosive compounds, VOCs, semivolatile organic compounds (SVOCs), and metals. Analytical results for this study are provided in Appendix A.

The results of the soil analyses showed that VOCs were present in only a few locations and only minor concentrations were typically detected (Albertson et al., 1998). Maximum concentrations of TCE, cis-1,2-dichloroethene (DCE), and trans-1,2-DCE were 0.2, 2.3, and 0.29 mg/kg, respectively; all of these maximums occurred in boring 03/10-17 for the 30 to 60 inch depth range.

HMX, RDX, trinitrobenzene, TNT, 2,4-dinitrotoluene (DNT), 2,6-DNT, 2-amino-DNT (ADNT), and 4ADNT were detected in the surface and subsurface ABG soils. RDX and TNT occurred at several samples at concentrations greater than 1,000 mg/kg, and HMX occurred in concentrations greater than 200 mg/kg. The remaining energetic compounds had maximum concentrations generally less than 100 mg/kg. Higher concentrations of these explosive compounds seemed to occur at depths of 0 to 60 inches [0 to 5 feet below ground surface (bgs)]. However, only seven samples were collected at a depth greater than 60 inches, so conclusions regarding the presence of energetic compounds in the deeper soils are limited. Locations where the highest concentrations of energetic compounds were detected include surface grab sample 03/10-61 and boring 03/10-35 for the 60 to 90 inch depth range.

1.5.2.1.1.2 TtNUS CMS Field Investigation

A field investigation was conducted by Tetra Tech NUS, Inc. (TtNUS) at the MTA in April 2004 in an effort to fill data gaps in support of developing the conceptual site model. Detailed information including documentation regarding the field investigation is presented in Section 2.0. Figure 1-18 includes the locations of the 67 soil borings that were completed within the ABG MTA during this investigation. All soil samples were analyzed for explosives. Selected soil samples were analyzed for VOCs, RDX degradation

products, target analyte list (TAL) metals, total organic carbon (TOC), pH, and cation exchange capacity (CEC). Sample depths were generally taken from 0 to 2 feet, 2 to 6 feet, 6 to 10 feet, and 10 to 14 feet or until refusal. Table 1-5 provides a list of the samples that were collected, sample depths, and the analyses that were conducted on those samples. Eight soil samples (see Table 1-5) were also collected and analyzed for geochemical properties (TOC, CEC, and pH). Analytical results showing positive hits in surface and subsurface soil are provided in Appendix A.

All target explosives were detected at least once in all surface soil samples. However, the most frequently detected explosives were RDX, HMX and 2, 4, 6-trinitrotoluene. Most detections of explosives were less than 1.0 milligrams per kilogram (mg/kg). With the exception of 2,4-dinitrotoluene, maximum explosive concentrations were all detected at 03SB120, which is the location of the former pink water tanks. The maximum in soil concentrations of HMX, RDX, and TNT were 1,100, 660, and 400 mg/kg, respectively, at 03SB120. HMX concentrations at sample locations 03SS088, 03SS119, and 03SS120 were above the soil to groundwater soil screening level (SSL) level of 52.6 mg/kg. RDX concentrations at locations 03SS080, 03SS107, 03SS109, 03SS119, and 03SS120 were all above the RDX SSL of 0.004 mg/kg. TNT concentrations at surface soil locations 03SS050, 03SS075, 03SS079, 03SS088, 03SS108, 03SS119, and 03SS120 were all above the TNT SSL of 0.011 mg/kg.

In subsurface samples, six of the 11 target explosives were detected (HMX, RDX, TNT, 1,3,5-trinitrotoluene, 2-6-DBT, and 4ADNT). Concentrations of 1,3,5-trinitrotoluene, 2-6-DNT, and 4ADNT were all less than 1.0 mg/kg. The maximum concentrations of HMX, RDX, and TNT were 16, 2.1, and 45.0 mg/kg, respectively. The maximum concentrations of HMX, RDX, and TNT were detected in soil borings 03SB119, 03SB120, and 03SB079, respectively. None of the positive detections of HMX in subsurface soil were above the 52.6 mg/kg SSL. Positive detections of RDX at soil borings 03SB061, 03SB080, 03SB119, and 03SB120 at soil levels of 2 to 6 feet and 10 to 14 feet were all above the RDX SSL (0.004 mg/kg). TNT concentrations at soil borings 03SB079 (10 to 14 feet) and 03SB088 (2 to 6 feet) exceeded the TNT SSL of 0.011 mg/kg.

Surface soil samples were not analyzed for TCE. Positive detections of TCE in five subsurface soil samples exceeded the TCE SSL of 0.057 mg/kg. The maximum TCE concentration was 19 mg/kg at 03SB061 within the 2 to 6 foot interval. A TCE concentration of 2.3 mg/kg was detected in the 6 to 10 foot interval from the same soil boring. TCE concentrations in the 6 to 10 foot interval at both 03SB103 and 03SB112 were 0.33 and 0.57 mg/kg, respectively. The 10 to 14 foot interval sample from soil boring 03SB102 detected a TCE concentration of 8.6 mg/kg.

A summary of descriptive statistics for ABG surface and subsurface soil samples is presented in Tables 1-6 and 1-7.

1.5.2.1.2 Groundwater

1.5.2.1.2.1 USACE Phase III Ground Water Release Study and NSWC Crane Quarterly Monitoring

About 150 monitoring wells exist at the ABG and ABG vicinity. The majority of the wells at the ABG and the LSC watershed are screened in the BC/BC aquifer. These wells were sampled sporadically between 1987 and 1993 (Murphy, 1994). As part of RCRA quarterly monitoring at selected ABG wells, 12 Beech Creek monitoring wells have been sampled between 8 and 20 times since the fall of 1998. The samples have been analyzed for inorganics, VOCs, and explosives. Analytical results for this study are provided in Appendix A.

The primary contaminants in groundwater at the ABG include TCE and RDX. The highest TCE concentrations were detected as follows:

- The 3rd Quarter of the 2000 groundwater sampling reported results of 4,500 micrograms per liter (µg/L) for well 03C20.
- The 2nd quarter of the 2000 groundwater sampling reported results of 2,500 µg/L for well 03C11.
- The October 24, 1988 groundwater sampling result was 640 µg/L for well 03C15.
- The April 25, 1988 groundwater sampling result was 321µg/L for well 03C03P2.

The highest RDX concentrations were detected as follows:

- The April 25, 1988 groundwater sampling result was 709 µg/L for well 03C03P2.
- The 3rd Quarter of the 1990 groundwater sampling reported results of 400 µg/L for well 03C04.
- The 3rd Quarter of the 1990 groundwater sampling reported results of 400 µg/L for well 03C05.
- The July 16, 1989 groundwater sampling result was 300 µg/L for well 03C08P2.
- The 1st Quarter of the 2004 groundwater sampling reported results of 270 µg/L for well 03C20.

1.5.2.1.2.2 TtNUS CMS Field Investigation

The field investigation conducted by TtNUS at the MTA in April 2004 also included the collection of groundwater samples. Detailed information regarding the collection of the groundwater samples is presented in Section 2.0. Figure 1-19 presents the locations of the 26 monitoring wells that were

sampled at the MTA during this investigation. All groundwater samples were analyzed for explosives, VOCs, and metals. Selected samples were also analyzed for perchlorates. In the case of metals, unfiltered samples were analyzed for total metals. If the turbidity of a sample was greater than 10 nephelometric turbidity units (NTUs), a filtered sample was collected and analyzed for dissolved metals. Table 1-8 presents a summary of the groundwater samples that were collected and the analysis performed on each sample. Analytical results showing positive hits in groundwater are provided in Appendix A.

The most frequently detected explosives in groundwater at the MTA were HMX and RDX. Better than 80 percent of the positive detections were greater than 1 µg/L. The maximum detected concentrations of RDX and HMX were 620 and 82 µg/L, respectively. RDX concentrations at 11 locations exceeded the US EPA Region IX Preliminary Remediation Goal (PRG) screening criteria value of 0.61 µg/L. The locations included wells 03-01, 03-31, 03-33, 03-38, 03-39, 03C03P2, 03C14, 03TW01, 03TW02, 03TW04, and 03TW05 (see Figure 1-19). None of the HMX positive detections in groundwater exceeded the PRG screening criteria value (1,800 µg/L). In addition to RDX and HMX, there were also positive detections of TNT, 2ADNT, and 4ADNT that exceeded PRG screening criteria. There were two positive detections of 2,4,6-trinitrotoluene. However, only one detection (4.0 µg/L) at well 03-21 exceeded the TNT screening criteria value of 2.2 µg/L. There were eight positive detections of 4ADNT; however, only three concentrations were greater than the PRG screening criteria value of 2.2 µg/L. The three concentrations were 2.2, 2.7, and 4.5 µg/L and occurred at well locations 03TW05, 03-21, and 03C03P2, respectively. There were six positive detections of 2ADNT, but only one location, 03C03P2, exceeded the PRG screening criteria value of 2.2 µg/L.

There were 14 positive detections of TCE in groundwater at the MTA. However, only 11 of these positive detections exceeded the PRG screening criteria concentration of 1.6 µg/L. The positive detected concentrations greater than the PRG ranged from 2.2 µg/L at location 03-12 to 920 µg/L at location 03-07. The remaining nine concentrations greater than the PRG value occurred at locations 03-01, 03-15, 03-24, 03-38, 03-39, 03C03P2, 03C06, 03TW02, and 03TW05.

A summary of descriptive statistics for ABG groundwater samples is presented in Table 1-9.

1.5.2.2 OJT

1.5.2.2.1 Soil

1.5.2.2.1.1 2001 OJT/LSC RFI

Forty-eight surface soil and 62 subsurface soil samples were collected from 48 soil borings ranging from 1 to 15 feet bgs at the OJT during the 2001 OJT-LSC RFI. The maximum RDX soil concentration was 4.4 mg/kg in soil boring 03SB24 on the west side of the burn pit. This and other soil RDX concentrations might account for the high RDX concentration detected in well 03-21. The burn pit was identified as the potential source area of energetic contamination (i.e., RDX) and TCE in groundwater. However, the levels of TCE concentrations detected in soil were not high enough to account for the TCE concentrations detected in well 03-07. Summaries of the analytical data for surface and subsurface soil samples collected during the 2001 OJT-LSC RFI are presented in Appendix E of the RFI Report.

1.5.2.2.1.1 TtNUS CMS Field Investigation

Four soil borings were completed at the OJT during the April 2004 field investigation. Figure 1-20 presents the locations of the four soil borings 03SB049, 03SB050, 03SB051, and 03S0B52. Detailed information regarding the collection of these samples is included in Section 2.0. As indicated in Table 1-5, all OJT surface and subsurface samples were analyzed for explosives and TAL metals. However, selected sample depths were analyzed only for VOCs, RDX degradation products, and perchlorates. Analytical results showing positive hits in groundwater are provided in Appendix A.

There were only two detections of explosives in surface soil at the OJT. The detections included TNT (0.39 mg/kg) and HMX (0.31 mg/kg) in the 0 to 2 foot interval of sample 03SS050. Only the TNT concentration exceeded the soil to groundwater SSL. There were no detections of explosives in subsurface soil. There were no detections of TCE in OJT surface or subsurface soil samples.

A summary of descriptive statistics for OJT surface and subsurface soil samples is presented in Tables 1-10 and 1-11, respectively.

1.5.2.2.2 Groundwater

1.5.2.2.2.1 USACE Ground Water Study – 1981 to 1983 and 1994

The USACE installed 17 monitoring wells in the OJT area between 1981 and 1983 (Murphy, 1996). TCE concentrations in well 03-07 exceeded 1,000 µg/L on several occasions, and reached as high as

19,000 µg/L in 1982. TCE and cis-1,2-DCE were measured at 4,000 and 1,000 µg/L in this well, respectively, in September 1994 (Murphy, 1996). TCE contamination was also detected but at lower concentrations in two wells to the northeast (wells 03-15 and 03-24), and two wells to the southwest (03-12 and 03-20) of well 03-07. In 1994, the highest RDX concentration (365 µg/L) was detected in well 03-21, located north of well 03-07 and southeast of the burn pit. Figure 1-20 shows the location of these wells.

1.5.2.2.2.2 2001 OJT/LSC RFI

The OJT monitoring wells were resampled in 2001 during the OJT-LSC RFI. The TCE concentration in well 03-07 was 640 µg/L (TtNUS, 2003). The RDX concentration in well 03-21 was 280 µg/L. A comparison of these concentrations to concentrations detected in 1994 indicated that the maximum concentrations dropped significantly for TCE at well 03-07, but dropped only moderately for RDX at well 03-21. Analytical results for this study are presented in Appendix E of the OJT-LSC RFI Report.

1.5.2.2.2.3 TtNUS CMS Field Investigation

A total of six groundwater wells were sampled during the field investigation conducted in April 2004. These wells included locations 03-07, 03-12, 03-15, 03-16, 03-21, and 03-24. Figure 1-20 shows the locations of the OJT monitoring wells. Detailed information regarding the collection of the groundwater samples is presented in Section 2.0. All samples were analyzed for VOCs, explosives, and metals. Samples at locations 03-07 and 03-15 were also analyzed for perchlorates. Table 1-8 presents a summary of the groundwater samples that were collected and the analysis performed on each sample. Analytical results showing positive hits in groundwater are provided in Appendix A.

Explosives were detected in all wells sampled during the investigation. RDX and HMX were detected in all wells. The other explosives detected were 2ADNT, 4ADNT, and TNT. The maximum detected concentrations of RDX and HMX were 120 and 82 µg/L at locations 03-21 and 03-12, respectively. There was only one detection of TNT (4.0 µg/L) at well 03-21 which exceeded the PRG concentration of 2.2 µg/L. RDX concentrations at all wells exceeded the PRG concentration of 0.61 µg/L and ranged between 1.1 and 120 µg/L. None of the detected HMX concentrations exceeded the PRG concentration of 1,800 µg/L.

A summary of descriptive statistics for OJT groundwater samples is presented in Table 1-12.

1.5.3 Distribution of Contaminants

1.5.3.1 Main Treatment Area

1.5.3.1.1 Soils

During the USACE investigations in the 1990s and the more recent investigation for the CMS in 2004, soils at the MTA were found to be contaminated primarily with RDX and TCE. Highest concentrations were generally found near the surface (i.e., 0-2 foot depth interval) and concentrations typically decreased with depth down to the bedrock surface. The bedrock surface is usually between 7 and 15 feet below ground surface (bgs) in most areas of the MTA.

Main Treatment Area: Figure 1-21 is a tag map which shows all RDX, HMX, TNT, and TCE results for soil borings collected in the MTA during the April 2004 CMS field investigation. Soil samples were collected throughout the soil column to the top of the bedrock or to refusal.

RDX -Main Treatment Area

RDX was detected at 6 of the 67 locations in a total of 11 of the 223 samples that were collected and analyzed for RDX at the MTA. Following is a listing of the locations and positive detections for RDX.

- 03SB061 - nondetect (ND) at 0-2 feet, 1.9 mg/kg at 2-6 feet, and ND at 6-10 feet. No sample was collected at 10-14 feet because bedrock was encountered.
- 03SB107 - 0.29 mg/kg at 0-2 feet and ND at 2-6, 6-10, and 10-14 feet.
- 03SB080 - 0.98 mg/kg at 0-2 feet, 0.82 mg/kg at 2-6 feet, and ND at 6-10 feet and 10-14 feet.
- 03SB109 - 1.0 mg/kg at 0-2 feet, and ND at 2-6, 6-10, and 10-14 feet.
- 03SB119 - 31 mg/kg at 0-2 feet, 1.6 mg/kg at 2-6 feet, ND at 6-10 feet, and 1.4 mg/kg at 10-14 feet.
- 03SB120 - 660 mg/kg at 0-2 feet, 2.1 mg/kg at 2-6 feet, ND at 6-10 feet, and 0.32 mg/kg at 10-14 feet.

RDX contamination in soils was sporadic. The only locations where RDX was found in surface, near subsurface, and in deep surface soil samples were 03SB119 and 03SB120. In both cases, the highest

concentrations were found in the surface soil samples (31 mg/kg and 660 mg/kg, respectively) with much lower RDX concentrations near the subsurface soils (1.6 mg/kg and 2.1 mg/kg, respectively), and deep subsurface soils (1.4 mg/kg and 0.32 mg/kg, respectively). At the other four locations where RDX was detected (03SB061, 03SB080, 03SB107, and 03SB109), the RDX concentration ranged from 0.29 mg/kg to 1.9 mg/kg.

In general, RDX concentrations decreased with depth. RDX was detected in only 2 of 223 samples collected immediately above bedrock. In order for RDX to migrate into groundwater, it would be expected that RDX would be found in the soil overburden immediately above bedrock which is 7 to 15 feet bgs. However, the samples collected during the April 2004 sampling event do not provide direct evidence that RDX in deep soils is migrating into bedrock.

TCE - Main Treatment Area

TCE was detected at 11 of the 67 locations in 15 of the 93 samples that were collected and analyzed for TCE at the MTA. Following is a listing of the locations and positive detections for TCE.

- 03SB063 - 44 µg/kg at 6-10 feet and ND at 10-14 feet.
- 03SB065 - ND at 6-10 feet and 19 µg/kg at 10-14 feet.
- 03SB061 - 19,000 µg/kg at 2-6 feet and 2,300 µg/kg at 6-10 feet.
- 03SB080 - ND at 6-10 feet and 2 µg/kg at 10-14 feet.
- 03SB100 - 31 µg/kg at 6-10 feet and 45 µg/kg at 10-14 feet.
- 03SB119 - ND at 6-10 feet and 3 µg/kg at 10-14 feet.
- 03SB120 - 9 µg/kg at 6-10 feet and 6 µg/kg at 10-14 feet.
- 03SB102 - 7 µg/kg at 6-10 feet and 8,600 µg/kg at 10-14 feet.
- 03SB103 - 330 µg/kg at 6-10 feet.
- 03SB101 - ND at 6-10 feet and 11 at 10-14 feet.
- 03SB112 - 570 µg/kg at 6-10 feet.

TCE contamination was found in the deepest soil samples immediately above bedrock in 8 of the 11 locations where TCE was detected. The highest concentrations of TCE were found in 03SB061 (19,000 µg/kg at 2-6 feet and 2,300 µg/kg at 6-10 feet), and 03SB102 (8,600 µg/kg in 10-14 feet). surface soil samples (0-2 feet) were not analyzed for TCE. It was assumed that any TCE present in surface soils would have volatilized.

In order for TCE to migrate into groundwater from soil, it would be expected TCE would be found in the soil overburden immediately above bedrock. The samples collected during April 2004 show evidence of a direct link between the soil overburden and the bedrock for TCE.

Barium - Main Treatment Area

Routine groundwater monitoring is conducted by NSWC Crane in compliance with the RCRA operating permit for the open burning treatment operations. The statistical evaluations have shown that the metals (barium, zinc, and manganese) have been detected in Point-of-Compliance wells in statistically significant concentration and above the RBTLs, which have been established in the RCRA Permit. Barium is the metal that has been detected with the greatest frequency in statistically significant concentrations above the RBTL. (The annual groundwater monitoring report for CY 2000, 2001, 2002, 2003, and 2004 contain detailed information.)

Barium, a naturally occurring metal in soils, was analyzed during the April 2004 field investigation. Figure 1-22 is a tag map which shows the barium concentration in soil samples collected during the April 2004 CMS field investigation. A site-specific soil screening value for the protection of groundwater was calculated to be 1,600 mg/kg. Following is a listing of the location where one or more soil sample(s) exceeded this soil screening value.

- 03SB86 - 2,120 mg/kg at 0-2 feet, 108 mg/kg at 2-4 feet, 142 mg/kg at 6-10 feet, and 70.9 mg/kg at 10-14 feet.
- 03SB116 - 4,120 mg/kg at 0-2 feet, 75.1 mg/kg at 2-6 feet, and 312 mg/kg at 6-10 feet.
- 03SB120 - 2,920 mg/kg at 0-2 feet, 344 mg/kg at 2-6 feet, 98 mg/kg at 6-10 feet, and 89 mg/kg at 10-14 feet.

Barium contamination above the screening value was limited to surface soils at three locations. No barium contamination above the screening value was found in subsurface soils. This indicated that barium concentration in soils is limited to the surface soils with no evidence that subsurface soils have been contaminated.

1.5.3.1.2 Perched Groundwater

During the most recent investigation at the MTA in 2004, soil samples were collected using direct-push technology (DPT). During the soil coring activity, the soil cores were logged. One soil characteristic that was carefully observed and recorded was soil moisture. If soils became saturated near the bottom of a

soil core, the borehole was left open for up to one hour, and the presence or absence of perched groundwater was observed. Perched water is water that has percolated down through the soil and has presumably accumulated on the weathered bedrock surface. This perched water can migrate laterally on the bedrock surface (in the direction the bedrock surface is dipping), but ultimately it will seep downward into the Big Clifty/Beech Creek aquifer.

Perched groundwater was collected from four different soil borings and one large depression in the soil surface. Sample locations are designated as 03TW01 through 03TW05 in Table 1-13; "TW" refers to a temporary well. The locations of the five perched groundwater samples are shown on Figure 1-18.

The RDX and TCE concentrations detected in these perched groundwater samples are summarized in Table 1-14. The highest RDX concentration was 76 µg/L, which was detected in 03TW05. This sample was collected on the far northeast side of the MTA about 270 feet northeast of monitoring well 03C11. The soil borings were drilled and this area was investigated specifically because of the flash pits that were reported to be formerly located in this area (see Figure 1-18). However, no RDX was found in the soil boring (03SB103) where 03TW05 was collected.

Moderate concentrations of RDX (0.73 to 2.3 µg/L) were detected in temporary wells 03TW01, 03TW02, and 03TW04. No RDX was found in soil boring 03SB060 where 03TW01 sample was collected in 03SB63 where 03TW02 sample was collected. Therefore, the presence of RDX in perched groundwater samples cannot be directly linked to a soil source of RDX.

The highest TCE concentration in perched groundwater was 310 µg/L, which was detected in 03TW02. This perched groundwater sample was collected from soil boring 03SB063, which had no TCE detection. This soil boring is located to the northeast of 03SB061 which had TCE concentrations of 19,000 µg/kg in the 2-6 foot depth intervals and 2,300 µg/kg in the 6-10 foot depth intervals. The TCE in the perched groundwater sample can only be indirectly linked to a specific soil source from which they were obtained.

An elevated concentration of TCE was also detected in temporary well 03TW05. Elevated concentrations of TCE (330 µg/kg) were detected in subsurface soils (6-10 feet) in 03SB103 from which the 03TW05 sample was collected. The former flash pits located on the hillside were the likely source for the contaminants in the perched groundwater.

TCE was not detected in temporary wells 03TW01, 03TW03, and 03TW04.

1.5.3.1.3 Groundwater

Groundwater samples have been collected from the MTA on numerous occasions over the past 26 years. Some monitoring wells have been sampled much more frequently than other wells. In addition, some of the monitoring wells have been destroyed and are no longer available for monitoring. Figure 1-19 shows the locations of all of the monitoring wells in the MTA. The wells that were sampled during the recent CMS investigation in 2004 are listed in Table 1-13.

Plots of RDX and TCE concentrations over time in monitoring wells screened in the BC-BC aquifer are included in Appendix F. Table 1-15 lists the wells for which concentration-time plots were prepared, the maximum concentration detected in each well, and whether the concentrations are increasing or decreasing over time (based on visual interpretation of best-fit linear trend line).

As shown in Table 1-15, there are six monitoring wells (03C03P2, 03C04, 03C05, 03C08P2, 03C09P2, and 03C20) where RDX concentrations greater than 200 µg/L have been detected. The highest RDX concentration (709 µg/L) in the BC/BC aquifer was detected in the groundwater sampling on April 25, 2004 for monitoring well 03C03P2, located near the center of the MTA. In the four wells exhibiting the highest concentrations, RDX appears to be increasing in three of the wells over time and decreasing in the fourth well (03C08P2). In the wells with lower RDX concentrations, the concentrations are either increasing or stable over time (Table 1-15).

A map showing the distribution of RDX concentrations in the BC/BC aquifer near the end of 1989 and beginning of 1990 is presented in Figure 1-23. The highest concentrations were found near the center of the MTA southward to monitoring well 03C08P2. A smaller area on the southeast side of the MTA also had moderate concentrations of RDX (5-50 µg/L). Numerous wells on the western, northern, and eastern sides of the MTA did not show any detectable RDX, supporting the hydrogeologic evidence that all groundwater in the MTA is migrating south-southeastward.

A second map showing the distribution of RDX concentrations in the BC/BC aquifer in 2004 is presented in Figure 1-24. The concentrations found near the center of the MTA were even higher than were detected previously in 1990 (maximum RDX concentration = 650 µg/L in 03C03P2). However, the concentrations to the east toward wells 03-35 and 03-33 were reduced. Conversely, RDX concentrations on the north side of the MTA were much greater and concentrations on the west side were somewhat greater than what was observed in 1990.

Table 1-15 lists the wells in the MTA where significant TCE concentrations have been detected. The maximum concentration detected in each well, and whether the concentrations are increasing or decreasing over time (based on visual interpretation of best-fit linear trend line) are also listed in Table 1-15. There are three monitoring wells (03C03P2, 03C11, and 03C20) where TCE concentrations greater than 300 µg/L have been detected in the past. The highest TCE concentration (4,500 µg/L) in the BC/BC aquifer was detected in monitoring well 03C20 in 2000. This well is located on the southwest side of the MTA. Well 03C11 had the next highest TCE concentrations (up to 2,500 µg/L). This well is located on the east-central side of the MTA, about 700 feet east-northeast of well 03C20 (see Figure 1-19). Since there are no other wells between these two where analytical data are available, it must be assumed that the TCE plume is continuous between these two wells. The TCE concentration-time plots for each well are included in Appendix F and summarized in Table 1-15. For the two wells with the highest TCE concentrations (03C11 and 03C20), the concentrations in each well are still increasing. In four other wells, the TCE concentrations also appear to be increasing. In five of the wells, TCE concentrations appear to be stable or decreasing (Table 1-15).

A map showing the distribution of TCE concentrations in the BC/BC aquifer near the end of 1989 and beginning of 1990 is presented in Figure 1-25. The highest concentrations were found around monitoring wells 03C20 and 03C11. A smaller area on the north side of the MTA also had moderate concentrations of TCE (50-100 µg/L). Numerous wells on the western, northern, and eastern sides of the MTA did not show any detectable TCE, supporting the hydrogeologic evidence that all groundwater in the MTA is migrating south-southeastward.

A second map showing the distribution of TCE concentrations in 2004 is presented in Figure 1-26. The concentrations found near the center of the MTA were higher than were detected previously in 1990 (maximum TCE concentration = 2300 µg/L in 03C11). The TCE concentrations on the north and east sides of the MTA were also greater than what was observed in 1990. TCE concentrations on the west side of the MTA generally decreased over time.

Vertically, RDX and TCE contamination in groundwater extends no deeper than the BC/BC aquifer (See Figure 1-8 for a cross-section of the MTA). No RDX or TCE is present in the deeper wells (e.g., in the Beaver Bend aquifer). Thus the RDX and TCE contamination is well bounded vertically in groundwater.

1.5.3.1.4 Springs A and A'

It is known that contaminated groundwater in the BC/BC aquifer within the MTA is flowing southeast and into a karst conduit system (inferred location is shown in Figure 1-12). This karst conduit transmits

groundwater at a rapid velocity southeastward to Springs A and A' (see Section 1.3.4.4). RDX has been detected in Springs A and A' since the late 1980s. A plot of RDX concentration in Spring A over time is included in Appendix F. The concentration varies widely over short time intervals, but appears to be decreasing over the past 27 years. The short-term variations are so great that the long-term linear trend that appears on the graph may not be real. The highest concentration found in Spring A has been 140 µg/L, which was detected twice (1987 and 2002). However, the RDX concentration in Spring A has been averaging about 30 to 40 µg/L. The RDX concentration in Spring A' in 2004 was measured at 7.4 µg/L, which is in the same range as concentrations measured in Spring A.

TCE in Spring A has been detected sporadically at low concentrations (<0.6 µg/L) between 1987 and 2004. In April 2004, the TCE concentration in Spring A' was 1.0 µg/L. It is assumed that TCE will volatize from the spring waters as soon as it is exposed to the atmosphere. In addition, the waters from Springs A and A' are diluted within water from Spring C upon entering Little Sulphur Creek. During most times of the year, the flow in LSC consists entirely of flow from Springs A, A', and C. Therefore, it is doubtful that the TCE concentrations observed in the two springs would ever have a measurable impact on Little Sulphur Creek.

1.5.3.2 OJT Area

1.5.3.2.1 Soils

A total of 48 soil borings were advanced in the OJT area in June 2001 during the RFI. Of these 48 borings, 28 were advanced to the bedrock surface or DPT refusal (10 - 15 feet bgs). The other 20 borings were advanced one to ten feet bgs using a soil hand auger. The locations of the boreholes advanced in 2001 are shown in Figure 1-5 of the RFI (TtNUS, 2003). During the 2001 investigation, 48 surface (i.e., 0-2 feet bgs) and 62 subsurface soil samples were collected and analyzed. In 2004, an additional four surface soil and 11 subsurface soil samples were collected from four new soil borings (Figure 1-20).

Old Jeep Trail: Figure 1-27 is a tag map showing all positive RDX and TCE sampling results for soil boring locations at the OJT. Soil samples were collected throughout the soil column to the top of the bedrock or to refusal.

RDX at the Old Jeep Trail

RDX was detected in 6 of the 52 locations in a total of 11 of the 125 samples that were collected and analyzed for RDX at the OJT. Following is a listing of the locations and positive detections for RDX.

- 03SB013 - 0.93 mg/kg and ND at 2-10 feet.
- 03SB018 - 1.2 mg/kg at 0-2 feet and 3.9 mg/kg at 2-6 feet.
- 03SB019 - 6.2 mg/kg at 0-2 feet, 0.92 mg/kg at 2-6 feet, and ND at 10-15 feet.
- 03SB022 - 140 mg/kg at 0-2 feet, ND at 2-6 feet, and 2.1 mg/kg at 10-15 feet.
- 03SB024 - 2,400 mg/kg at 0-2 feet, 1.4 mg/kg at 2-6 feet, and 4.4 mg/kg at 10-15 feet.
- 03SB026 - 4.3 mg/kg at 0-2 feet and ND at 6-10 feet.

RDX contamination in soils was found mainly in the central part of the OJT with the highest concentrations found in the 0-2 feet of 03SB024 sample (2,400 mg/kg), which is also the only sample where RDX was encountered throughout the entire sample column. The second highest RDX concentration was found in 03SB022 (140 mg/kg at 0-2 feet). The only locations where RDX was encountered at a depth greater than 10 feet were 03SB022 (2.1 mg/kg at 10-15 feet) and 03SB024 (4.4 mg/kg at 10-15 feet). No RDX detection was encountered at 03SB022 at the 2-6 foot sample interval. The other four soil locations where RDX was detected (03SB013, 03SB108, 03SB109, and 03SB026), ranged in concentration from 0.92 mg/kg to 6.2 mg/kg.

RDX concentrations tended to decrease with sample depth, as indicated by only 2 of the 6 sample locations having RDX at the 10-15 foot interval. In order for RDX to migrate into groundwater, it would be expected that RDX would be found in the soil overburden immediately above bedrock. However, the samples collected during the April 2004 sampling event do not provide direct evidence that RDX in deep soils is migrating into bedrock.

<u>TCE - Old Jeep Trail</u>

TCE was detected at 5 of the 52 locations in 8 of the 47 samples that were collected and analyzed for TCE at the OJT. Following is a listing of the locations and positive detections for TCE.

- 03SB023 - 14 µg/kg at 0-2 feet and ND at 6-10 feet.
- 03SB026 - 4.0 µg/kg at 0-2 feet and ND at 6-10 feet.
- 03SB046 - ND at 0-2 feet, 10 µg/kg at 2-6 feet, and ND at 6-10 feet.
- 03SB047 - ND at 0-2 feet, 18 µg/kg at 2-6 feet, and 15 µg/kg at 6-10 feet.
- 03SB048 - 3.0 µg/kg at 0-2 feet, 20 µg/kg at 2-6 feet, and 33 µg/kg at 6-10 feet.

TCE contamination was found in the deepest soil samples immediately above bedrock in three of the five locations where TCE was detected. The highest concentrations of TCE are in location 13SB048 in which

TCE was found at all three sampling intervals (0-2 feet at 3.0 µg/kg, 2-6 feet at 20 µg/kg, and 6-10 feet at 33 µg/kg). TCE concentrations in the other soil locations ranged from 4 µg/kg to 18 µg/kg.

In locations where TCE was found in samples directly above the bedrock, the concentrations tended to remain fairly consistent with the 2-6 foot sample or to slightly increase with depth, which would indicate a direct link between the soil overburden and the bedrock.

Barium - Old Jeep Trail

As noted in Section 1.5.3.1.1, barium concentrations in groundwater at the MTA have been detected in Point-of-Compliance wells in statistically significant concentration and above the RBTLs, which have been established in the RCRA Permit. The RFI Investigation analyzed for metals including barium. Figure 1-28 presents the results of the RFI Investigation. The results indicate that barium was present in concentrations above the calculated cleanup level of 1,600 mg/kg in only one sample (03SB048). Barium was present in 03SB048 in surface soil (0 to 2 feet bgs) at a concentration of 2,400 mg/kg.

1.5.3.2.2 Perched Groundwater

Groundwater was encountered at the bottom of one of the four new soil borings in 2004. The soil boring (03SB050/03TW06) was located about 75 feet northeast of monitoring well 03-07. Based on USACE interpretations, this area does not contain competent Beech Creek or Big Clifty Formations. Apparently, karst conduits in the Beech Creek Formation were so prevalent along the present day location of Little Sulphur Creek, that sometime in the geologic past, the cave system collapsed and filled in with alluvium. The USACE interpretation is that the material now occupying the valley bottom is collapse breccia of the Beech Creek or Big Clifty Formations. Hence, it is doubtful that groundwater would perch on the top of the breccia. However, the groundwater sample collected near the top of the water table surface from 03SB48 might represent water that has just leached down from the overlying soil, but has not yet mixed with the bulk of groundwater in the breccia immediately below the finer-grained soil above. The sample from soil boring 03SB050 (i.e., 03TW06) had no detectable concentrations of RDX or TCE. Thus, soils in the vicinity of boring 03SB050 (to the northwest of well 03-07) do not appear to be a source of TCE detected in 03-07.

1.5.3.2.3 Groundwater

During the RFI, RDX was detected in 13 out of 16 groundwater samples collected in the OJT area (TtNUS, 2003). The distribution of RDX in groundwater is presented in Figure 5-5 of the RFI. The highest concentration of RDX (280 µg/L) during the RFI was detected in monitoring well 03-21, which is

located on the east-southeast side of the Burn Pit (Figure 1-20). Other wells with moderate concentrations of RDX included 03-12 (35 µg/L), 03-22 (18 µg/L), 03-10 (14 µg/L), and 03-23 (12 µg/L). This group of wells is located south of the Burn Area. The one monitoring well north (upgradient) of the Burn Pit and Burn Area (03-16) also had moderately high concentrations of RDX (24 µg/L). These data indicate that the Burn Area and perhaps the Burn Pit were a source of RDX in groundwater. However, as shown by well 03-16, there appears that some RDX is also migrating down the valley from the MTA.

In 2004, the three OJT monitoring wells with the highest RDX concentrations were resampled. Wells 03-21, 03-12, and 03-16 had 120, 39, and 19 µg/L, respectively. The RDX declined significantly in two of the wells (03-21 and 03-16) and remained relatively the same in 03-12. Concentration-time graphs for RDX in these wells are presented in Appendix F. The RDX concentrations of most wells have declined by more than 50 percent between 1994 and 2004.

During the RFI, TCE was detected in 6 out of 16 groundwater samples collected in the OJT area (TtNUS, 2003). The distribution of TCE in groundwater is presented in Figure 5-5 of the RFI. The highest concentration of TCE (640 µg/L) during the RFI was detected in monitoring well 03-07, which is located on the southeast side of the Burn Pit (Figure 1-20). Other wells with moderate to low concentrations of TCE included 03-15 (57ug/L), 03-24 (23 µg/L), 03-22 (6 µg/L), and 03-12 (3.7 µg/L). This group of wells is located south of the Burn Area and surround well 03-07. The one monitoring well north (upgradient) of the Burn Pit and Burn Area (03-16) had no detectable TCE. These data indicate that the Burn Area and/or the area southeast of the Burn Area was the source of TCE in groundwater. As shown by well 03-16, there appears to be no TCE migrating down the valley from the MTA.

In 2004, the four OJT monitoring wells with the highest TCE concentrations were resampled. Wells 03-07, 03-15, 03-24, and 03-12 had 1010, 30, 17, and 2.2 µg/L, respectively. TCE increased significantly in well 03-07, but decreased in the other three wells. Concentration-time graphs for TCE in these wells are presented in Appendix F. The TCE concentrations of most wells have declined between 1994 and 2004.

1.5.3.2.4 Spring C

Based on dye tracer tests performed by Indiana University (Jock and Krothe, 2002), monitoring well 03-24 (located on the eastern side of the OJT area) is hydraulically connected to Spring C. The potentiometric surface for the OJT area also suggests that groundwater is flowing eastward from the OJT area toward well 03-24 and then southward. This conduit on the eastern side of Little Sulphur Creek drains the eastern side of the watershed and carries the groundwater southward to Spring C. Previous dye tracer

studies performed in the MTA indicate that groundwater from the MTA is not flowing under Little Sulphur Creek and is not contributing water to Spring C.

A concentration-time graph for RDX in Spring C is presented in Appendix F. Except for one sample collected in 1989, the RDX concentrations have been relatively steady in Spring C, ranging from nondetect up to 5 µg/L. The latest sample collected in June 2004 had an RDX concentration of 4.6 µg/L. TCE has been detected in only one sample from Spring C and that occurred in April 1991. For all practical purposes, it has never been detected in Spring C. Therefore, the RDX in Spring C is of concern, but not TCE.

TABLE 1-1

AMMUNITION BURNING GROUNDS MAIN TREATMENT AREA AND OLD JEEP TRAIL
KEY OPERATIONS AND POTENTIAL SOURCE AREAS
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

ABG - MTA	
Key ABG Operation Area Considered to be Potential Source Area	**Contaminant Detections in Source Area**
Storage Area	TCE was detected in well 03C01P2 above 50 µg/L in 1989
None	Encompasses area where two previous soil borings (03/10-17 and 03/10-61) indicated elevated RDX and TCE concentrations
Former flash pits	TCE was detected in well 03C10 above 50 µg/L in 2000
Former flash pits, burning pad, and UST	Elevated TCE and RDX concentrations detected in well 03C09P2
Dewatering units	TCE frequently detected above 5 µg/L in wells 03C07 and 03C26
Former flash pits, two burning pads, and UST	Area where highest ground water concentrations of RDX and TCE are typically found
Former ash pile	RDX and TCE ground water concentrations commonly above 50 µg/L in well 03C08P2, located south of the former ash pile
None	Elevated RDX concentrations detected previously in soil borings 03/10-35 and 03/10-69
Former flash pits	TCE was detected above 50 µg/L in well 03C04
OJT	
Key OJT Operation Area Considered to be Potential Source Area	**Contaminant Detections in Source Area**
Burn Pit	TCE concentration in well 03-07 at 920 ug/L and RDX concentration 120 ug/L in well 03-21in 2004

TABLE 1-2

SUMMARY OF AQUIFER TESTING RESULTS MAIN TREATMENT AREA
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Aquifer	Area	Well No.	Test Type	Method of Data Analysis	Hydraulic Conductivity (feet/day)	Source of Data
Mansfield Formation (Pennsylvanian)	DBG	02-03 (1)	Slug	JSL	0.0001	Fisher, 1996
	DBG	02-03 (2)	Slug	JSL	0.0238	Fisher, 1996
	DBG	02-04	Slug	JSL	0.3260	Fisher, 1996
	DBG	02-08	Slug	JSL	0.0686	Fisher, 1996
	DBG	02C10P3	Slug	JSL	0.5556	Fisher, 1996
	DBG	02C11P3	Slug	JSL	0.1488	Fisher, 1996
	DBG	02C12P3	Slug	JSL	0.1517	Fisher, 1996
	DBG	02C14P3	Slug	JSL	0.1412	Fisher, 1996
	DBG	02C17P2	Slug	JSL	0.2027	Fisher, 1996
	DBG	02C18P2	Slug	JSL	0.1100	Fisher, 1996
	DBG	02C20P3	Slug	JSL	0.9411	Fisher, 1996
Big Clifty/Beech Creek	ABG	03PMP08	SW Pump Test	JSL	0.2387	Murphy, 1995
	ABG	03PMP20	SW Pump Test	JSL	0.0870	Murphy, 1995
	ABG	03-01	LF Purge Test	Ogden (Q/s Estimation)	23.5688	This Document
	ABG	03-38	LF Purge Test	Ogden (Q/s Estimation)	23.5688	This Document
	ABG	03-39	LF Purge Test	Ogden (Q/s Estimation)	23.5688	This Document
	ABG	03-31	LF Purge Test	Ogden (Q/s Estimation)	0.0747	This Document
	ABG	03-09	LF Purge Test	Ogden (Q/s Estimation)	0.1450	This Document
	ABG	03-33	LF Purge Test	Ogden (Q/s Estimation)	0.1571	This Document
	ABG	03C30	LF Purge Test	Ogden (Q/s Estimation)	0.0602	This Document
	ABG	03C04	LF Purge Test	Ogden (Q/s Estimation)	0.0726	This Document
	ABG	03C06	LF Purge Test	Ogden (Q/s Estimation)	0.0860	This Document
	ABG	03C26	LF Purge Test	Ogden (Q/s Estimation)	0.1073	This Document
	ABG	03C08P2	LF Purge Test	Ogden (Q/s Estimation)	0.2073	This Document
	ABG	03C28	LF Purge Test	Ogden (Q/s Estimation)	0.2525	This Document
	ABG	03C05	LF Purge Test	Ogden (Q/s Estimation)	0.2741	This Document
	ABG	03C07	LF Purge Test	Ogden (Q/s Estimation)	0.3803	This Document
	ABG	03C21	LF Purge Test	Ogden (Q/s Estimation)	0.6173	This Document
	ABG	03C20	LF Purge Test	Ogden (Q/s Estimation)	2.0770	This Document
	ABG	03C27	LF Purge Test	Ogden (Q/s Estimation)	2.9592	This Document
	ABG	03C01P2	LF Purge Test	Ogden (Q/s Estimation)	5.0505	This Document
	ABG	03C14	LF Purge Test	Ogden (Q/s Estimation)	6.5993	This Document
	ABG	03C25	LF Purge Test	Ogden (Q/s Estimation)	8.6026	This Document
	ABG	03-24	LF Purge Test	Ogden (Q/s Estimation)	10.2132	This Document

TABLE 1-2

SUMMARY OF AQUIFER TESTING RESULTS MAIN TREATMENT AREA
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Aquifer	Area	Well No.	Test Type	Method of Data Analysis	Hydraulic Conductivity (feet/day)	Source of Data
Big Clifty/Beech Creek (Continued)	ABG	03C03P2	LF Purge Test	Ogden (Q/s Estimation)	11.7844	This Document
	ABG	03C17	LF Purge Test	Ogden (Q/s Estimation)	12.8057	This Document
	ABG	03-21	LF Purge Test	Ogden (Q/s Estimation)	37.7101	This Document
	ABG	03C09P2	LF Purge Test	Ogden (Q/s Estimation)	44.5451	This Document
	ABG	03C15	LF Purge Test	Ogden (Q/s Estimation)	44.5451	This Document
	ABG	03C11	LF Purge Test	Ogden (Q/s Estimation)	0.1985	This Document
	ABG	03PMP03	SW Pump Test	JSL	1.7008	Murphy, 1995
	ABG	03PMP11	SW Pump Test	JSL	0.1879	Murphy, 1995
	OJT	03-24	LF Purge Test	Ogden	2.53	TtNUS, 2003
	OJT	03-25	LF Purge Test	Ogden	0.0658	TtNUS, 2003
				JSL	0.0887	TtNUS, 2003
	OJT	03-15	LF Purge Test	Ogden	1.48	TtNUS, 2003
	OJT	03-23	LF Purge Test	Ogden	4.08	TtNUS, 2003
Collapse Breccia	OJT	03-07	LF Purge Test	Ogden	3.67	TtNUS, 2003
				JSL	2.09	TtNUS, 2003
	OJT	03-10	LF Purge Test	Ogden	0.0582	TtNUS, 2003
	OJT	03-11	LF Purge Test	Ogden	0.113	TtNUS, 2003
				JSL	0.118	TtNUS, 2003
	OJT	03-12	LF Purge Test	Ogden	0.0223	TtNUS, 2003
	OJT	03-13	LF Purge Test	Ogden	0.122	TtNUS, 2003
	OJT	03-14	LF Purge Test	Ogden	0.0775	TtNUS, 2003
				JSL	0.068	TtNUS, 2003
	OJT	03-16	LF Purge Test	Ogden	0.563	TtNUS, 2003
	OJT	03-17	LF Purge Test	Ogden	1.06	TtNUS, 2003
				JSL	0.689	TtNUS, 2003
	OJT	03-18	LF Purge Test	Ogden	0.639	TtNUS, 2003
				JSL	0.502	TtNUS, 2003
	OJT	03-20	LF Purge Test	Ogden	1.80	TtNUS, 2003
				JSL	0.706	TtNUS, 2003
	OJT	03-22	LF Purge Test	Ogden	0.156	TtNUS, 2003
				JSL	0.123	TtNUS, 2003
Beaver Bend	ABG	03C03	LF Purge Test	Ogden (Q/s Estimation)	108.61	This Document

DBG = Dye Burial Grounds.
ABG = Ammunition Burning Grounds.
OJT= Old Jeep Trail.
JSL = Jacob Straight Line method.
SW = Surface water.
LF = Low Flow

TABLE 1-3

PHYSICAL CHARACTERISTICS OF MONITORING WELLS AND WATER LEVEL MEASUREMENTS
OLD JEEP TRAIL/LITTLE SULPHUR CREEK FOR JUNE 2002 AND APRIL 2004
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Monitoring Well Number	Date Installed	Horizontal Location		Ground Surface Elevation* (feet amsl)	Top of Riser or Measuring Reference Point Elevation* (feet amsl)	Well Screen Interval		Well Screen Interval		Monitored Unit	Ground Water Depth & Elevation		Ground Water Depth & Elevation	
											June 2002		April 2004	
		North Coord. (feet N/AD 27)	East Coord. (feet N/AD 27)			Depth to Top (feet btor)	Depth to Bottom (feet btor)	Elevation* of Top (feet amsl)	Elevation* of Bottom (feet amsl)		Depth to Water (feet btor)	Groundwater Elevation*(1) (feet amsl)	Depth to Water (feet btor)	Ground Water Elevation*(1) (feet amsl)
02-01	8/26/1981	491384.48	596550.97	743.47	746.17	23.52	33.12	722.65	713.05	Upper Pennsylvanian	25.76	720.41	25.92	720.25
02-02	9/2/1981	491143.00	596074.00	724.67	727.67	42.70	52.30	684.97	675.37	Lower Pennsylvanian	45.31	682.36	45.67	682.00
02-03	9/3/1981	491058.00	595916.00	719.38	722.38	54.20	63.30	668.18	659.08	Hardinsburg	43.09	679.29	43.65	678.73
02-04	9/4/1981	490919.00	595915.00	716.02	719.02	38.90	48.10	680.12	670.92	Lower Pennsylvanian	37.77	681.25	38.27	680.75
02-05	9/5/1981	491491.00	596645.00	738.28	741.28	53.20	62.70	688.08	678.58	Lower Pennsylvanian	56.43	684.85	56.95	684.33
02-06	9/23/1981	491298.24	596384.94	742.56	744.65	59.48	68.78	685.17	675.87	Lower Pennsylvanian	59.87	684.78	60.36	684.29
02-07	9/24/1981	491192.73	596232.83	735.55	738.42	53.36	61.56	685.06	676.86	Lower Pennsylvanian	54.37	684.05	54.74	683.68
02-08	9/24/1981	491092.55	596224.65	730.06	732.20	48.88	56.14	683.32	676.06	Lower Pennsylvanian	48.52	683.68	48.88	683.32
02C09	1/23/1987	491331.00	597056.00	737.86	740.36	169.50	179.50	570.86	560.86	Beech Creek	170.26	570.10	170.02	570.34
02C09P2	1/26/1987	491331.00	597056.00	738.16	740.66	94.50	99.50	646.16	641.16	Golconda	N/A	N/A	Dry	N/A
02C10	2/13/1988	491789.00	596142.00	713.97	716.47	144.50	154.50	571.97	561.97	Beech Creek	146.56	569.91	146.90	569.57
02C10P2	2/16/1988	491789.00	596147.00	713.89	716.39	64.00	74.00	652.39	642.39	Golconda	40.46	675.93	41.98	674.41
02C10P3	2/22/1988	491784.00	596142.00	713.86	716.36	34.20	39.20	682.16	677.16	Lower Pennsylvanian	28.77	687.59	29.52	686.84
02C11	2/29/1988	490987.00	595829.00	712.81	715.31	150.50	160.50	564.81	554.81	Beech Creek	149.13	566.18	149.29	566.02
02C11P2	3/2/1988	490987.00	595823.00	712.86	715.36	72.30	82.30	643.06	633.06	Golconda	73.55	641.81	73.75	641.61
02C11P3	3/5/1988	490987.00	595817.00	713.16	715.66	38.80	43.80	676.86	671.86	Lower Pennsylvanian	34.65	681.01	35.21	680.45
02C12	3/14/1988	491496.00	596670.00	739.07	741.57	174.10	184.10	567.47	557.47	Beech Creek	171.22	570.35	171.37	570.20
02C12P2	3/21/1988	491496.00	596681.00	739.32	741.82	95.70	105.70	646.12	636.12	Golconda	89.22	652.60	89.70	652.12
02C12P3	3/18/1988	491496.00	596676.00	739.33	741.83	31.50	36.50	710.33	705.33	Upper Pennsylvanian	23.31	718.52	23.40	718.43
02C13	3/28/1988	491692.00	596436.00	722.61	725.11	71.80	81.80	653.31	643.31	Golconda	61.82	663.29	57.61	667.50
02C13P2	3/29/1988	491695.00	596439.00	722.28	724.78	36.50	46.50	688.28	678.28	Lower Pennsylvanian	39.82	684.96	40.31	684.47
02C13P3	3/30/1988	491698.00	596434.00	723.01	725.51	17.50	22.50	708.01	703.01	Upper Pennsylvanian	10.23	715.28	11.90	713.61
02C14	4/13/1988	490671.00	595964.00	713.90	716.40	156.40	166.40	560.00	550.00	Beech Creek	149.10	567.30	Dry	N/A
02C14P2	4/15/1988	490675.00	595964.00	713.93	716.43	76.90	86.90	639.53	629.53	Golconda	63.60	652.83	63.45	652.98
02C14P3	4/19/1988	490665.00	595964.00	713.76	716.26	39.60	49.60	676.66	666.66	Lower Pennsylvanian	36.58	679.68	36.83	679.43
02C15	5/10/1988	491186.00	595880.00	713.38	715.88	68.80	78.80	647.08	637.08	Golconda	69.88	646.00	70.08	645.80
02C15P2	5/11/1988	491181.00	595880.00	713.27	715.77	31.70	41.70	684.07	674.07	Lower Pennsylvanian	33.02	682.75	33.78	681.99
02C16	5/16/1988	490893.00	596177.00	722.86	725.36	81.10	91.10	644.26	634.26	Golconda	84.90	640.46	85.10	640.26
02C16P2	5/17/1988	490899.00	596177.00	722.68	725.18	46.00	56.00	679.18	669.18	Lower Pennsylvanian	42.67	682.51	43.03	682.15
02C17	5/23/1988	491022.00	596473.00	730.46	732.96	88.60	98.50	644.36	634.46	Golconda	84.53	648.43	85.17	647.79
02C17P2	5/26/1988	491027.00	596473.00	730.34	732.84	52.20	62.20	680.64	670.64	Lower Pennsylvanian	48.53	684.31	48.98	683.86
02C17P3	5/27/1988	491022.00	596473.00	730.34	733.38	23.10	28.10	710.28	705.28	Upper Pennsylvanian	Dry	Dry	Dry	N/A
02C18	6/6/1988	491103.00	596611.00	734.81	737.31	90.80	100.80	646.51	636.51	Golconda	88.73	648.58	88.82	648.49
02C18P2	6/7/1988	491107.00	596614.00	734.74	737.24	54.90	64.90	682.34	672.34	Lower Pennsylvanian	52.53	684.71	52.98	684.26
02C18P3	6/7/1988	491107.00	596614.00	734.74	737.45	15.50	20.50	721.95	716.95	Upper Pennsylvanian	20.98	716.47	21.08	716.37
02C19	6/14/1988	491338.00	596225.00	730.85	733.35	82.70	92.70	650.65	640.65	Golconda	87.10	646.25	87.14	646.21
02C19P2	6/15/1988	491332.00	596225.00	730.78	733.28	48.10	58.10	685.18	675.18	Lower Pennsylvanian	48.62	684.66	48.97	684.31
02C19P3	6/16/1988	491338.00	596225.00	730.78	733.63	13.20	18.20	720.43	715.43	Upper Pennsylvanian	Dry	Dry	Dry	N/A
02C20	6/29/1988	492114.00	596769.00	712.56	715.06	134.71	144.70	580.35	570.36	Beech Creek	137.47	577.59	140.92	574.14
02C20P2	6/22/1988	492120.00	596763.00	712.42	714.92	58.50	68.50	656.42	646.42	Golconda	57.69	657.23	58.32	656.60
02C20P3	6/23/1988	492120.00	596769.00	712.27	714.78	30.50	40.50	684.28	674.28	Lower Pennsylvanian	17.30	697.48	17.78	697.00

TABLE 1-3

PHYSICAL CHARACTERISTICS OF MONITORING WELLS AND WATER LEVEL MEASUREMENTS
OLD JEEP TRAIL/LITTLE SULPHUR CREEK FOR JUNE 2002 AND APRIL 2004
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Monitoring Well Number	Date Installed	Horizontal Location		Ground Surface Elevation* (feet amsl)	Top of Riser or Measuring Reference Point Elevation* (feet amsl)	Well Screen Interval		Well Screen Interval		Monitored Unit	Ground Water Depth & Elevation		Ground Water Depth & Elevation	
											June 2002		April 2004	
		North Coord. (feet N/AD 27)	East Coord. (feet N/AD 27)			Depth to Top (feet btor)	Depth to Bottom (feet btor)	Elevation* of Top (feet amsl)	Elevation* of Bottom (feet amsl)		Depth to Water (feet btor)	Groundwater Elevation*(1) (feet amsl)	Depth to Water (feet btor)	Ground Water Elevation*(1) (feet amsl)
02C21	9/12/1990	491004.00	597187.00	726.48	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
02C22	10/15/1990	490129.00	597610.00	740.13	742.99	179.20	189.20	563.79	553.79	Beech Creek	Dry	Dry	Dry	N/A
02C22P2	10/17/1990	490124.00	597613.00	740.13	742.63	102.50	107.50	640.13	635.13	Golconda	Dry	Dry	Dry	N/A
02C22P3	10/18/1990	490119.00	597617.00	740.00	742.50	61.10	71.10	681.40	671.40	Lower Pennsylvanian	58.33	684.17	58.91	683.59
03C01	12/12/1986	490064.00	593140.00	624.58	627.28	176.70	186.70	450.58	440.58	Beaver Bend	114.86	512.42	115.38	511.90
03C01P2	9/22/1986	490068.00	593146.00	624.35	626.85	94.50	104.50	532.35	522.35	Beech Creek	69.90	556.95	70.05	556.80
03C01P3	04/--/86	490061.00	593147.00	624.00	626.50	22.10	27.10	604.40	599.40	Golconda	14.15	612.35	133.90	492.60
03C02	10/24/1986	489931.00	594793.00	580.99	583.49	122.00	132.00	461.49	451.49	Beaver Bend	71.28	512.21	71.69	511.80
03C02P2	10/29/1986	489931.82	594798.08	580.65	583.15	40.50	50.50	542.65	532.65	Beech Creek	37.54	545.61	37.45	545.70
03C03	9/13/1986	490202.94	594055.53	597.58	600.08	141.50	151.50	458.58	448.58	Beaver Bend	87.50	512.58	88.00	512.08
03C03P2	10/23/1986	490208.00	594056.00	597.70	600.20	58.30	68.30	541.90	531.90	Beech Creek	41.55	558.65	41.85	558.35
03C04	11/25/1986	490260.55	594783.22	621.92	624.42	76.00	86.00	548.42	538.42	Beech Creek	76.95	547.47	75.82	548.60
03C05	10/29/1986	489782.00	595114.00	578.86	581.36	34.50	44.50	546.86	536.86	Beech Creek	34.75	546.61	34.77	546.59
03C06	10/16/1986	489581.00	594596.00	622.90	625.40	89.50	99.50	535.90	525.90	Beech Creek	76.76	548.64	76.92	548.48
03C07	10/21/1986	490422.52	594370.95	633.97	636.47	91.20	101.20	545.27	535.27	Beech Creek	78.61	557.86	78.73	557.74
03C08P2	11/26/1986	489701.00	594014.00	626.84	629.34	92.50	102.50	536.84	526.84	Beech Creek	74.48	554.86	74.48	554.86
03C08A	4/3/1987	489680.00	594051.00	628.00	630.50	173.50	183.50	457.00	447.00	Beaver Bend	118.47	512.03	119.01	511.49
03C08AP3	4/5/1987	489685.00	594047.00	627.93	630.43	17.00	22.00	613.43	608.43	Golconda	16.48	613.95	16.11	614.32
03C09	12/5/1986	490615.00	593777.00	600.89	603.39	147.50	157.50	455.89	445.89	Beaver Bend	91.05	512.34	91.55	511.84
03C09P2	12/7/1986	490619.57	593775.83	601.06	603.56	64.50	74.50	539.06	529.06	Beech Creek	45.17	558.39	45.54	558.02
03C10	1/22/1987	490242.71	593656.93	605.53	608.03	68.50	78.50	539.53	529.53	Beech Creek	49.85	558.18	50.28	557.75
03C11	1/28/1987	490024.65	594440.55	589.86	592.36	50.00	60.00	542.36	532.36	Beech Creek	43.75	548.61	43.61	548.75
03C12	2/3/1987	489957.37	594574.22	584.70	587.20	41.50	51.50	545.70	535.70	Beech Creek	41.85	545.35	41.85	545.35
03C13	2/9/1987	490901.00	593860.00	615.25	617.75	72.70	82.70	545.05	535.05	Beech Creek	59.46	558.29	N/A	N/A
03C14	2/20/1987	489932.00	593575.00	640.29	642.79	107.00	117.00	535.79	525.79	Beech Creek	84.92	557.87	85.35	557.44
03C15	2/26/1987	489849.54	593146.29	618.51	621.34	91.33	101.33	530.01	520.01	Beech Creek	64.37	556.97	64.53	556.81
03C15P3	4/--/87	489855.00	593143.00	618.61	621.11	18.10	23.10	603.01	598.01	Golconda	6.20	614.91	5.70	615.41
03C16	3/12/1987	490478.00	593362.00	680.75	683.25	148.50	158.50	534.75	524.75	Beech Creek	125.17	558.08	125.70	557.55
03C17	3/19/1987	492763.63	594371.09	693.65	696.15	141.00	151.00	555.15	545.15	Beech Creek	137.97	558.18	138.01	558.14
03C18	4/--/87	489992.00	592967.00	622.59	625.09	18.00	23.00	607.09	602.09	Golconda	4.49	620.60	4.46	620.63
03C19	5/8/1987	491442.00	593351.00	648.00	650.50	113.30	123.30	537.20	527.20	Beech Creek	92.13	558.37	92.45	558.05
03C19P3	5/13/1987	491431.00	593354.00	647.20	649.70	39.50	44.50	610.20	605.20	Golconda	32.74	616.96	33.08	616.62
03C20	5/24/1987	489880.21	593773.34	644.12	646.62	110.50	120.50	536.12	526.12	Beech Creek	89.29	557.33	89.54	557.08
03C21	5/28/1987	489925.00	593356.00	639.72	642.22	110.90	120.90	531.32	521.32	Beech Creek	84.96	557.26	85.25	556.97
03C21P2	5/29/1987	489925.00	593361.00	639.72	642.22	36.10	41.10	606.12	601.12	Golconda	34.08	608.14	34.25	607.97
03C22	6/4/1987	490090.00	593319.00	615.08	617.58	12.50	17.50	605.08	600.08	Golconda	9.66	607.92	9.95	607.63
03C23	6/9/1987	490259.00	593462.00	616.11	618.61	11.00	16.00	607.61	602.61	Golconda	5.70	612.91	7.80	610.81
03C24	6/16/1987	485159.00	592615.00	550.64	553.24	24.60	29.60	528.64	523.64	Beech Creek	21.50	531.74	21.64	531.60
03C25	6/18/1987	487148.51	592610.07	594.53	597.03	62.20	72.20	534.83	524.83	Beech Creek	46.68	550.35	46.45	550.58
03C26	8/3/1987	490695.18	594134.16	638.07	640.57	96.50	106.50	544.07	534.07	Beech Creek	82.44	558.13	82.68	557.89
03C27	8/14/1987	489658.33	594767.37	601.34	603.84	63.00	73.00	540.84	530.84	Beech Creek	60.78	543.06	60.75	543.09

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SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Monitoring Well Number	Date Installed	Horizontal Location		Ground Surface Elevation* (feet amsl)	Top of Riser or Measuring Reference Point Elevation* (feet amsl)	Well Screen Interval		Well Screen Interval		Monitored Unit	Ground Water Depth & Elevation		Ground Water Depth & Elevation	
											June 2002		April 2004	
		North Coord. (feet N/AD 27)	East Coord. (feet N/AD 27)			Depth to Top (feet btor)	Depth to Bottom (feet btor)	Elevation* of Top (feet amsl)	Elevation* of Bottom (feet amsl)		Depth to Water (feet btor)	Groundwater Elevation*(1) (feet amsl)	Depth to Water (feet btor)	Ground Water Elevation*(1) (feet amsl)
03C28	8/22/1987	489884.00	595269.00	610.76	612.96	67.20	77.20	545.76	535.76	Beech Creek	67.41	545.55	67.47	545.49
03C29	9/1/1987	488529.00	591095.00	794.67	797.37	270.20	280.20	527.17	517.17	Beech Creek	242.40	554.97	242.50	554.87
03C30	9/17/1987	488967.44	592402.75	776.41	778.91	253.00	263.00	525.91	515.91	Beech Creek	223.23	555.68	222.64	556.27
03C31	11/1/1987	488492.00	593743.00	789.70	792.10	257.40	267.40	534.70	524.70	Beech Creek	238.06	554.04	237.60	554.50
03C32	11/14/1987	491056.00	594471.00	709.06	711.56	166.50	176.50	545.06	535.06	Beech Creek	153.65	557.91	153.82	557.74
03C33	11/31/87	486651.00	594224.00	782.53	785.03	241.00	251.00	544.03	534.03	Beech Creek	234.48	550.55	234.45	550.58
03C34	8/11/1989	487870.00	599301.00	724.57	727.07	180.00	190.00	547.07	537.07	Beech Creek	178.56	548.51	178.51	548.56
03C35	8/19/1989	485347.00	598082.00	695.50	697.00	166.00	176.00	531.00	521.00	Beech Creek	174.85	522.15	174.85	522.15
03C36	9/6/1989	485203.00	599202.00	715.74	718.24	171.50	181.50	546.74	536.74	Beech Creek	Dry	Dry	Dry	N/A
03C37	9/21/1989	483933.00	596471.00	617.78	620.28	107.00	117.00	513.28	503.28	Beech Creek	108.47	511.81	108.54	511.74
03C38	9/29/1989	485309.00	595951.00	570.47	572.97	45.50	55.50	527.47	517.47	Beech Creek	55.15	517.82	55.14	517.83
03B01	6/19/1987	482590.00	595584.00	501.97	504.47	10.00	15.00	494.47	489.47	Alluvium	6.96	497.51	6.66	497.81
03B02	6/27/1987	482573.03	595505.44	501.46	503.96	12.10	17.10	491.86	486.86	Alluvium	6.10	497.86	5.91	498.05
03B03	6/29/1987	482578.00	595406.00	502.46	504.96	11.00	16.00	493.96	488.96	Alluvium	5.74	499.22	5.70	499.26
03B04	6/30/1987	482630.95	595292.56	503.97	506.47	12.00	17.00	494.47	489.47	Alluvium	6.92	499.55	6.77	499.70
03B05	7/1/1987	482623.00	595192.00	504.55	507.05	11.50	16.50	495.55	490.55	Alluvium	7.05	500.00	6.91	500.14
03B06	7/2/1987	482666.00	594960.00	506.76	509.26	10.50	15.50	498.76	493.76	Alluvium	7.75	501.51	7.68	501.58
03B07	8/4/1987	482672.00	594768.00	508.22	510.72	6.50	11.50	504.22	499.22	Alluvium	6.60	504.12	Dry	N/A
03B08	8/5/1987	482667.00	594594.00	510.90	513.40	8.50	13.50	504.90	499.90	Alluvium	8.45	504.95	8.28	505.12
03B09	8/7/1987	482657.00	594417.00	513.54	516.04	8.00	13.00	508.04	503.04	Alluvium	9.82	506.22	9.80	506.24
03B10	10/22/1987	482607.00	594209.00	559.46	561.96	51.00	61.00	510.96	500.96	Beech Creek	50.60	511.36	50.60	511.36
03-01	9/4/1981	490748.00	593688.00	601.67	604.67	44.60	53.80	560.07	550.87	Big Clifty and Beech Creek	45.78	558.89	46.14	558.53
03-02	9/7/1981	489940.00	593060.00	619.67	622.67	6.50	13.00	616.17	609.67	Mansfield	N/A	N/A	6.35	616.32
03-03	9/8/1981	489838.00	594843.00	581.29	584.29	88.90	98.00	495.39	486.29	Sample Shale	N/A	N/A	N/A	N/A
03-04	9/24/1981	489791.00	594610.00	591.17	594.17	58.10	67.50	536.07	526.67	Beech Creek	N/A	N/A	N/A	N/A
03-05	9/29/1981	N/A	N/A	592.75	595.75	48.40	57.70	547.35	538.05	Beech Creek	N/A	N/A	N/A	N/A
03-06	10/6/1981	489796.00	594636.00	586.71	589.71	40.30	49.60	549.41	540.11	Beech Creek	N/A	N/A	N/A	N/A
03-07	10/8/1981	487837.91	596315.43	553.46	556.48	15.42	24.72	541.06	531.76	Alluvium and Beech Creek (breccia zone)	11.93	544.55	11.70	544.78
03-08	10/9/1981	N/A	N/A	583.76	586.76	35.40	44.80	551.36	541.96	Beech Creek	N/A	N/A	N/A	N/A
03-09	10/28/1981	489909.00	593047.00	621.72	624.72	68.90	78.10	555.82	546.62	Big Clifty	67.80	556.92	67.88	556.84
03-10	11/3/1982	487821.20	596515.84	554.94	557.99	15.25	24.55	542.74	533.44	Beech Creek (breccia zone	16.60	541.39	16.79	541.20
03-11	11/4/1982	487708.67	596434.59	550.05	553.41	9.06	18.46	544.35	534.95	Beech Creek (breccia zone	9.77	543.64	9.55	543.86
03-12	11/4/1982	487765.38	596231.91	554.99	558.24	15.45	24.85	542.79	533.39	Beech Creek (breccia zone	16.55	541.69	16.44	541.80
03-13	11/5/1982	487633.96	596376.32	549.24	552.26	15.02	24.42	537.24	527.84	Beech Creek (breccia zone	12.95	539.31	13.04	539.22
03-14	11/6/1982	487672.86	596420.54	549.37	552.41	8.24	17.74	544.17	534.67	Beech Creek (breccia zone	11.57	540.84	11.48	540.93
03-15	11/22/1982	487874.92	596346.66	556.09	559.31	18.92	28.32	540.39	530.99	Breccia zone and Beech Creek+K158	17.98	541.33	17.95	541.36
03-16	11/23/1982	488566.76	595786.62	568.61	571.70	26.29	35.69	545.41	536.01	Beech Creek (breccia zone	29.14	542.56	29.19	542.51
03-17	11/24/1982	487650.31	596264.68	550.44	553.47	15.33	24.73	538.14	528.74	Beech Creek (breccia zone	16.18	537.29	16.25	537.22
03-18	1/14/1983	487508.18	596288.23	549.80	553.12	17.92	27.22	535.20	525.90	Beech Creek (breccia zone	17.71	535.41	17.75	535.37

TABLE 1-3

PHYSICAL CHARACTERISTICS OF MONITORING WELLS AND WATER LEVEL MEASUREMENTS
OLD JEEP TRAIL/LITTLE SULPHUR CREEK FOR JUNE 2002 AND APRIL 2004
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Monitoring Well Number	Date Installed	Horizontal Location		Ground Surface Elevation* (feet amsl)	Top of Riser or Measuring Reference Point Elevation* (feet amsl)	Well Screen Interval		Well Screen Interval		Monitored Unit	Ground Water Depth & Elevation		Ground Water Depth & Elevation	
											June 2002		April 2004	
		North Coord. (feet N/AD 27)	East Coord. (feet N/AD 27)			Depth to Top (feet btor)	Depth to Bottom (feet btor)	Elevation* of Top (feet amsl)	Elevation* of Bottom (feet amsl)		Depth to Water (feet btor)	Groundwater Elevation*(1) (feet amsl)	Depth to Water (feet btor)	Ground Water Elevation*(1) (feet amsl)
03-19	1/15/1983	N/A	N/A	556.37	559.37	23.10	32.50	536.27	526.87	Beech Creek (breccia zone	N/A	N/A	N/A	N/A
03-20	1/17/1983	487674.48	596119.27	551.83	554.76	17.33	26.63	537.43	528.13	Beech Creek (breccia zone	18.28	536.48	17.80	536.96
03-21	1/27/1983	488039.00	596246.09	557.12	560.11	15.79	25.09	544.32	535.02	Beech Creek	18.92	541.19	18.95	541.16
03-22	1/27/1983	487791.08	596369.15	555.72	558.68	17.46	26.86	541.22	531.82	Beech Creek (breccia zone	16.58	542.10	16.51	542.17
03-23	1/28/1983	487958.48	596055.94	559.34	562.49	18.05	26.45	544.44	536.04	reccia zone and Beech Cre	18.10	544.39	11.71	550.78
03-24	2/6/1983	488012.65	596461.97	586.04	589.28	45.24	54.64	544.04	534.64	Beech Creek	49.34	539.94	N/A	N/A
03-25	2/7/1983	487901.68	596498.01	570.64	573.97	27.53	36.83	546.44	537.14	Beech Creek	32.80	541.17	9.84	564.13
03-26	10/1/1983	N/A	N/A	592.89	595.89	38.90	48.00	556.99	547.89	Big Clifty	N/A	N/A	N/A	N/A
03-27	10/3/1983	489964.00	593967.00	596.08	599.08	21.50	30.60	577.58	568.48	Big Clifty	N/A	N/A	N/A	N/A
03-28	10/6/1983	489705.00	594006.00	624.49	627.49	15.50	24.60	611.99	602.89	Hardinsburg/Gol	11.16	616.33	9.34	618.15
03-29	10/8/1983	489992.00	593981.00	595.61	598.61	39.60	48.60	559.01	550.01	Big Clifty	N/A	N/A	N/A	N/A
03-30	10/4/1985	490818.00	593630.00	N/A	608.60	N/A	N/A	N/A	N/A	Big Clifty	50.15	558.45	55.06	553.54
03-31	10/10/1985	489788.00	594804.00	N/A	582.84	N/A	N/A	N/A	N/A	Big Clifty	37.73	545.11	37.70	545.14
03-32	10/11/1985	489857.00	594822.00	N/A	583.54	N/A	N/A	N/A	N/A	Big Clifty	N/A	N/A	N/A	N/A
03-33	10/13/1985	489923.00	594836.00	N/A	583.39	N/A	N/A	N/A	N/A	Big Clifty	36.67	546.72	36.66	546.73
03-34	10/21/1985	489844.00	594662.00	N/A	585.06	N/A	N/A	N/A	N/A	Big Clifty	N/A	N/A	N/A	N/A
03-35	10/23/1985	489830.00	594561.00	N/A	586.60	N/A	N/A	N/A	N/A	Beech Creek	N/A	N/A	N/A	N/A
03-36	10/25/1985	489691.00	594603.00	N/A	617.54	N/A	N/A	N/A	N/A	Beech Creek	N/A	N/A	N/A	N/A
03-37	10/27/1985	489890.00	594618.00	N/A	586.52	N/A	N/A	N/A	N/A	Beech Creek	N/A	N/A	N/A	N/A
03-38	11/2/1985	490676.00	593744.00	N/A	604.79	N/A	N/A	N/A	N/A	Big Clifty	46.25	558.54	46.60	558.19
03-39	11/2/1985	490700.00	593792.00	N/A	603.25	N/A	N/A	N/A	N/A	Big Clifty	44.36	558.89	44.70	558.55
03SG01	6/9/2001	490124.27	594313.10	N/A	587.20	N/A	N/A	N/A	N/A	N/A	2.80	584.40	2.49	584.71
03SG02	6/9/2001	488570.67	595726.88	555.50	561.84	N/A	N/A	N/A	N/A	N/A	Dry	Dry	Dry	N/A
03SG03	6/9/2001	487330.50	596436.67	541.07	547.42	N/A	N/A	N/A	N/A	N/A	Dry	Dry	Dry	N/A
03SG04	6/9/2001	485646.58	596328.42	525.94	533.32	N/A	N/A	N/A	N/A	N/A	Dry	Dry	Dry	N/A
03SG05	6/9/2001	484740.20	596109.74	N/A	525.05	N/A	N/A	N/A	N/A	N/A	6.93	518.12	6.52	518.53
03SG06	6/9/2001	483694.26	595518.08	N/A	513.57	N/A	N/A	N/A	N/A	N/A	6.30	507.27	6.00	507.57
03SG07	6/9/2001	482632.16	595545.26	N/A	499.95	N/A	N/A	N/A	N/A	N/A	1.04	498.91	N/A	N/A

amsl = Above mean sea level.
N/A = Not available or not applicable because well was abandoned or damaged.
btor = Below top of riser.
1 = Ground water elevation estimated due to well riser damage.
* All elevations are based on National Geodetic Vertical Datum of 1929 (NGVD 29).

TABLE 1-4

GROUND WATER ELEVATIONS MEASURED IN 1994 AND 2001 IN MONITORING WELLS
LOCATED IN THE OLD JEEP TRAIL AREA
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Monitoring Well Number	Groundwater Depth & Elevation September 1994		Groundwater Depth & Elevation June 2001		Groundwater Depth & Elevation September 2001		Groundwater Depth & Elevation April 2004	
	Depth to Water (feet btor)	Groundwater Elevation (feet amsl)	Depth to Water (feet btor)	Groundwater Elevation (feet amsl)	Depth to Water (feet bor)	Groundwater Elevation (feet amsl)	Depth to Water (feet bor)	Groundwater Elevation (feet amsl)
03-07	13.36	542.72	11.62	544.46	15.02	3049047.90	11.70	544.78
03-10	17.00	540.59	16.63	540.96	17.00	3049246.32	16.79	528.60
03-11	11.80	541.21	9.81	543.20	13.04	3049169.04	9.55	537.76
03-12	17.45	540.39	16.85	540.99	17.53	3048961.86	16.44	529.20
03-13	13.46	538.40	13.01	538.85	13.53	3049110.28	13.04	526.82
03-14	12.42	539.59	11.58	540.43	13.58	3049154.45	11.48	535.33
03-15	18.46	540.45	17.98	540.93	18.46	3049075.69	17.95	525.26
03-16	29.67	541.63	29.29	542.01	29.47	3048504.62	29.19	518.91
03-17	16.45	536.62	16.22	536.85	16.98	3048995.18	16.25	524.52
03-18	17.98	534.74	17.73	534.99	18.15	3049017.56	17.75	520.37
03-19	NF	NF	NF	NF	NF	NF	N/A	N/A
03-20	19.20	535.56	18.00	536.76	19.00	3048847.76	17.80	522.56
03-21	19.08	540.63	18.90	540.81	19.14	3048974.43	18.95	527.96
03-22	17.61	540.67	16.58	541.70	17.41	3049099.23	16.51	527.27
03-23	18.30	543.79	17.50	544.59	19.47	3048783.95	11.71	535.48
03-24	49.32	539.56	49.35	539.53	49.36	3049160.09	N/A	N/A
03-25	33.06	540.51	33.00	540.57	33.04	3049212.45	9.84	539.53

NF = Not found, presumed to be destroyed.
N/A = Not available or not applicable because well was abandoned or damaged.
amsl = Above mean sea level.
btor = Below top of riser.
Survey coordinates for all wells except 03-19 were taken from the TtNUS survey performed in 2001.
Vertical elevations are based on National Geodetic Vertical Datum of 1929 (NGVD 29).

TABLE 1-5

SUMMARY OF SOIL BORING SAMPLES AND LABORATORY ANALYSES - SURFACE/SUBSURFACE SOILS
MAIN TREATMENT AREA
SWMU 3 - AMMUNITION BURNING GROUNDS
CORRECTIVE MEASURES STUDY APRIL 2004
NSWC CRANE
CRANE, INDIANA

Soil Boring Group(1)	Boring Location	Sample Number(2,3)	VOCs(4)	Explosives(4)	RDX Degradation Products(4)	Target Analyte List Metals(4)	Perchlorate	Total Organic Carbon	pH	Cation Exchange Capacity
OJT	03SB049	03SS0490002	-	S	S	S	S	-	-	-
OJT	03SB049	03SB0490206	-	S	S	S	S	-	-	-
OJT	03SB049	03SB0490610	S	S	S	S	S	-	-	-
OJT	03SB049	03SB0491014	S	S	S	S	S	-	-	-
OJT	03SB050	03SS0500002	-	S	-	S	-	-	-	-
OJT	03SB050	03SB0500206	-	S	-	S	-	-	-	-
OJT	03SB050	03SB0500610	S	S	-	S	-	-	-	-
OJT	03SB050	03SB0501014	S	S	-	S	-	-	-	-
OJT	03SB051	03SS0510002	-	S	S	S	S	-	-	-
OJT	03SB051	03SB0510206	-	S	S	S	S	-	-	-
OJT	03SB051	03SB0510610	S	S	S	S	S	-	-	-
OJT	03SB051	03SB051xxxx	O	O	O	O	O	-	-	-
OJT	03SB052	03SS0520002	-	S	-	S	-	-	-	-
OJT	03SB052	03SB0520206	-	S	-	S	-	-	-	-
OJT	03SB052	03SB0520610	S	S	-	S	-	-	-	-
OJT	03SB052	03SB0521014	S	S	-	S	-	-	-	-
A	03SB053	03SS0530002	-	S	S	S	S	-	-	-
A	03SB053	03SB0530206	-	S	S	S	S	-	-	-
A	03SB053	03SB0530610	O	O	O	O	O	-	-	-
A	03SB053	03SB053xxxx	O	O	O	O	O	-	-	-
B	03SB054	03SS0540002	-	S	-	S	-	-	-	-
B	03SB054	03SB0540206	E	S	-	S	-	-	-	-
B	03SB054	03SB0540610	O	O	-	O	-	-	-	-
B	03SB054	03SB054xxxx	O	O	-	O	-	-	-	-
B	03SB055	03SS0550002	-	O	O	-	O	-	-	-
B	03SB055	03SB0550206	-	O	O	-	O	-	-	-
B	03SB055	03SB0550610	O	O	O	-	O	-	-	-
B	03SB055	03SB055xxxx	O	O	O	-	O	-	-	-
B	03SB056	03SS0560002	-	S	-	S	-	-	-	-
B	03SB056	03SB0560206	-	O	-	O	-	-	-	-
B	03SB056	03SB0560610	O	O	-	O	-	-	-	-
B	03SB056	03SB056xxxx	O	O	-	O	-	-	-	-
B	03SB057	03SS0570002	-	S	-	-	-	-	-	-
B	03SB057	03SB0570206	-	S	-	-	-	-	-	-
B	03SB057	03SB0570610	O	O	-	-	-	-	-	-
B	03SB057	03SB057xxxx	O	O	-	-	-	-	-	-
B	03SB058	03SS0580002	-	S	-	S	-	-	-	-
B	03SB058	03SB0580206	-	S	-	S	-	-	-	-
B	03SB058	03SB0580610	S	S	-	S	-	-	-	-

TABLE 1-5

SUMMARY OF SOIL BORING SAMPLES AND LABORATORY ANALYSES - SURFACE/SUBSURFACE SOILS
MAIN TREATMENT AREA
SWMU 3 - AMMUNITION BURNING GROUNDS
CORRECTIVE MEASURES STUDY APRIL 2004
NSWC CRANE
CRANE, INDIANA

Soil Boring Group[1]	Boring Location	Sample Number[2,3]	VOCs[4]	Explosives[4]	RDX Degradation Products[4]	Target Analyte List Metals[4]	Perchlorate	Total Organic Carbon	pH	Cation Exchange Capacity
B	03SB058	03SB0581012	S	S	-	S	-	-	-	-
B	03SB059	03SS0590002	-	S	S	-	S	-	-	-
B	03SB059	03SB0590206	-	S	S	-	S	-	-	-
B	03SB059	03SB0590610	O	O	O	-	O	-	-	-
B	03SB059	03SB059xxxx	O	O	O	-	O	-	-	-
B	03SB060	03SS0600002	-	S	-	S	-	-	-	-
B	03SB060	03SB0600206	-	S	-	S	-	-	-	-
B	03SB060	03SB0600610	S	S	-	S	-	-	-	-
B	03SB060	03SB0601014	S	S	-	S	-	-	-	-
B	03SB061	03SS0610002	-	S	S	-	S	-	-	-
B	03SB061	03SB0610206	E	S	S	-	S	-	-	-
B	03SB061	03SB0610610	S	S	S	-	S	-	-	-
B	03SB061	03SB061xxxx	O	O	O	-	O	-	-	-
B	03SB062	03SS0620002	-	O	-	O	-	-	-	-
B	03SB062	03SB0620206	-	O	-	O	-	-	-	-
B	03SB062	03SB0620610	O	O	-	O	-	-	-	-
B	03SB062	03SB062xxxx	O	O	-	O	-	-	-	-
B	03SB063	03SS0630002	-	S	-	-	-	-	-	-
B	03SB063	03SB0630206	-	S	-	-	-	-	-	-
B	03SB063	03SB0630610	S	S	-	-	-	-	-	-
B	03SB063	03SB0631014	S	S	-	-	-	-	-	-
B	03SB064	03SS0640002	-	S	-	S	-	-	-	-
B	03SB064	03SB0640206	-	S	-	S	-	-	-	-
B	03SB064	03SB0640610	O	O	-	O	-	-	-	-
B	03SB064	03SB064xxxx	O	O	-	O	-	-	-	-
B	03SB065	03SS0650002	-	S	S	-	S	-	-	-
B	03SB065	03SB0650206	-	S	S	-	S	-	-	-
B	03SB065	03SB0650610	S	S	S	-	S	-	-	-
B	03SB065	03SB0651014	S	S	S	-	S	-	-	-
C	03SB066	03SS0660002		S	-	S	-	-	-	-
C	03SB066	03SB0660206		S	-	S	-	-	-	-
C	03SB066	03SB0660610	S	S	-	S	-	-	-	-
C	03SB066	03SB0661014	S	S	-	S	-	-	-	-
C	03SB067	03SS0670002	-	S	S	-	S	-	-	-
C	03SB067	03SB0670206	-	S	S	-	S	-	-	-
C	03SB067	03SB0670610	S	S	S	-	S	-	-	-
C	03SB067	03SB0671012	S	S	S	-	S	-	-	-
C	03SB068	03SS0680002	-	S	-	S	-	-	-	-
C	03SB068	03SB0680206	-	S	-	S	-	-	-	-

TABLE 1-5

SUMMARY OF SOIL BORING SAMPLES AND LABORATORY ANALYSES - SURFACE/SUBSURFACE SOILS
MAIN TREATMENT AREA
SWMU 3 - AMMUNITION BURNING GROUNDS
CORRECTIVE MEASURES STUDY APRIL 2004
NSWC CRANE
CRANE, INDIANA

Soil Boring Group[1]	Boring Location	Sample Number[2,3]	VOCs[4]	Explosives[4]	RDX Degradation Products[4]	Target Analyte List Metals[4]	Perchlorate	Total Organic Carbon	pH	Cation Exchange Capacity
C	03SB068	03SB0680610	S	S	-	S	-	-	-	-
C	03SB068	03SB0681013	S	S	-	S	-	-	-	-
D	03SB069	03SS0690002	-	S	-	-	-	-	-	-
D	03SB069	03SB0690206	-	S	-	-	-	-	-	-
D	03SB069	03SB0690610	S	S	-	-	-	-	-	-
D	03SB069	03SB069xxxx	O	O	-	-	-	-	-	-
D	03SB070	03SS0700002	-	S	-	S	-	-	-	-
D	03SB070	03SB0700206	-	S	-	S	-	-	-	-
D	03SB070	03SB0700610	S	S	-	S	-	-	-	-
D	03SB070	03SB0701012	S	S	-	S	-	-	-	-
D	03SB071	03SS0710002	-	S	S	-	S	-	-	-
D	03SB071	03SB0710206	-	S	S	-	S	-	-	-
D	03SB071	03SB0710610	O	O	O	-	O	-	-	-
D	03SB071	03SB071xxxx	O	O	O	-	O	-	-	-
D	03SB072	03SS0720002	-	S	-	S	-	-	-	-
D	03SB072	03SB0720206	-	S	-	S	-	-	-	-
D	03SB072	03SB0720610	S	S	-	S	-	-	-	-
D	03SB072	03SB072xxxx	O	O	-	O	-	-	-	-
D	03SB073	03SS0730002	-	S	S	-	S	-	-	-
D	03SB073	03SB0730206	-	S	S	-	S	-	-	-
D	03SB073	03SB0730610	S	S	S	-	S	-	-	-
D	03SB073	03SB0731013	S	S	S	-	S	-	-	-
D	03SB074	03SS0740002	-	S	-	S	-	-	-	-
D	03SB074	03SB0740206	-	S	-	S	-	-	-	-
D	03SB074	03SB0740610	S	S	-	S	-	-	-	-
D	03SB074	03SB0741014	S	S	-	S	-	-	-	-
D	03SB075	03SS0750002	-	S	-	-	-	-	-	-
D	03SB075	03SB0750206	-	S	-	-	-	-	-	-
D	03SB075	03SB0750610	S	S	-	-	-	-	-	-
D	03SB075	03SB075xxxx	O	O	-	-	-	-	-	-
E	03SB076	03SS0760002	-	S	-	S	-	-	-	-
E	03SB076	03SB0760206	-	S	-	S	-	-	-	-
E	03SB076	03SB0760610	S	S	-	S	-	-	-	-
E	03SB076	03SB0761014	S	S	-	S	-	-	-	-
E	03SB077	03SS0770002	-	S	S	-	S	-	-	-
E	03SB077	03SB0770206	-	S	S	-	S	-	-	-
E	03SB077	03SB0770610	S	S	S	-	S	-	-	-
E	03SB077	03SB077xxxx	O	O	O	-	O	-	-	-
E	03SB078	03SS0780002	-	S	-	S	-	S	S	S

TABLE 1-5

SUMMARY OF SOIL BORING SAMPLES AND LABORATORY ANALYSES - SURFACE/SUBSURFACE SOILS
MAIN TREATMENT AREA
SWMU 3 - AMMUNITION BURNING GROUNDS
CORRECTIVE MEASURES STUDY APRIL 2004
NSWC CRANE
CRANE, INDIANA

Soil Boring Group[1]	Boring Location	Sample Number[2,3]	VOCs[4]	Explosives[4]	RDX Degradation Products[4]	Target Analyte List Metals[4]	Perchlorate	Total Organic Carbon	pH	Cation Exchange Capacity
E	03SB078	03SB0780206	-	S	-	S	-	S	S	S
E	03SB078	03SB0780610	S	S	-	S	-	S	S	S
E	03SB078	03SB078xxxx	O	O	-	O	-	O	O	O
F	03SB079	03SS0790002	-	S	S	-	S	-	-	-
F	03SB079	03SB0790206	-	S	S	-	S	-	-	-
F	03SB079	03SB0790610	S	S	S	-	S	-	-	-
F	03SB079	03SB0791012	S	S	S	-	S	-	-	-
F	03SB080	03SS0800002	-	S	-	S	-	-	-	-
F	03SB080	03SB0800206	-	S	-	S	-	-	-	-
F	03SB080	03SB0800610	S	S	-	S	-	-	-	-
F	03SB080	03SB0801013	S	S	-	S	-	-	-	-
F	03SB081	03SS0810002	-	S	-	-	-	-	-	-
F	03SB081	03SB0810206	-	S	-	-	-	-	-	-
F	03SB081	03SB0810610	S	S	-	-	-	-	-	-
F	03SB081	03SB081xxxx	O	O	-	-	-	-	-	-
F	03SB082	03SS0820002	-	S	-	S	-	-	-	-
F	03SB082	03SB0820206	-	S	-	S	-	-	-	-
F	03SB082	03SB0820610	S	S	-	S	-	-	-	-
F	03SB082	03SB0821013	S	S	-	S	-	-	-	-
F	03SB083	03SS0830002	-	S	S	-	S	-	-	-
F	03SB083	03SB0830206	-	S	S	-	S	-	-	-
F	03SB083	03SB0830610	S	S	S	-	S	-	-	-
F	03SB083	03SB083xxxx	O	O	O	-	O	-	-	-
F	03SB084	03SS0840002	-	S	-	S	-	-	-	-
F	03SB084	03SB0840206	-	S	-	S	-	-	-	-
F	03SB084	03SB0840610	S	S	-	S	-	-	-	-
F	03SB084	03SB084xxxx	O	O	-	O	-	-	-	-
F	03SB085	03SS0850002	-	S	-	-	-	-	-	-
F	03SB085	03SB0850206	-	S	-	-	-	-	-	-
F	03SB085	03SB0850610	S	S	-	-	-	-	-	-
F	03SB085	03SB0851013	S	S	-	-	-	-	-	-
F	03SB086	03SS0860002	-	S	-	S	-	-	-	-
F	03SB086	03SB0860206	-	S	-	S	-	-	-	-
F	03SB086	03SB0860610	S	S	-	S	-	-	-	-
F	03SB086	03SB0861014	S	S	-	S	-	-	-	-
F	03SB087	03SS0870002	-	S	S	-	S	-	-	-
F	03SB087	03SB0870206	-	S	S	-	S	-	-	-
F	03SB087	03SB0870610	S	S	S	-	S	-	-	-
F	03SB087	03SB0871013	S	S	S	-	S	-	-	-

TABLE 1-5

SUMMARY OF SOIL BORING SAMPLES AND LABORATORY ANALYSES - SURFACE/SUBSURFACE SOILS
MAIN TREATMENT AREA
SWMU 3 - AMMUNITION BURNING GROUNDS
CORRECTIVE MEASURES STUDY APRIL 2004
NSWC CRANE
CRANE, INDIANA

Soil Boring Group[1]	Boring Location	Sample Number[2,3]	VOCs[4]	Explosives[4]	RDX Degradation Products[4]	Target Analyte List Metals[4]	Perchlorate	Total Organic Carbon	pH	Cation Exchange Capacity
G	03SB088	03SS0880002	-	S	-	S	-	-	-	-
G	03SB088	03SB0880206	-	S	-	S	-	-	-	-
G	03SB088	03SB0880610	O	O	-	O	-	-	-	-
G	03SB088	03SB088xxxx	O	O	-	O	-	-	-	-
G	03SB089	03SS0890002	-	S	S	-	S	-	-	-
G	03SB089	03SB0890206	-	S	S	-	S	-	-	-
G	03SB089	03SB0890610	O	O	O	-	O	-	-	-
G	03SB089	03SB089xxxx	O	O	O	-	O	-	-	-
G	03SB090	03SS0900002	-	S	-	S	-	-	-	-
G	03SB090	03SB0900206	-	S	-	S	-	-	-	-
G	03SB090	03SB0900610	S	S	-	S	-	-	-	-
G	03SB090	03SB090xxxx	O	O	-	O	-	-	-	-
H	03SB091	03SS0910002	-	S	S	-	S	-	-	-
H	03SB091	03SB0910206	-	S	S	-	S	-	-	-
H	03SB091	03SB0910610	S	S	S	-	S	-	-	-
H	03SB091	03SB091xxxx	O	O	O	-	O	-	-	-
H	03SB092	03SS0920002	-	S	-	S	-	-	-	-
H	03SB092	03SB0920206	-	S	-	S	-	-	-	-
H	03SB092	03SB0920610	S	S	-	S	-	-	-	-
H	03SB092	03SB092xxxx	O	O	-	O	-	-	-	-
H	03SB093	03SS0930002	-	S	-	-	-	-	-	-
H	03SB093	03SB0930206	-	S	-	-	-	-	-	-
H	03SB093	03SB0930610	S	S	-	-	-	-	-	-
H	03SB093	03SB0931014	S	S	-	-	-	-	-	-
H	03SB094	03SS0940002	-	S	-	S	-	-	-	-
H	03SB094	03SB0940206	-	S	-	S	-	-	-	-
H	03SB094	03SB0940610	S	S	-	S	-	-	-	-
H	03SB094	03SB094xxxx	O	O	-	O	-	-	-	-
H	03SB095	03SS0950002	-	S	S	-	S	-	-	-
H	03SB095	03SB0950206	-	S	S	-	S	-	-	-
H	03SB095	03SB0950610	S	S	S	-	S	-	-	-
H	03SB095	03SB095xxxx	O	O	O	-	O	-	-	-
H	03SB096	03SS0960002	-	S	-	S	-	-	-	-
H	03SB096	03SB0960206	-	S	-	S	-	-	-	-
H	03SB096	03SB0960610	S	S	-	S	-	-	-	-
H	03SB096	03SB096xxxx	O	O	-	O	-	-	-	-
H	03SB097	03SS0970002	-	S	S	-	S	-	-	-
H	03SB097	03SB0970206	-	S	S	-	S	-	-	-
H	03SB097	03SB0970610	S	S	S	-	S	-	-	-

TABLE 1-5

SUMMARY OF SOIL BORING SAMPLES AND LABORATORY ANALYSES - SURFACE/SUBSURFACE SOILS
MAIN TREATMENT AREA
SWMU 3 - AMMUNITION BURNING GROUNDS
CORRECTIVE MEASURES STUDY APRIL 2004
NSWC CRANE
CRANE, INDIANA

Soil Boring Group[1]	Boring Location	Sample Number[2,3]	VOCs[4]	Explosives[4]	RDX Degradation Products[4]	Target Analyte List Metals[4]	Perchlorate	Total Organic Carbon	pH	Cation Exchange Capacity
H	03SB097	03SB097xxxx	O	O	O	-	O	-	-	-
H	03SB098	03SS0980002	-	S	-	S	-	-	-	-
H	03SB098	03SB0980206	-	S	-	S	-	-	-	-
H	03SB098	03SB0980610	S	S	-	S	-	-	-	-
H	03SB098	03SB098xxxx	O	O	-	O	-	-	-	-
H	03SB099	03SS0990002	-	S	-	-	-	-	-	-
H	03SB099	03SB0990206	-	S	-	-	-	-	-	-
H	03SB099	03SB0990610	S	S	-	-	-	-	-	-
H	03SB099	03SB099xxxx	O	O	-	-	-	-	-	-
I	03SB100	03SS1000002	-	S	-	S	-	-	-	-
I	03SB100	03SB1000206	-	S	-	S	-	-	-	-
I	03SB100	03SB1000610	S	S	-	S	-	-	-	-
I	03SB100	03SB1001014	S	S	-	S	-	-	-	-
I	03SB101	03SS1010002	-	S	S	S	S	-	-	-
I	03SB101	03SB1010206	-	S	S	S	S	-	-	-
I	03SB101	03SB1010610	S	S	S	S	S	-	-	-
I	03SB101	03SB1011014	S	S	S	S	S	-	-	-
I	03SB102	03SS1020002	-	S	-	-	-	-	-	-
I	03SB102	03SB1020206	-	S	-	-	-	-	-	-
I	03SB102	03SB1020610	S	S	-	-	-	-	-	-
I	03SB102	03SB1021013	S	S	-	-	-	-	-	-
I	03SB103	03SS1030002	-	S	S	S	S	-	-	-
I	03SB103	03SB1030206	-	S	S	S	S	-	-	-
I	03SB103	03SB1030610	S	S	S	S	S	-	-	-
I	03SB103	03SB1031011	S	O	O	O	O	-	-	-
J	03SB104	03SS1040002	-	S	-	-	-	-	-	-
J	03SB104	03SB1040206	-	S	-	-	-	-	-	-
J	03SB104	03SB1040610	S	S	-	-	-	-	-	-
J	03SB104	03SB1041014	S	S	-	-	-	-	-	-
MISC	03SB105	03SS1050002	-	S	S	S	S	-	-	-
MISC	03SB105	03SB1050206	-	S	S	S	S	-	-	-
MISC	03SB105	03SB1050610	S	S	S	S	S	-	-	-
MISC	03SB105	03SB1051012	S	S	S	S	S	-	-	-
MISC	03SB106	03SS1060002	-	S	-	-	-	-	-	-
MISC	03SB106	03SB1060206	-	S	-	-	-	-	-	-
MISC	03SB106	03SB1060610	S	S	-	-	-	-	-	-
MISC	03SB106	03SB1061014	S	S	-	-	-	-	-	-
MISC	03SB107	03SS1070002	-	S	S	-	S	-	-	-
MISC	03SB107	03SB1070206	-	S	S	-	S	-	-	-

TABLE 1-5

SUMMARY OF SOIL BORING SAMPLES AND LABORATORY ANALYSES - SURFACE/SUBSURFACE SOILS
MAIN TREATMENT AREA
SWMU 3 - AMMUNITION BURNING GROUNDS
CORRECTIVE MEASURES STUDY APRIL 2004
NSWC CRANE
CRANE, INDIANA

Soil Boring Group[1]	Boring Location	Sample Number[2,3]	VOCs[4]	Explosives[4]	RDX Degradation Products[4]	Target Analyte List Metals[4]	Perchlorate	Total Organic Carbon	pH	Cation Exchange Capacity
MISC	03SB107	03SB1070610	S	S	S	-	S	-	-	-
MISC	03SB107	03SB1071014	S	S	S	-	S	-	-	-
MISC	03SB108	03SS1080002	E	S	-	S	-	-	-	-
MISC	03SB108	03SB1080206	-	S	-	S	-	-	-	-
MISC	03SB108	03SB1080610	S	S	-	S	-	-	-	-
MISC	03SB108	03SB1081014	S	S	-	S	-	-	-	-
MISC	03SB109	03SS1090002	-	S	-	-	-	-	-	-
MISC	03SB109	03SB1090206	-	S	-	-	-	-	-	-
MISC	03SB109	03SB1090610	S	S	-	-	-	-	-	-
MISC	03SB109	03SB1091013	S	S	-	-	-	-	-	-
MISC	03SB110	03SS1100002	-	S	-	S	-	-	-	-
MISC	03SB110	03SB1100206	-	S	-	S	-	-	-	-
MISC	03SB110	03SB1100610	S	S	-	S	-	-	-	-
MISC	03SB110	03SB1101013	S	S	-	S	-	-	-	-
MISC	03SB111	03SS1110002	-	S	S	-	S	-	-	-
MISC	03SB111	03SB1110206	-	S	S	-	S	-	-	-
MISC	03SB111	03SB1110610	S	S	S	-	S	-	-	-
MISC	03SB111	03SB111xxxx	O	O	O	-	O	-	-	-
MISC	03SB112	03SS1120002	-	S	-	S	-	-	-	-
MISC	03SB112	03SB1120206	-	S	-	S	-	-	-	-
MISC	03SB112	03SB1120610	S	S	-	S	-	-	-	-
MISC	03SB112	03SB112xxxx	O	O	-	O	-	-	-	-
MISC	03SB113	03SS1130002	-	S	S	-	S	-	-	-
MISC	03SB113	03SB1130206	-	S	S	-	S	-	-	-
MISC	03SB113	03SB1130610	O	O	O	-	O	-	-	-
MISC	03SB113	03SB113xxxx	O	O	O	-	O	-	-	-
MISC	03SB114	03SS1140002	-	S	-	S	-	-	-	-
MISC	03SB114	03SB1140206	-	S	-	S	-	-	-	-
MISC	03SB114	03SB1140610	S	S	-	S	-	-	-	-
MISC	03SB114	03SB114xxxx	O	O	-	O	-	-	-	-
MISC	03SB115	03SS1150002	-	S	-	-	-	-	-	-
MISC	03SB115	03SB1150206	-	S	-	-	-	-	-	-
MISC	03SB115	03SB1150610	S	S	-	-	-	-	-	-
MISC	03SB115	03SB115xxxx	O	O	-	-	-	-	-	-
MISC	03SB116	03SB1160002	-	S	-	S	-	S	S	S
MISC	03SB116	03SB1160206	-	S	-	S	-	S	S	S
MISC	03SB116	03SB1160610	S	S	-	S	-	S	S	S
MISC	03SB116	03SB116xxxx	O	O	-	O	-	O	O	O
MISC	03SB117	03SS1170002	-	S	S	-	S	-	-	-

TABLE 1-5

SUMMARY OF SOIL BORING SAMPLES AND LABORATORY ANALYSES - SURFACE/SUBSURFACE SOILS
MAIN TREATMENT AREA
SWMU 3 - AMMUNITION BURNING GROUNDS
CORRECTIVE MEASURES STUDY APRIL 2004
NSWC CRANE
CRANE, INDIANA

Soil Boring Group[1]	Boring Location	Sample Number[2,3]	VOCs[4]	Explosives[4]	RDX Degradation Products[4]	Target Analyte List Metals[4]	Perchlorate	Total Organic Carbon	pH	Cation Exchange Capacity
MISC	03SB117	03SB1170206	-	S	S	-	S	-	-	-
MISC	03SB117	03SB1170610	S	S	S	-	S	-	-	-
MISC	03SB117	03SB1171013	S	S	S	-	S	-	-	-
MISC	03SB118	03SS1180002	-	S	-	S	-	-	-	-
MISC	03SB118	03SB1180206	-	S	-	S	-	-	-	-
MISC	03SB118	03SB1180610	S	S	-	S	-	-	-	-
MISC	03SB118	03SB1181012	S	S	-	S	-	-	-	-
MISC	03SB119	03SS1190002	-	S	-	-	-	-	-	-
MISC	03SB119	03SB1190206	-	S	-	-	-	-	-	-
MISC	03SB119	03SB1190610	S	S	-	-	-	-	-	-
MISC	03SB119	03SB1191014	S	S	-	-	-	-	-	-
MISC	03SB120	03SS1200002	-	S	S	S	S	-	-	-
MISC	03SB120	03SB1200206	-	S	S	S	S	-	-	-
MISC	03SB120	03SB1200610	S	S	S	S	S	-	-	-
MISC	03SB120	03SB1201012	S	S	S	S	S	-	-	-
MISC	03SB121	03SS1210002	-	S	-	S	-	-	-	-
MISC	03SB121	03SB1210206	-	S	-	S	-	-	-	-
MISC	03SB121	03SB1210610	S	S	-	S	-	-	-	-
MISC	03SB121	03SB1211013	S	S	-	S	-	-	-	-

VOC Volatile organic compound.
MISC Miscellaneous.
S Sample collected as proposed in the approved QAPP Addendum No. 1 (TtNUS, 2004).
O Sample NOT collected as proposed in the approved QAPP Addendum No. 1 (TtNUS, 2004) (See Table 2-3).
E Sample collected due to elevated PID readings in soil core.

1 Soil Boring Groups correspond to Groups given in Figure 3-1. "OJT" indicates borings located at the OJT; "MISC" indicates borings located in the spaces between soil boring groups on Figure 3-1.
2 Sample numbers ending with "xxxx" were not collected as proposed in the QAPP Addendum No. 1 due to steep slope conditions or refusal.
3 For sample numbers ending in 0002 or 0206 VOC samples were collected at the highest PID reading if a reading higher than background was obtained. See Section 3.5.1 of the QAPP Addendum No. 1.
4 See Table 1-3 of the QAPP Addendum No. 1 for specific analysis requirements and analyte list.

TABLE1-6

SUMMARY OF DESCRIPTIVE STATISTICS
MAIN TREATMENT AREA - SURFACE SOIL
2004 SAMPLING EVENT
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Hits	Sample of Maximum Detect
Volatile Organics (µg/kg)							
2-BUTANONE	1/1	7 J	7 J	---	7.00	7.00	03SS1080002
ACETONE	1/1	66 J	66 J	---	66.0	66.0	03SS1080002
Energetics (mg/kg)							
1,3,5-TRINITROBENZENE	4/67	0.27 J	14	0.25	0.351	3.91	03SS1200002
2,4,6-TRINITROTOLUENE	6/67	0.72	400	0.25	6.83	75.0	03SS1200002
2,4-DINITROTOLUENE	3/67	0.31 J	0.57	0.25	0.139	0.427	03SS1190002
2,6-DIAMINO-4-NITROTOLUENE	1/23	0.47 J	0.47 J	0.25	0.140	0.470	03SS1200002
2-AMINO-4,6-DINITROTOLUENE	5/67	0.38 J	12	0.25	0.337	2.96	03SS1200002
3,5-DINITROANILINE	1/23	1.1	1.1	0.25	0.167	1.10	03SS1200002
4,4'-TN-AZOXY	1/23	0.61 J	0.61 J	0.5	0.266	0.610	03SS1200002
4-AMINO-2,6-DINITROTOLUENE	5/67	0.27 J	10	0.25	0.308	2.58	03SS1200002
HMX	19/67	0.29 J	1100	0.25	23.3	81.7	03SS1200002
MNX	1/23	0.62 J	0.62 J	0.25	0.147	0.620	03SS1200002
RDX	5/67	0.29 J	660	0.25	10.5	139	03SS1200002
Inorganics (mg/kg)							
ALUMINUM	35/35	4500	26600	---	9529	9529	03SS1160002
ANTIMONY	19/35	0.34 J	32 J	0.23 - 0.73	2.54	4.51	03SS0880002
ARSENIC	35/35	4.3 J	27.9 J	---	8.69	8.69	03SS1160002
BARIUM	35/35	25.5 J	4120 J	---	415	415	03SS1160002
BERYLLIUM	33/35	0.29 J	1.8	0.57	0.763	0.792	03SS0780002
CADMIUM	20/35	0.22 J	38.5	0.17 - 0.56	2.70	4.63	03SS1200002
CALCIUM	35/35	177 J	78200 J	---	14023	14023	03SS1200002
CHROMIUM	35/35	10.4 J	56.6 J	---	18.2	18.2	03SS1160002
COBALT	35/35	3.6 J	20.6 J	---	11.7	11.7	03SS0700002
COPPER	35/35	5 J	10700 J	---	573	573	03SS1160002
IRON	35/35	10800 J	68900 J	---	25429	25429	03SS1200002
LEAD	35/35	9.8 J	14600 J	---	681	681	03SS1200002
MAGNESIUM	35/35	500 J	11300 J	---	2665	2665	03SS0700002
MANGANESE	35/35	57.1 J	5390 J	---	930	930	03SS1160002
MERCURY	26/35	0.012 J	5.5	0.018 - 0.061	0.257	0.339	03SS1200002
NICKEL	35/35	4.8 J	67.6 J	---	22.0	22.0	03SS1200002
POTASSIUM	35/35	325 J	3080 J	---	1044	1044	03SS1010002
SELENIUM	11/35	0.27 J	0.53 J	0.14 - 0.4	0.199	0.365	03SS1000002
SILVER	9/35	0.11 J	15.7	0.041 - 0.57	0.854	3.18	03SS1160002
SODIUM	19/35	52.4 J	684 J	14 - 67.9	100	170	03SS1120002
THALLIUM	8/35	0.08 J	0.12 J	0.06 - 0.21	0.0701	0.101	03SS0780002, 03SS1030002
TIN	11/35	0.44 J	44.2 J	0.29 - 1.8	3.81	11.3	03SS1160002
VANADIUM	35/35	8.8 J	29.6 J	---	18.0	18.0	03SS0680002
ZINC	34/35	15 J	11100 J	148	703	722	03SS1160002
Miscellaneous Parameters							
CATION EXCHANGE CAPACITY (MEQ/1)	2/2	14	19	---	16.5	16.5	03SS0780002
PERCHLORATE (mg/kg)	5/23	0.07 J	0.3 J	0.042 - 0.054	0.0692	0.234	03SS0590002, 03SS0670002, 03SS0910002
PERCHLORATE-8321 (µg/kg)	2/6	0.53 J	0.69 J	1.1 - 1.2	0.595	0.610	03SS0610002
PH (S.U.)	2/2	7.6	8	---	7.80	7.80	03SS1160002
TOTAL ORGANIC CARBON (mg/kg)	2/2	1700	15000	---	8350	8350	03SS1160002

TABLE 1-7

SUMMARY OF DESCRIPTIVE STATISTICS
MAIN TREATMENT AREA - SUBSURFACE SOIL
2004 SAMPLING EVENT
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detction	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Hits	Sample of Maximum Detect
Volatile Organics (µg/kg)							
1,1,2-TRICHLOROETHANE	3/92	3 J	14 J	0.917 - 2.05	0.895	9.67	03SB0610206
1,1-DICHLOROETHENE	4/92	2 J	7 J	0.917 - 2.05	0.748	4.00	03SB1030610
2-BUTANONE	27/47	3 J	36 J	0.917 - 2.05	5.89	9.78	03SB1021014
4-METHYL-2-PENTANONE	2/92	2 J	10 J	0.917 - 2.05	0.718	6.00	03SB1021014
ACETONE	58/87	4 J	7200 J	0.965 - 37	108	160	03SB1021014
BENZENE	7/92	2 J	31	0.917 - 2.05	1.07	6.86	03SB0700610
BROMOMETHANE	4/92	2 J	8	0.917 - 2.05	0.760	4.25	03SB1191014
CARBON DISULFIDE	11/92	2 J	8	0.917 - 2.05	0.931	3.36	03SB1090610
CHLOROFORM	6/92	2 J	7	0.917 - 2.05	0.811	3.83	03SB0920610
CHLOROMETHANE	1/92	4	4	0.917 - 2.05	0.638	4.00	03SB1191014
CIS-1,2-DICHLOROETHENE	16/92	2 J	3100 J	0.917 - 2.05	88.4	505	03SB1030610
ETHYLBENZENE	6/92	2 J	1200 J	0.917 - 2.05	14.3	211	03SB1030610
METHYL IODIDE	1/54	15 J	15 J	0.917 - 2.05	0.869	15.0	03SB1191014
STYRENE	1/91	33	33	0.917 - 2.05	0.957	33.0	03SB1020610
TOLUENE	11/92	2 J	160	0.917 - 2.05	3.96	28.7	03SB1021014
TOTAL XYLENES	8/92	2 J	2000 J	0.917 - 2.05	23.5	264	03SB1030610
TRANS-1,2-DICHLOROETHENE	10/92	2 J	250 J	0.917 - 2.05	4.42	35.7	03SB0610610
TRICHLOROETHENE	15/92	2 J	19000	0.917 - 2.05	337	2065	03SB0610206
TRICHLOROFLUOROMETHANE	2/92	2 J	2 J	0.917 - 2.05	0.629	2.00	03SB0731014, 03SB0900610
VINYL CHLORIDE	9/92	2 J	20	0.917 - 2.05	1.40	8.78	03SB1011014
Energetics (mg/kg)							
1,3,5-TRINITROBENZENE	2/156	0.34 J	0.91 J	0.25	0.131	0.625	03SB0791014
2,4,6-TRINITROTOLUENE	2/156	3.7	45	0.25	0.436	24.4	03SB0791014
2,6-DINITROTOLUENE	3/156	0.33 J	0.41 J	0.25	0.130	0.360	03SB0821014
2-AMINO-4,6-DINITROTOLUENE	1/156	0.35 J	0.35 J	0.25	0.126	0.350	03SB0570206
4-AMINO-2,6-DINITROTOLUENE	1/156	0.26 J	0.26 J	0.25	0.126	0.260	03SB0880206
HMX	22/156	0.27 J	16	0.25	0.356	1.77	03SB1191014
RDX	6/156	0.32 J	2.1	0.25	0.172	1.36	03SB1200206

TABLE 1-7

SUMMARY OF DESCRIPTIVE STATISTICS
MAIN TREATMENT AREA - SUBSURFACE SOIL
2004 SAMPLING EVENT
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detction	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Hits	Sample of Maximum Detect
Inorganics (mg/kg)							
ALUMINUM	82/82	20.4 J	47200 J	---	9215	9215	03SB0601014
ANTIMONY	42/82	0.27 J	32.6 J	0.12 - 0.74	0.952	1.68	03SB1000610
ARSENIC	81/82	1.3 J	22 J	0.13	8.59	8.69	03SB0681014
BARIUM	81/82	18.3 J	595 J	0.59	122	124	03SB1000610
BERYLLIUM	70/82	0.23 J	2.3 J	0.018 - 0.88	0.954	1.07	03SB0820206
CADMIUM	33/82	0.18 J	3.5	0.034 - 0.84	0.375	0.711	03SB1000610
CALCIUM	80/82	81.2 J	129000 J	8.6 - 951	8625	8835	03SB0701014
CHROMIUM	81/82	6.7 J	65.3 J	0.25	19.5	19.7	03SB1000610
COBALT	81/82	0.2 J	39.9 J	2.6	14.6	14.8	03SB0660610
COPPER	81/82	3.9 J	508 J	0.18	24.0	24.3	03SB1000610
IRON	81/82	7170 J	86000 J	44.1	32666	33069	03SB1211014
LEAD	81/82	7.6 J	524 J	0.05	28.1	28.4	03SB1000610
MAGNESIUM	81/82	334 J	23900 J	3	1939	1963	03SB0700206
MANGANESE	81/82	46.4	7380	1.3	936	948	03SB1000610
MERCURY	45/82	0.008 J	1.5 J	0.007 - 0.077	0.0541	0.0862	03SB0600206
NICKEL	82/82	0.25 J	48.4 J	---	24.1	24.1	03SB0681014
POTASSIUM	81/82	312 J	8980 J	3.5	1267	1283	03SB0601014
SELENIUM	18/82	0.25 J	0.56 J	0.026 - 1	0.164	0.364	03SB0740610
SILVER	4/82	0.05 J	16.8	0.041 - 0.29	0.245	4.38	03SB1000610
SODIUM	40/82	44.8 J	520 J	3.47 - 59.3	67.4	122	03SB1000610
THALLIUM	15/82	0.08 J	0.14 J	0.012 - 0.27	0.0655	0.101	03SB0940610
TIN	22/82	0.26 J	58.6 J	0.31 - 3.4	1.70	5.31	03SB1211014
VANADIUM	82/82	0.21 J	39.5 J	---	18.6	18.6	03SB1101014
ZINC	81/82	13.4 J	1430 J	1.13	88.0	89.0	03SB1000610
Miscellaneous Parameters							
BULK DENSITY (g/cm^3)	4/4	1.57	1.81	---	1.69	1.69	03ST0990204
CATION EXCHANGE CAPACITY (MEQ/1)	4/4	10	31	---	19.5	19.5	03SB0780206
PERCHLORATE (mg/kg)	9/51	0.05 J	0.8	0.041 - 0.053	0.0640	0.252	03SB0670610
PERCHLORATE-8321 (µg/kg)	2/13	3	9	1.1 - 1.3	1.43	6.00	03SB0890206
PH (S.U.)	4/4	7.6	8	---	7.75	7.75	03SB1160610
POROSITY (%)	4/4	31.9	40.1	---	36.1	36.1	03ST0770608
SPECIFIC GRAVITY (S.U.)	4/4	2.63	2.66	---	2.64	2.64	03ST0990204
TOTAL ORGANIC CARBON (mg/kg)	4/4	3700	9300	---	5850	5850	03SB0780610

TABLE 1-8

GROUNDWATER SAMPLES AND LABORATORY ANALYSES
MAIN TREATMENT AREA AND OLD JEEP TRAIL
SWMU 3 – AMMUNITION BURNING GROUNDSA
2004 SAMPLING EVENT
NSWC CRANE
CRANE, INDIANA

Location	Sample Number	VOCs[1]	Explosives[1]	Metals[1]	Dissolved Metals	Perchlorate[1]
Ammunition Burning Grounds Main Treatment Area						
03-01	03GW0101	X	X	X		-
03-04	03GW0401	X	X	X		-
03-06	03GW0601	X	X	X		-
03-09	03GW0901	X	X	X		X
03-27	03GW2701	X	X	X		-
03-29	03GW2901	X	X	X		-
03-30	03GW3001	X	X	X		X
03-31	03GW3101	X	X	X		-
03-32	03GW3201	X	X	X		-
03-33	03GW3301	X	X	X	X	X
03-34	03GW3401	X	X	X		-
03-35	03GW3501	X	X	X		-
03-36	03GW3601	X	X	X		-
03-37	03GW3701	X	X	X		-
03-38	03GW3801	X	X	X		X
03-39	03GW3901	X	X	X		-
03C01P2	03GWC01P201	X	X	X		-
03C03P2	03GWC03P201	X	X	X	X	-
03C05	03GWC0501	X	X	X		X
03C06	03GWC0601	X	X	X		-
03C11	03GWC1101	X	X	X		X
03C13	03GWC1301	X	X	X		X
03C14	03GWC1401	X	X	X		-
03C21	03GWC2101	X	X	X		-
03C28	03GWC2801	X	X	X		-
03TW01[2]	03GWTW01[2]	X	X	X		X
03TW02[2]	03GWTW02[2]	X	X	X	X	-
03TW03[2]	03GWTW03[2]	X	X	X	X	-
03TW04[2]	03GWTW04[2]	X	X	X	X	-
03TW05[2]	03GWTW05[2]	X	X	X	X	-

TABLE 1-8

GROUNDWATER SAMPLES AND LABORATORY ANALYSES
MAIN TREATMENT AREA AND OLD JEEP TRAIL
SWMU 3 – AMMUNITION BURNING GROUNDSA
2004 SAMPLING EVENT
NSWC CRANE
CRANE, INDIANA

Location	Sample Number	VOCs[1]	Explosives[1]	Metals[1]	Dissolved Metals	Perchlorate[1]
Old Jeep Trail						
03-07	03GW0702	X	X	X		X
03-12	03GW1202	X	X	X		-
03-15	03GW1502	X	X	X		X
03-16	03GW1602	X	X	X		-
03-21	03GW2102	X	X	X		-
03-24	03GW2402	X	X	X		-
03TW06[2]	03GWTW06[2]	X	X	X	X	-
Spring A'						
03SPA'	03SPAp01	X	X	X		-
Totals		39	39	39	10	

1 See Table 1-3 of this QAPP Addendum No. 1 for specific analysis requirements and analyte list.
2 "TW" refers to temporary wells, which are actually DPT borings from which ground water will be extracted from near the bedrock-overburden interface.

VOCs – Volatile organic compounds

TABLE 1-9

SUMMARY OF DESCRIPTIVE STATISTICS
FOR EXISTING AND TEMPORARY MONITORING WELLS
MAIN TREATMENT AREA - 2004 SAMPLING EVENT
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

EXISTING MONITORING WELLS							
Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Hits	Sample of Maximum Detect
Volatile Organics (µg/L)							
1,2-DICHLOROETHANE	5/13	0.8 J	5.5	0.3	1.45	3.54	03GW3801
CARBON TETRACHLORIDE	1/13	0.3 J	0.3 J	0.3	0.162	0.300	03GW3801
CHLOROFORM	2/13	0.4 J	0.7 J	0.3	0.212	0.550	03GWC03P201
CIS-1,2-DICHLOROETHENE	1/13	62	62	0.3	4.91	62.0	03GWC03P201
TRANS-1,2-DICHLOROETHENE	1/13	5.1	5.1	0.3	0.531	5.10	03GWC03P201
TRICHLOROETHENE	7/13	0.6 J	180	0.3	37.8	70.1	03GW3901
Energetics (µg/L)							
1,3,5-TRINITROBENZENE	1/13	6.6 J	6.6 J	0.24 - 0.272	0.626	6.60	03GWC03P201
2,4,6-TRINITROTOLUENE	1/13	1.5 J	1.5 J	0.24 - 0.272	0.234	1.50	03GWC03P201
2,6-DINITROTOLUENE	3/13	0.33 J	0.5 J	0.24 - 0.272	0.199	0.433	03GWC03P201
2-AMINO-4,6-DINITROTOLUENE	3/13	0.35 J	4.3	0.24 - 0.272	0.484	1.67	03GWC03P201
4-AMINO-2,6-DINITROTOLUENE	4/13	0.7	4.5	0.24 - 0.272	0.625	1.74	03GWC03P201
HMX	6/13	3	75	0.248 - 0.272	15.1	32.6	03GWC03P201
RDX	7/13	0.9	620	0.25 - 0.272	71.0	132	03GWC03P201
Total Metals (µg/L)							
ALUMINUM	6/13	36.6 J	478 J	8.35 - 28.3	66.9	136	03GWC0501
BARIUM	13/13	14.6 J	93.3 J	---	47.3	47.3	03GWC03P201
CALCIUM	13/13	46800 J	155000 J	---	104423	104423	03GW0901
CHROMIUM	2/13	1.1 J	3.4 J	0.22 - 1.9	0.692	2.25	03GW3101
IRON	10/13	82.9 J	1080 J	6.8 - 17	292	377	03GWC0501
LEAD	1/13	2.2 J	2.2 J	0.069 - 0.83	0.281	2.20	03GWC03P201
MAGNESIUM	13/13	2990 J	87400 J	---	28562	28562	03GW0901
MANGANESE	13/13	2.8 J	445	---	88.5	88.5	03GW0901
NICKEL	2/13	3.4 J	9.3 J	0.1 - 1.3	1.15	6.35	03GW0901
POTASSIUM	13/13	1060 J	12900 J	---	2598	2598	03GWC03P201
SELENIUM	2/13	0.72 J	1.7 J	0.094 - 0.42	0.254	1.21	03GWC0501
SODIUM	13/13	3260 J	135000 J	---	23364	23364	03GW3301
VANADIUM	3/13	1.2 J	1.5 J	1.14	0.762	1.40	03GWC0501, 03GW0901
ZINC	12/13	1.3 J	7.5 J	1.6	3.98	4.25	03GWC0501
Dissolved Metals (µg/L)							
BARIUM, FILTERED	2/2	71.1 J	83.8 J	---	77.5	77.5	03GWC03P201-F
CALCIUM, FILTERED	2/2	113000 J	130000 J	---	121500	121500	03GW3301-F
COBALT, FILTERED	1/2	3.1 J	3.1 J	1.1	1.83	3.10	03GW3301-F
IRON, FILTERED	1/2	68.6 J	68.6 J	6.15	35.8	68.6	03GWC03P201-F
MAGNESIUM, FILTERED	2/2	16400 J	23000 J	---	19700	19700	03GWC03P201-F
MANGANESE, FILTERED	2/2	4.3 J	76.3	---	40.3	40.3	03GWC03P201-F
NICKEL, FILTERED	1/2	2.4 J	2.4 J	0.43	1.31	2.40	03GWC03P201-F
POTASSIUM, FILTERED	2/2	3260 J	9520 J	---	6390	6390	03GWC03P201-F
SODIUM, FILTERED	2/2	25600 J	123000 J	---	74300	74300	03GW3301-F
ZINC, FILTERED	2/2	3.7 J	5.1 J	---	4.40	4.40	03GWC03P201-F
Field Parameters							
DISSOLVED OXYGEN - METER (µg/L)	13/13	340	12930	---	5855	5855	03GW3301
OXIDATION REDUCTION POTENTIAL (MV)	13/13	-97.5	462	---	211	211	03GWC0601
PH (S.U.)	13/13	5.95	8.01	---	7.10	7.10	03GW3101
SPECIFIC CONDUCTANCE (MS/CM)	13/13	0.209	1.166	---	0.621	0.621	03GW3301
TEMPERATURE (C)	13/13	11.79	15.6	---	13.4	13.4	03GWC03P201
TURBIDITY (NTU)	13/13	0.85	15.6	---	7.02	7.02	03GWC03P201
Miscellaneous Parameters (µg/L)							
PERCHLORATE	1/4	74	74	2	19.3	74.0	03GW3801
PERCHLORATE-8321	1/1	67	67	---	67.0	67.0	03GW3801

TABLE 1-9

SUMMARY OF DESCRIPTIVE STATISTICS
FOR EXISTING AND TEMPORARY MONITORING WELLS
MAIN TREATMENT AREA - 2004 SAMPLING EVENT
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

TEMPORARY MONITORING WELLS (PERCHED WATER)							
Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Hits	Sample of Maximum Detect
Volatile Organics (µg/L)							
1,1-DICHLOROETHENE	1/5	0.8 J	0.8 J	0.3	0.280	0.800	03GWTW02
CIS-1,2-DICHLOROETHENE	3/5	0.6 J	180	0.3	51.6	85.9	03GWTW05
ETHYLBENZENE	1/5	1.7	1.7	0.3	0.460	1.70	03GWTW05
TOTAL XYLENES	1/5	0.8 J	0.8 J	0.3	0.280	0.800	03GWTW05
TRANS-1,2-DICHLOROETHENE	2/5	0.3 J	17	0.3	3.55	8.65	03GWTW02
TRICHLOROETHENE	2/5	23	310	0.3	66.7	167	03GWTW02
VINYL CHLORIDE	2/5	1.2	7	0.3	1.73	4.10	03GWTW05
Energetics (µg/L)							
2-AMINO-4,6-DINITROTOLUENE	1/5	0.81 J	0.81 J	0.24 - 0.25	0.259	0.810	03GWTW05
4-AMINO-2,6-DINITROTOLUENE	1/5	2.2	2.2	0.24 - 0.25	0.537	2.20	03GWTW05
HMX	4/5	1.6	16	0.242	4.94	6.15	03GWTW05
RDX	4/5	0.73	76	0.242	16.0	20.0	03GWTW05
Total Metals (uµ/L)							
ALUMINUM	5/5	76.1 J	76200 J	---	15714	15714	03GWTW03
ANTIMONY	3/5	1.4 J	27.9 J	0.085 - 0.27	6.42	10.6	03GWTW05
ARSENIC	5/5	1.3 J	45.8 J	---	12.4	12.4	03GWTW03
BARIUM	5/5	62.9 J	1140 J	---	370	370	03GWTW03
BERYLLIUM	1/5	2.9 J	2.9 J	0.02 - 0.07	0.595	2.90	03GWTW03
CADMIUM	2/5	1.5 J	2.9 J	0.039 - 0.85	0.990	2.20	03GWTW03
CALCIUM	5/5	34600 J	197000 J	---	90300	90300	03GWTW03
CHROMIUM	4/5	0.98 J	72.2 J	0.33	15.6	19.4	03GWTW03
COBALT	5/5	1 J	56.2 J	---	13.1	13.1	03GWTW03
COPPER	4/5	5.3 J	195 J	0.24	51.9	64.8	03GWTW03
IRON	5/5	620 J	141000 J	---	30990	30990	03GWTW03
LEAD	4/5	1.5 J	329 J	0.18	71.9	89.9	03GWTW03
MAGNESIUM	5/5	14100 J	82500 J	---	38880	38880	03GWTW05
MANGANESE	5/5	122	2000	---	1188	1188	03GWTW03
MERCURY	1/5	0.087 J	0.087 J	0.03	0.0294	0.0870	03GWTW05
NICKEL	5/5	2.4 J	188 J	---	41.9	41.9	03GWTW03
POTASSIUM	5/5	2620 J	275000 J	---	92504	92504	03GWTW02
SELENIUM	3/5	0.57 J	67.4 J	0.094 - 0.17	14.3	23.8	03GWTW05
SODIUM	5/5	10500 J	1190000 J	---	297900	297900	03GWTW05
VANADIUM	4/5	1.5 J	53.3	1.14	13.8	17.2	03GWTW03
ZINC	4/5	22.3 J	1180 J	3.2	304	380	03GWTW03
Dissolved Metals (µg/L)							
ALUMINUM, FILTERED	3/4	11.5 J	26 J	8.35	14.2	17.6	03GWTW04-F
ANTIMONY, FILTERED	3/4	1.5 J	29.3 J	0.43	8.53	11.3	03GWTW05-F
ARSENIC, FILTERED	2/4	2.4 J	9.5 J	0.35 - 0.65	3.10	5.95	03GWTW05-F
BARIUM, FILTERED	4/4	53.5 J	247 J	---	148	148	03GWTW04-F
CADMIUM, FILTERED	1/4	1.5 J	1.5 J	0.09 - 0.33	0.464	1.50	03GWTW05-F
CALCIUM, FILTERED	4/4	32400 J	156000 J	---	86175	86175	03GWTW03-F
COBALT, FILTERED	3/4	1.8 J	4.4 J	0.22	2.40	3.17	03GWTW03-F
COPPER, FILTERED	4/4	1.3 J	30.2 J	---	11.5	11.5	03GWTW05-F
IRON, FILTERED	4/4	14 J	522	---	163	163	03GWTW05-F
LEAD, FILTERED	1/4	1.5 J	1.5 J	0.39 - 0.47	0.541	1.50	03GWTW04-F
MAGNESIUM, FILTERED	4/4	13000 J	87700 J	---	40025	40025	03GWTW05-F
MANGANESE, FILTERED	4/4	59.2	1560	---	861	861	03GWTW05-F
MERCURY, FILTERED	1/4	0.074 J	0.074 J	0.03	0.0298	0.0740	03GWTW04-F
NICKEL, FILTERED	4/4	2.3 J	8.5 J	---	4.40	4.40	03GWTW05-F
POTASSIUM, FILTERED	4/4	1780 J	274000 J	---	111060	111060	03GWTW02-F
SELENIUM, FILTERED	2/4	3.4 J	70.5 J	0.094 - 0.1	18.5	37.0	03GWTW05-F
SODIUM, FILTERED	4/4	12200 J	1400000 J	---	423325	423325	03GWTW05-F
VANADIUM, FILTERED	1/4	11.4	11.4	1.14	3.28	11.4	03GWTW05-F
ZINC, FILTERED	3/4	51.9 J	108 J	3.1	55.3	73.2	03GWTW04-F
Field Parameters							
DISSOLVED OXYGEN - METER (µg/L)	4/4	540	10130	---	3140	3140	03GWTW04
OXIDATION REDUCTION POTENTIAL (MV)	5/5	-50.9	159	---	47.2	47.2	03GWTW03
PH (S.U.)	5/5	6.35	7.92	---	7.19	7.19	03GWTW04
SPECIFIC CONDUCTANCE (MS/CM)	5/5	0.311	5.77	---	1.86	1.86	03GWTW05
TEMPERATURE (C)	5/5	11.7	18.18	---	14.4	14.4	03GWTW04
TURBIDITY (NTU)	5/5	6.54	1000 >	---	224	224	03GWTW03

TABLE 1-10

SUMMARY OF DESCRIPTIVE STATISTICS
OLD JEEP TRAIL - SURFACE SOIL
2004 SAMPLING EVENT
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Hits	Sample of Maximum Detect
Energetics (mg/kg)							
2,4,6-TRINITROTOLUENE	1/4	0.39 J	0.39 J	0.25	0.191	0.390	03SS0500002
HMX	1/4	0.31 J	0.31 J	0.25	0.171	0.310	03SS0500002
Inorganics (mg/kg)							
ALUMINUM	4/4	3670	8290	---	6893	6893	03SS0490002
ANTIMONY	2/4	0.71 J	1.8 J	0.33 - 0.43	0.723	1.26	03SS0500002
ARSENIC	4/4	4 J	7.5 J	---	5.95	5.95	03SS0510002
BARIUM	4/4	67.3 J	516 J	---	185	185	03SS0500002
BERYLLIUM	4/4	0.58 J	0.85 J	---	0.663	0.663	03SS0510002
CADMIUM	1/4	1.6 J	1.6 J	0.29 - 0.38	0.528	1.60	03SS0500002
CALCIUM	4/4	1630 J	48900	---	20423	20423	03SS0490002
CHROMIUM	4/4	10.1 J	19.4 J	---	13.7	13.7	03SS0510002
COBALT	4/4	4.9 J	11.7 J	---	7.83	7.83	03SS0500002
COPPER	4/4	6.7 J	66.3 J	---	24.9	24.9	03SS0500002
IRON	4/4	15400 J	46300 J	---	23475	23475	03SS0510002
LEAD	4/4	13 J	105 J	---	44.1	44.1	03SS0500002
MAGNESIUM	4/4	414 J	2030 J	---	1299	1299	03SS0490002
MANGANESE	4/4	216 J	1310 J	---	626	626	03SS0500002
MERCURY	4/4	0.012 J	0.48	---	0.144	0.144	03SS0500002
NICKEL	4/4	9.4 J	13.3 J	---	11.6	11.6	03SS0500002
POTASSIUM	4/4	355 J	747 J	---	594	594	03SS0520002
TIN	3/4	0.37 J	4.9	0.49	1.47	1.88	03SS0500002
VANADIUM	4/4	14.1 J	23.3 J	---	17.2	17.2	03SS0510002
ZINC	4/4	25.9 J	314 J	---	99.2	99.2	03SS0500002
Miscellaneous Parameters (µg/kg)							
PERCHLORATE	1/2	0.3	0.3	0.044	0.161	0.300	03SS0490002

TABLE 1-11

SUMMARY OF DESCRIPTIVE STATISTICS
SWMU 3 - OLD JEEP TRAIL - SUBSURFACE SOIL
2004 SAMPLING EVENT
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Hits	Sample of Maximum Detection
Volatile Organics (µg/kg)							
CARBON DISULFIDE	1/7	4 J	4 J	0.863 - 2.46	1.16	4.00	03SB0501014
Inorganics (mg/kg)							
ALUMINUM	11/11	4030	9620 J	---	5786	5786	03SB0500206
ANTIMONY	4/11	0.58 J	1.4 J	0.27 - 0.55	0.467	0.948	03SB0500206
ARSENIC	11/11	3.2 J	16 J	---	6.23	6.23	03SB0491014
BARIUM	11/11	53.4 J	652 J	---	200	200	03SB0500610
BERYLLIUM	10/11	0.49 J	1.4 J	0.42	0.824	0.885	03SB0490610
CADMIUM	3/11	0.61 J	0.78 J	0.17 - 0.46	0.311	0.707	03SB0491014
CALCIUM	11/11	745	6000	---	1843	1843	03SB0510610
CHROMIUM	11/11	8 J	27.1 J	---	13.8	13.8	03SB0490610
COBALT	11/11	4.4 J	17 J	---	10.3	10.3	03SB0510206
COPPER	11/11	5.4 J	17.2 J	---	8.96	8.96	03SB0500206
IRON	11/11	13200 J	60000 J	---	26300	26300	03SB0490610
LEAD	11/11	9.8 J	43.6 J	---	20.3	20.3	03SB0491014
MAGNESIUM	11/11	414 J	1730 J	---	783	783	03SB0500206
MANGANESE	11/11	245 J	2960 J	---	1139	1139	03SB0490610
MERCURY	11/11	0.008 J	0.39	---	0.0771	0.0771	03SB0500610
NICKEL	11/11	8.8 J	38.4 J	---	15.9	15.9	03SB0491014
POTASSIUM	11/11	362 J	864 J	---	590	590	03SB0500206
TIN	11/11	0.21 J	0.94 J	---	0.383	0.383	03SB0500206
VANADIUM	11/11	9.8 J	28.2 J	---	17.7	17.7	03SB0490610
ZINC	11/11	16.8 J	138 J	---	50.4	50.4	03SB0500206
Miscellaneous Parameters							
PERCHLORATE (mg/kg)	2/5	0.3	0.6	0.045 - 0.05	0.194	0.450	03SB0490206
PERCHLORATE-8321 (µg/kg)	1/2	0.33 J	0.33 J	1.1	0.440	0.330	03SB0490206

TABLE 1-12

SUMMARY OF DESCRIPTIVE STATISTICS
OLD JEEP TRAIL - GROUNDWATER
2004 SAMPLING EVENT
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Postive Hits	Sample of Maximum Detection
Volatile Organics (µg/L)							
1,1,2,2-TETRACHLOROETHANE	3/6	5.3	940	0.3	161	322	03GW0702
1,1,2-TRICHLOROETHANE	3/6	0.4 J	35 J	0.3	6.11	12.1	03GW0702
1,1-DICHLOROETHENE	1/6	2.9 J	2.9 J	0.3	0.608	2.90	03GW0702
CHLOROETHANE	1/6	2.6 J	2.6 J	0.5	0.642	2.60	03GW0702
CHLOROFORM	1/6	1	1	0.3	0.292	1.00	03GW0702
CIS-1,2-DICHLOROETHENE	3/6	6.5	210	0.3	38.2	76.2	03GW0702
TETRACHLOROETHENE	1/6	9.8 J	9.8 J	0.3	1.76	9.80	03GW0702
TRANS-1,2-DICHLOROETHENE	3/6	1	99 J	0.3	17.0	33.9	03GW0702
TRICHLOROETHENE	5/6	0.6 J	920	0.3	162	194	03GW0702
VINYL CHLORIDE	1/6	7.4 J	7.4 J	0.3	1.36	7.40	03GW0702
Energetics (µg/L)							
2,4,6-TRINITROTOLUENE	1/6	4	4	0.24 - 0.26	0.772	4.00	03GW2102
2-AMINO-4,6-DINITROTOLUENE	2/6	0.56 J	0.68 J	0.24 - 0.26	0.290	0.620	03GW2102
4-AMINO-2,6-DINITROTOLUENE	3/6	0.43 J	2.7	0.24 - 0.26	0.736	1.35	03GW2102
HMX	6/6	0.28 J	82	---	26.0	26.0	03GW1202
RDX	6/6	1.1	120	---	33.3	33.3	03GW2102
Inorganics (µg/L)							
ALUMINUM	5/6	30.5 J	163 J	37.5	71.0	81.5	03GW1602
BARIUM	6/6	42.9 J	252 J	---	100	100	03GW2102
CALCIUM	6/6	48900 J	101000 J	---	76500	76500	03GW0702
CHROMIUM	1/6	1.6 J	1.6 J	0.3 - 1.5	0.643	1.60	03GW1202
COPPER	1/6	2 J	2 J	0.11 - 0.24	0.402	2.00	03GW0702
IRON	6/6	47 J	308 J	---	132	132	03GW1602
MAGNESIUM	6/6	4880 J	39600 J	---	17903	17903	03GW0702
MANGANESE	6/6	5.2	285 J	---	56.6	56.6	03GW0702
NICKEL	2/6	1.5 J	1.6 J	0.23 - 0.66	0.657	1.55	03GW0702
POTASSIUM	6/6	1310 J	10400 J	---	3805	3805	03GW0702
SELENIUM	1/6	0.6 J	0.6 J	0.094 - 0.44	0.191	0.600	03GW1502
SODIUM	6/6	1800 J	9140 J	---	4033	4033	03GW2402
ZINC	3/6	3.9 J	8.7 J	2 - 4.4	3.58	5.60	03GW2102
Field Parameters							
DISSOLVED OXYGEN - METER (µg/L)	6/6	4.92	11.22	---	7.13	7.13	03GW1602
OXIDATION REDUCTION POTENTIAL (MV)	6/6	145	480	---	345	345	03GW2102
PH (S.U.)	6/6	6.09	7.57	---	6.68	6.68	03GW1602
SPECIFIC CONDUCTANCE (MS/CM)	6/6	0.238	0.608	---	0.400	0.400	03GW0702
TEMPERATURE (C)	6/6	11.54	16.98	---	13.3	13.3	03GW1502
TURBIDITY (NTU)	6/6	1.69	9.62	---	6.12	6.12	03GW2402

TABLE 1-13

SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSIS – GROUNDWATER
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Location	Sample Number	VOCs[1]	Explosives[1]	Metals[1][2]	Perchlorate[1]
Ammunition Burning Grounds Main Treatment Area					
03-01	03GW0101	S	S	S	-
03-04	03GW0401	O	O	O	-
03-06	03GW0601	O	O	O	-
03-09	03GW0901	S	S	S	S
03-27	03GW2701	O	O	O	-
03-29	03GW2901	O	O	O	-
03-30	03GW3001	O	O	O	O
03-31	03GW3101	S	S	S	-
03-32	03GW3201	O	O	O	-
03-33	03GW3301	S	S	S	S
03-34	03GW3401	O	O	O	-
03-35	03GW3501	O	O	O	-
03-36	03GW3601	O	O	O	-
03-37	03GW3701	O	O	O	-
03-38	03GW3801	S	S	S	S
03-39	03GW3901	S	S	S	-
03C01P2	03GWC01P201	S	S	S	-
03C03P2	03GWC03P201	S	S	S	-
03C05	03GWC0501	S	S	S	S
03C06	03GWC0601	S	S	S	-
03C10	03GWC1001	O	O	O	O
03C11	03GWC1101	O	O	O	O
03C13	03GWC1301	O	O	O	O
03C14	03GWC1401	S	S	S	-
03C21	03GWC2101	S	S	S	-
03C28	03GWC2801	S	S	S	-
03TW01[3]	03GWTW01[3]	S	S	S	S
03TW02[3]	03GWTW02[3]	S	S	S	-
03TW03[3]	03GWTW03[3]	S	S	S	-
03TW04[3]	03GWTW04[3]	S	S	S	-
03TW05[3]	03GWTW05[3]	S	S	S	-

TABLE 1-13

SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSIS – GROUNDWATER
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Location	Sample Number	VOCs(1)	Explosives(1)	Metals(1)(2)	Perchlorate(1)
Old Jeep Trail					
03-07	03GW0702	S	S	S	S
03-12	03GW1202	S	S	S	-
03-15	03GW1502	S	S	S	S
03-16	03GW1602	S	S	S	-
03-21	03GW2102	S	S	S	-
03-24	03GW2402	S	S	S	-
03TW06(3)	03GWTW06(3)	S	S	S	-
Spring A'					
03SPA'	03SPAp01	S	S	S	-

1 See Table 1-3 of the QAPP Addendum No. 1 for specific analysis requirements and analyte list.
2 Unfiltered samples will be analyzed for total metals. If turbidity of water was greater than 10 nephelometric turbidity units, a filtered sample was also collected and analyzed for dissolved metals.
3 "TW" refers to temporary wells, which were actually DPT borings from which ground water (perched sample) was extracted from near the bedrock-overburden interface.

VOCs – Volatile organic compounds.
S= Sample collected as proposed in the approved QAPP Addendum No. 1 (TtNUS, 2004).
O = Sample NOT collected as proposed in the approved QAPP Addendum No.1 (TtNUS, 2004) (See Table 2-3).

TABLE 1-14

CONTAMNINANT CONCENTRATIONS DETECTED IN PERCHED GROUNDWATER SAMPLES
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE,
CRANE, INDIANA

Temporary Well	Associated Soil Boring	RDX (µg/L)	TCE (µg/L)
Main Treatment Area			
03TW01	03SB060	0.99	0.3 U
03TW02	03SB063	2.3	310
03TW03	03SB090	0.242 U	0.3 U
03TW04	(1)	0.73	0.3 U
03TW05	03SB103	76	23
Old Jeep Trail Area			
03TW06	03SB050	0.266 U	0.3 U

1 — Sample collected from deep depression in land surface.

µg/L — micrograms per liter.

TCE — trichloroethene.

TABLE 1-15

MAXIMUM CONCENTRATONS AND TEMPORAL TRENDS OF CONTAMINANTS IN MONITORING WELLS AND SPRINGS SWMU 3 - AMMUNITION BURNING GROUNDS NSWC CRANE, CRANE, INDIANA

Location	RDX		TCE	
	Maximum Concentration (µg/L)	Temporal Trend	Maximum Concentration (µg/L)	Temporal Trend
Main Treatment Area				
03-01	70	stable	52	increasing
03C02P2	30	stable	30	decreasing
03C03P2	709	increasing	321	decreasing
03C04	400	stable	1	increasing
03C05	400	decreasing	7	increasing
03C07	43	increasing	20	stable
03C08P2	300	decreasing	73	increasing
03C09P2	330	increasing	190	increasing
03C10	140	increasing	72	increasing
03C11	150	increasing	2,500	increasing
03C12	32	increasing	810	stable
03C14	ND	ND	50	decreasing
03C20	270	increasing	4,500	stable
03C26	3.1	increasing	40	stable
03C27	ND	ND	13	stable
Spring A	140	decreasing	0.6	stable
Old Jeep Trail Area				
03-07	1.5	stable	1,010	stable
03-12	79	decreasing	3.9	decreasing
03-13	91	decreasing	ND	ND
03-15	13	increasing	57	decreasing
03-16	40	decreasing	ND	ND
03-21	365	decreasing	ND	ND
03-24	7.7	increasing	23	decreasing
Spring C	20	stable	ND	ND

ND — Not Detected.
µg/L — micrograms per liter.
TCE — trichloroethene.

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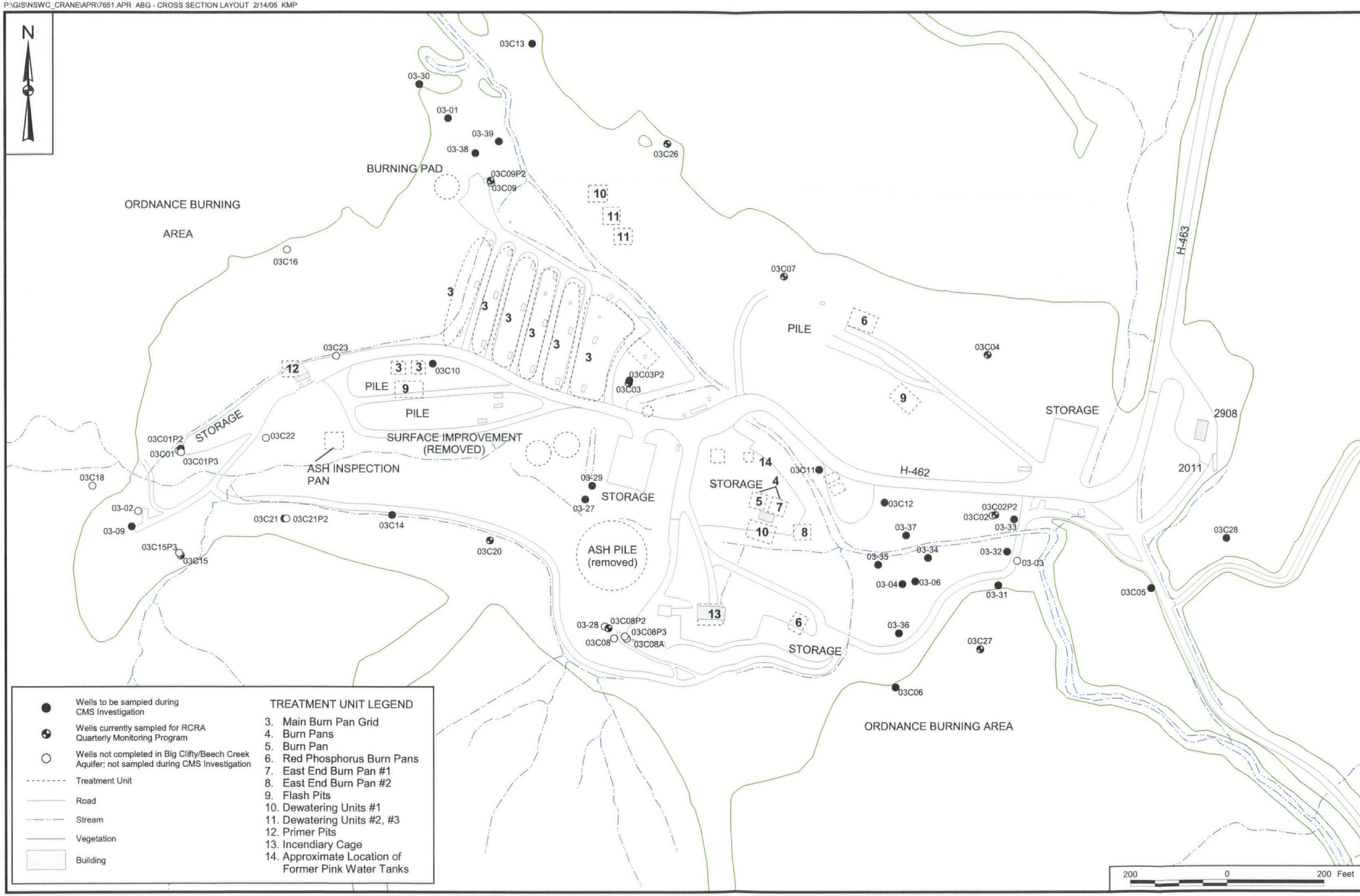


CONTRACT NO. 8383

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 1 - 1

REV 0

PHYSICAL FEATURES OF
AMMUNITION BURNING GROUNDS
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

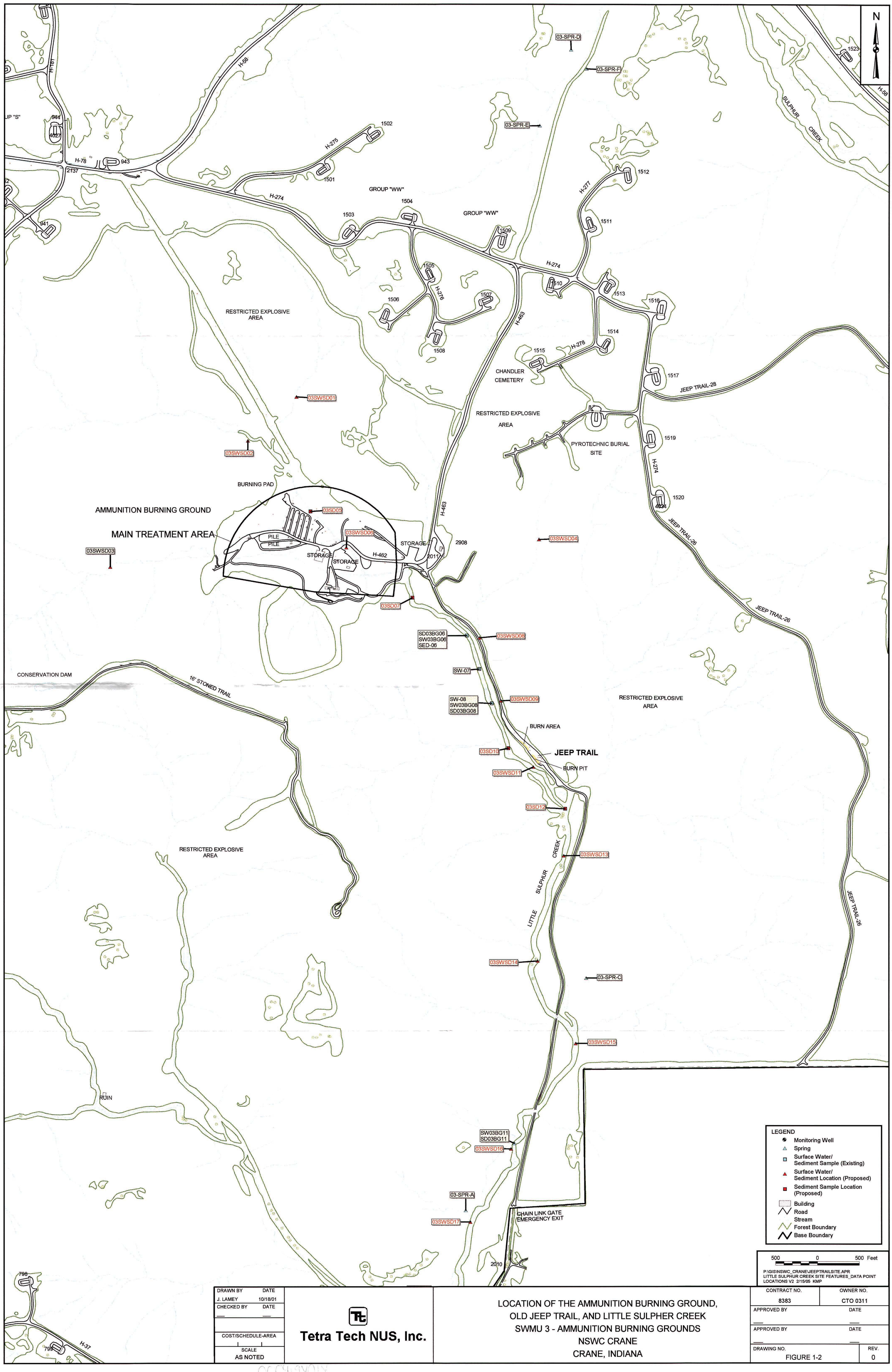
NAVFAC

DRAWN BY A. JANOCHA DATE 3/03/04

CHECKED BY J. GOERDT DATE 3/19/04

COST/SCHED-AREA

SCALE AS NOTED



DRAWN BY	DATE
J. LAMEY	10/18/01
CHECKED BY	DATE
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

Tetra Tech NUS, Inc.

LOCATION OF THE AMMUNITION BURNING GROUND,
OLD JEEP TRAIL, AND LITTLE SULPHER CREEK
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

CONTRACT NO.	OWNER NO.
8383	CTO 0311
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING NO.	REV.
FIGURE 1-2	0

OCC919V01Y

PERIOD	EPOCH	THICKNESS (FEET)	LITHOLOGY	FORMATION	GROUP
PENN-SYL-VANIAN	POTTS-VILLE	150-300		MANSFIELD FM.	"RACCOON CREEK"
MISSISSIPPI	CHESTER	20-30		GLEN DEAN LS	STEPHENS-PORT
		30-40		HARDINSBURG SS.	
		40-50		GOLCONDA LS.	
		25-40		BIG CLIFTY FM.	
		15-25		BEECH CREEK LS.	
		20-40		ELWREN FM.	WEST BADEN
		0-5		REELSVILLE LS.	
		20-40		SAMPLE FM.	
		10-20		BEAVER BEND LS.	
		12-30		BETHEL FM.	
	MERAMEC	15-20		PAOLI LS.	BLUE RIVER
		100-120		STE. GENEVIEVE LS.	
		100-120		ST. LOUIS LS.	
		90-100		SALEM LS.	SANDERS
		50-80		HARRODSBURG LS.	
	OSAGE	600-800		MULDRAUGH FM.	BORDEN

Source: Palmer, 1989

DRAWN BY	DATE
A. JANOCHA	7/21/02
CHECKED BY	DATE
J. SCHUBERT	8/21/02

COST/SCHEDULE-AREA

SCALE
AS NOTED

NAVFAC

GENERALIZED STRATIGRAPHIC COLUMN
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

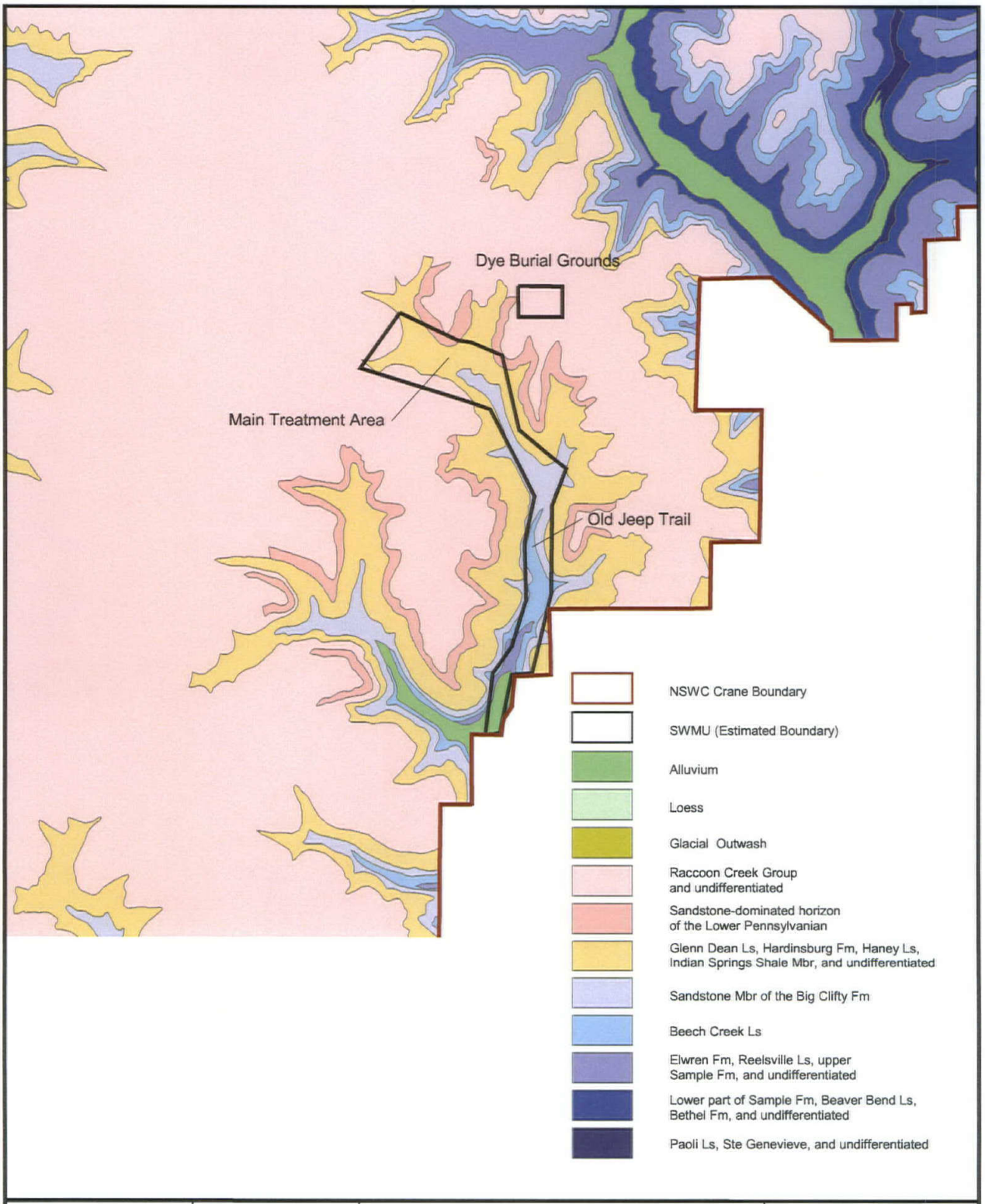
CONTRACT NUMBER 8383

APPROVED BY — DATE —

APPROVED BY — DATE —

DRAWING NO. FIGURE 1-3 REV 0

P:\GIS\NSWC_CRANE\APR\JEEPTRAIL_WORKPLAN.APR GENERALIZED STRATIGRAPHIC COLUMN LAYOUT 2/14/05 KMP



DRAWN BY A. JANOCHA	DATE 11/20/02	SURFICIAL BEDROCK MAP SWMU 3 - AMMUNITION BURNING GROUNDS NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER 8383
CHECKED BY J. GOERDT	DATE 11/20/02		APPROVED BY T. JOHNSTON — DATE 11/20/02
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED	NAVFAC		DRAWING NO. FIGURE 1-4 — REV 0

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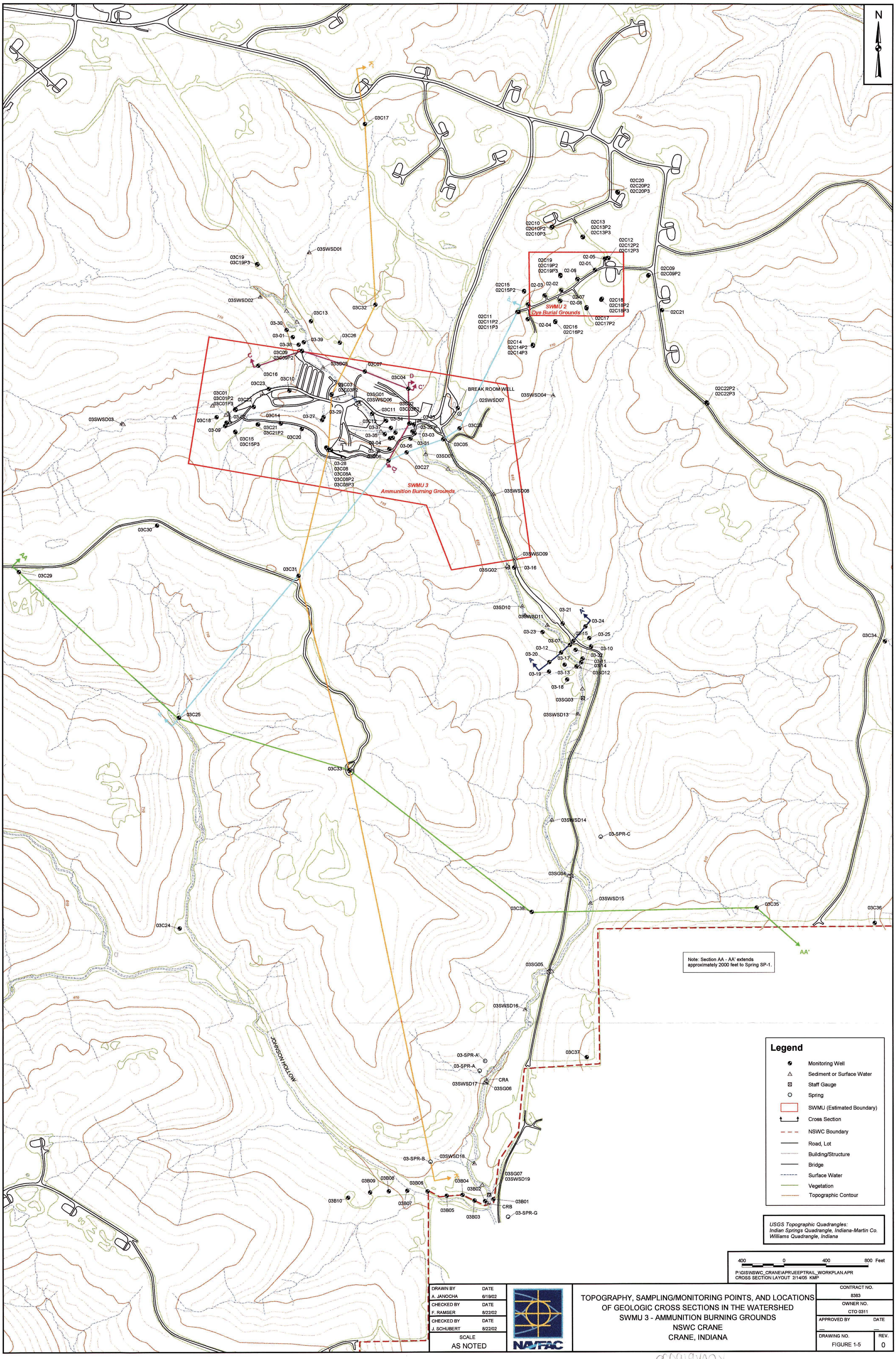
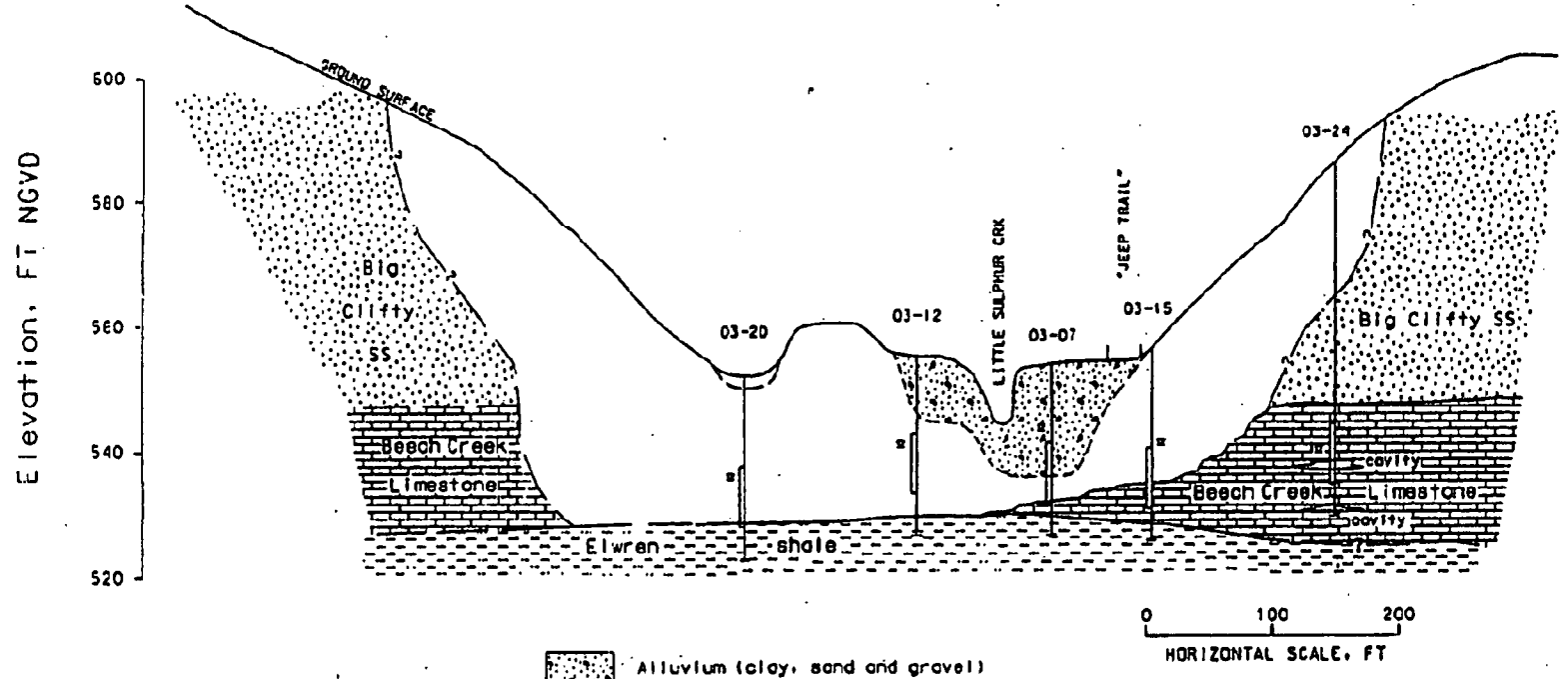

N
SWMU 2
Dye Burial Grounds
SWMU 3
Ammunition Burning Grounds
BREAK ROOM WELL
JOHNSON HOLLOW
AA'
Note: Section AA - AA' extends approximately 2000 feet to Spring SP-1.
Legend
Monitoring Well
Sediment or Surface Water
Staff Gauge
Spring
SWMU (Estimated Boundary)
Cross Section
NSWC Boundary
Road, Lot
Building/Structure
Bridge
Surface Water
Vegetation
Topographic Contour
USGS Topographic Quadrangles:
Indian Springs Quadrangle, Indiana-Martin Co.
Williams Quadrangle, Indiana
400 0 400 800 Feet
P:\GIS\NSWC_CRANE\APR\JEEPTRAIL_WORKPLAN.APR
CROSS SECTION LAYOUT 2/14/05 KMP
DRAWN BY A. JANOCHA DATE 6/19/02
CHECKED BY F. RAMSER DATE 8/22/02
CHECKED BY J. SCHUBERT DATE 8/22/02
SCALE AS NOTED
NAVFAC
TOPOGRAPHY, SAMPLING/MONITORING POINTS, AND LOCATIONS OF GEOLOGIC CROSS SECTIONS IN THE WATERSHED
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA
CONTRACT NO. 8383
OWNER NO. CTO 0311
APPROVED BY
DATE
DRAWING NO. FIGURE 1-5
REV. 0



Well screen

Water level Sept 94

Alluvium (clay, sand and gravel)

Sandstone

Limestone

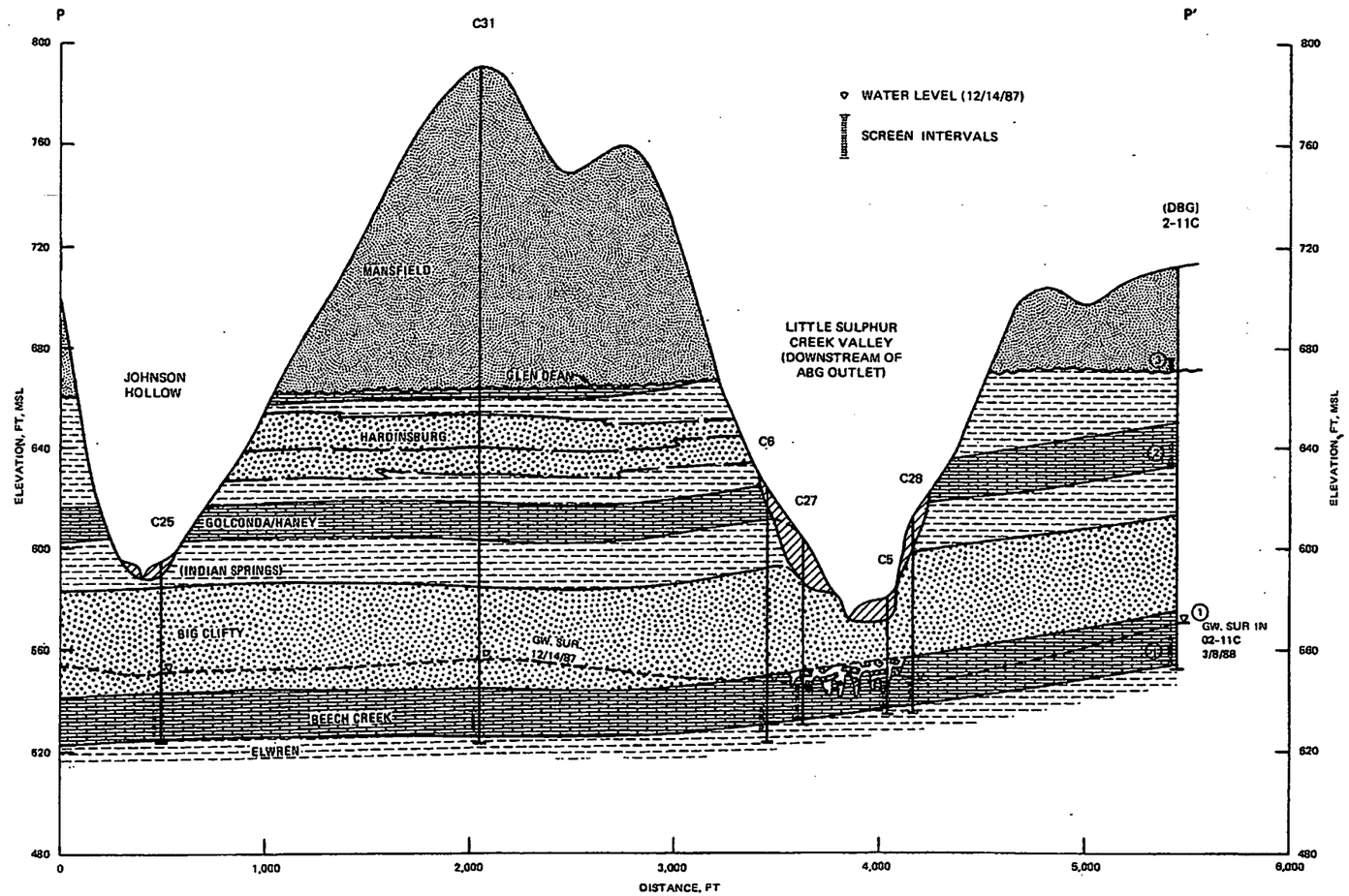
Shale

Weathered Sandstone and Limestone Collapse Breccia

MODIFIED FROM MURPHY, 1996

DRAWN BY	DATE			CONTRACT NUMBER
A. JANOCHA	7/17/02		GEOLOGIC CROSS SECTION A-A'	8383
CHECKED BY	DATE		SWMU 3 - AMMUNITION BURNING GROUNDS	APPROVED BY / DATE
J. SCHUBERT	7/17/02		NSWC CRANE	— / —
COST/SCHEDULE-AREA			CRANE, INDIANA	APPROVED BY / DATE
				— / —
SCALE		NAVFAC		DRAWING NO. / REV
AS NOTED				FIGURE 1-6 / 0

P:\GIS\NSWC_CRANE\APR\JEEPTRAIL_WORKPLAN.APR GEOLOGIC CROSS SECTION A-A' LAYOUT 2/14/05 KMP



LEGEND

- UNDIFFERENTIATED
- CLAY SYMBOL
- SHALE AND SANDSTONE
- SANDSTONE
- SHALE
- LIMESTONE

Modified from Hunt, 1988.

CONTRACT NO. 8383

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 1-7

REV 0

GEOLOGIC CROSS SECTION P-P'
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

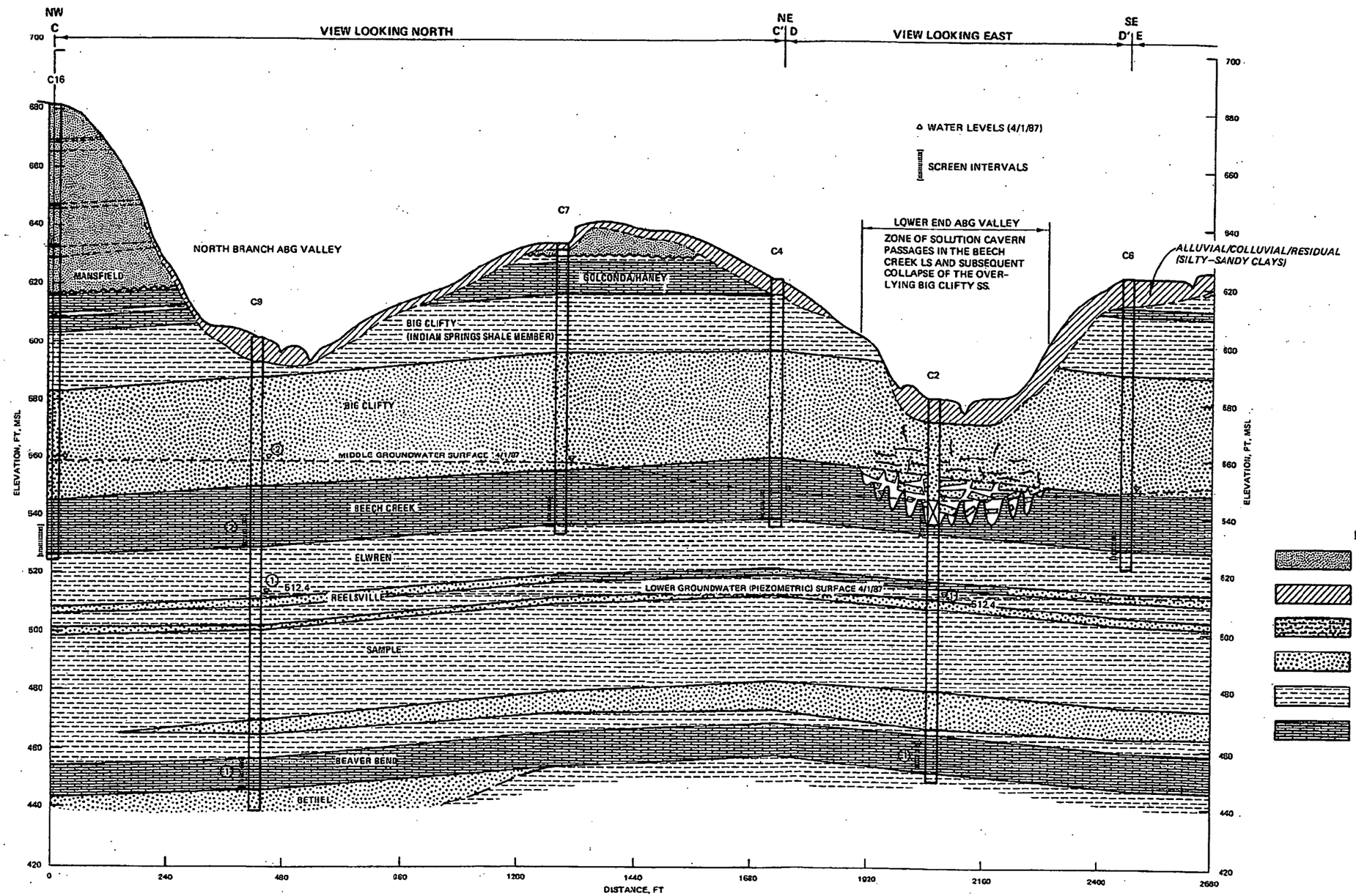
NAVFAC

DRAWN BY A. JANOCHA DATE 7/17/02

CHECKED BY J. SCHUBERT DATE 7/17/02

COST/SCHED-AREA

SCALE AS NOTED



Modified from Hunt, 1988.

CONTRACT NO. 8383

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 1-8

REV 0

GEOLOGIC CROSS SECTION C-C' AND D-D'
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

NAVFAC

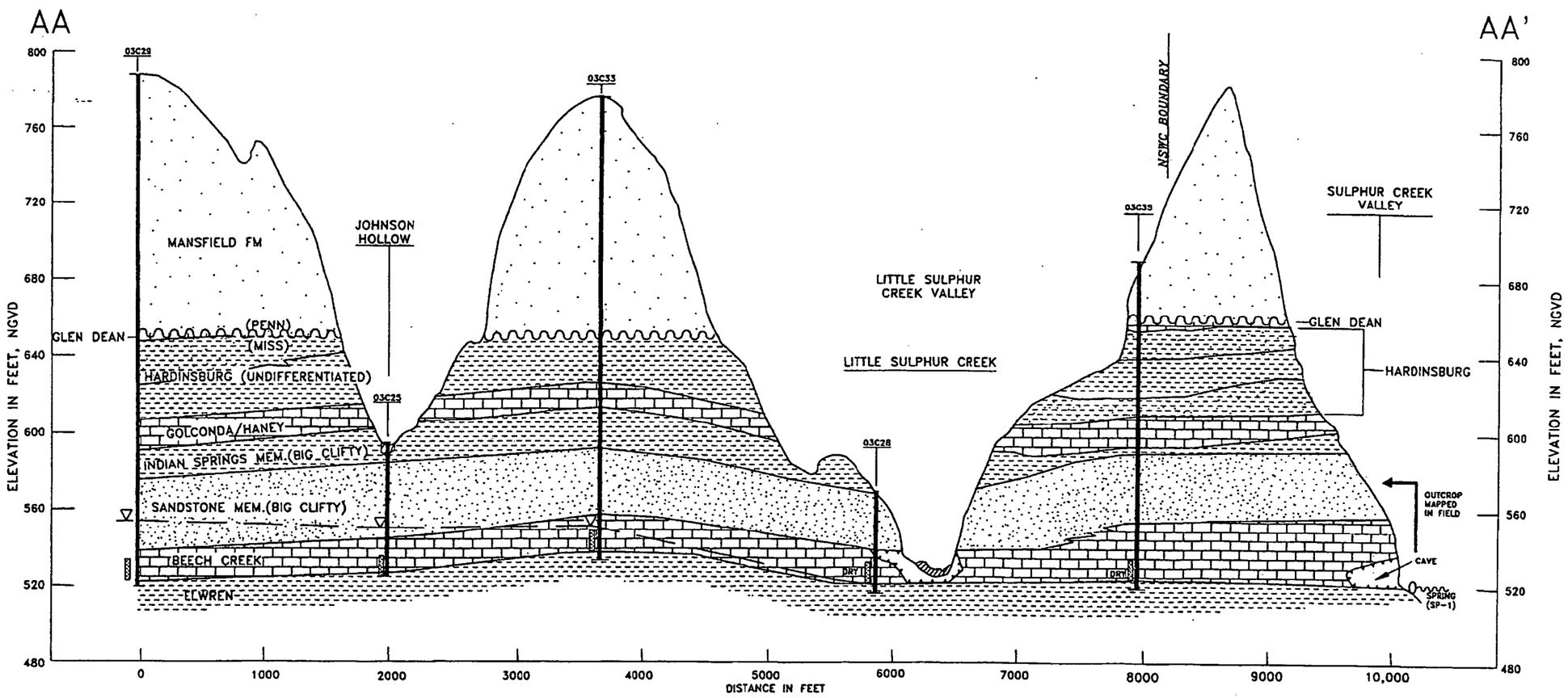
DRAWN BY A. JANOCHA DATE 7/17/02

CHECKED BY J. SCHUBERT DATE 7/17/02

COST/SCHED-AREA

SCALE AS NOTED

/GIS/NSWC_CRANE/APR/JEEPTRAIL_WORKPLAN.APR GEOLOGIC CROSS SECTION AA-AA' LAYOUT 2/14/05 KMP



LEGEND

- SOIL OVERBURDEN
- UNDIFFERENTIATED (PENNSYLVANIAN)
- SHALE AND SANDSTONE
- SANDSTONE
- SHALE
- LIMESTONE
- WATER SURFACE (3/29/91)
- SCREEN INTERVAL
- POSTULATED COLLAPSE OR SOLUTION ZONE

Modified from Murphy, 1994.

CONTRACT NO. 8383

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 1-9

REV 0

GEOLOGIC CROSS SECTION AA-AA'
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

NAVFAC

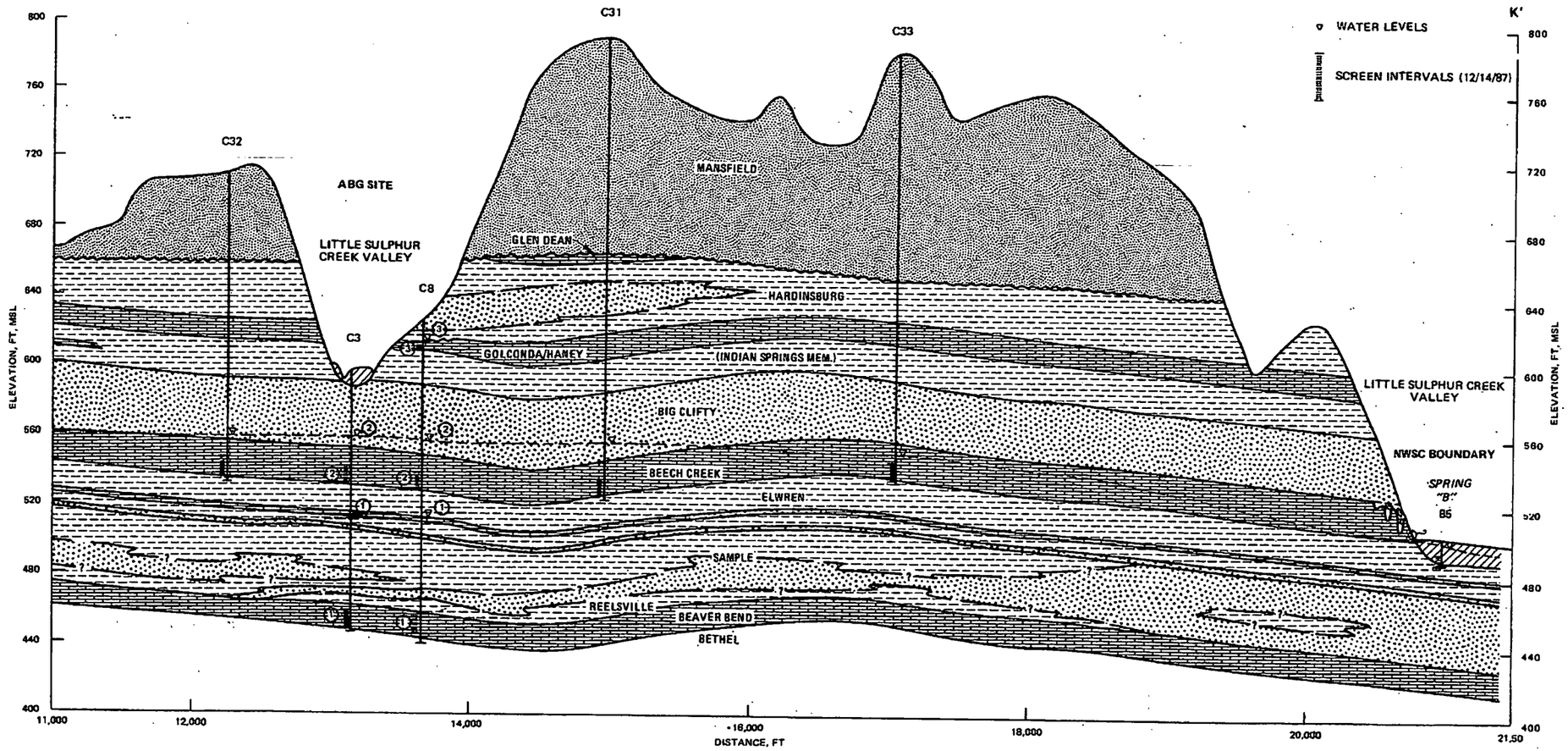
DRAWN BY A. JANOCHA DATE 7/17/02

CHECKED BY J. SCHUBERT DATE 7/17/02

COST/SCHED-AREA

SCALE AS NOTED

/GIS/NSWC_CRANE/APR/JEEPTRAIL_WORKPLAN.APR GEOLOGIC CROSS SECTION K'-K" LAYOUT 2/14/05 KMP



LEGEND

- UNDIFFERENTIATED
- CLAY SYMBOL
- SHALE AND SANDSTONE
- SANDSTONE
- SHALE
- LIMESTONE

Modified from Hunt, 1988.

CONTRACT NO. 8383

APPROVED BY ___ DATE ___

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DRAWING NO. FIGURE 1-10

REV 0

GEOLOGIC CROSS SECTION K'-K"
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

NAVFAC

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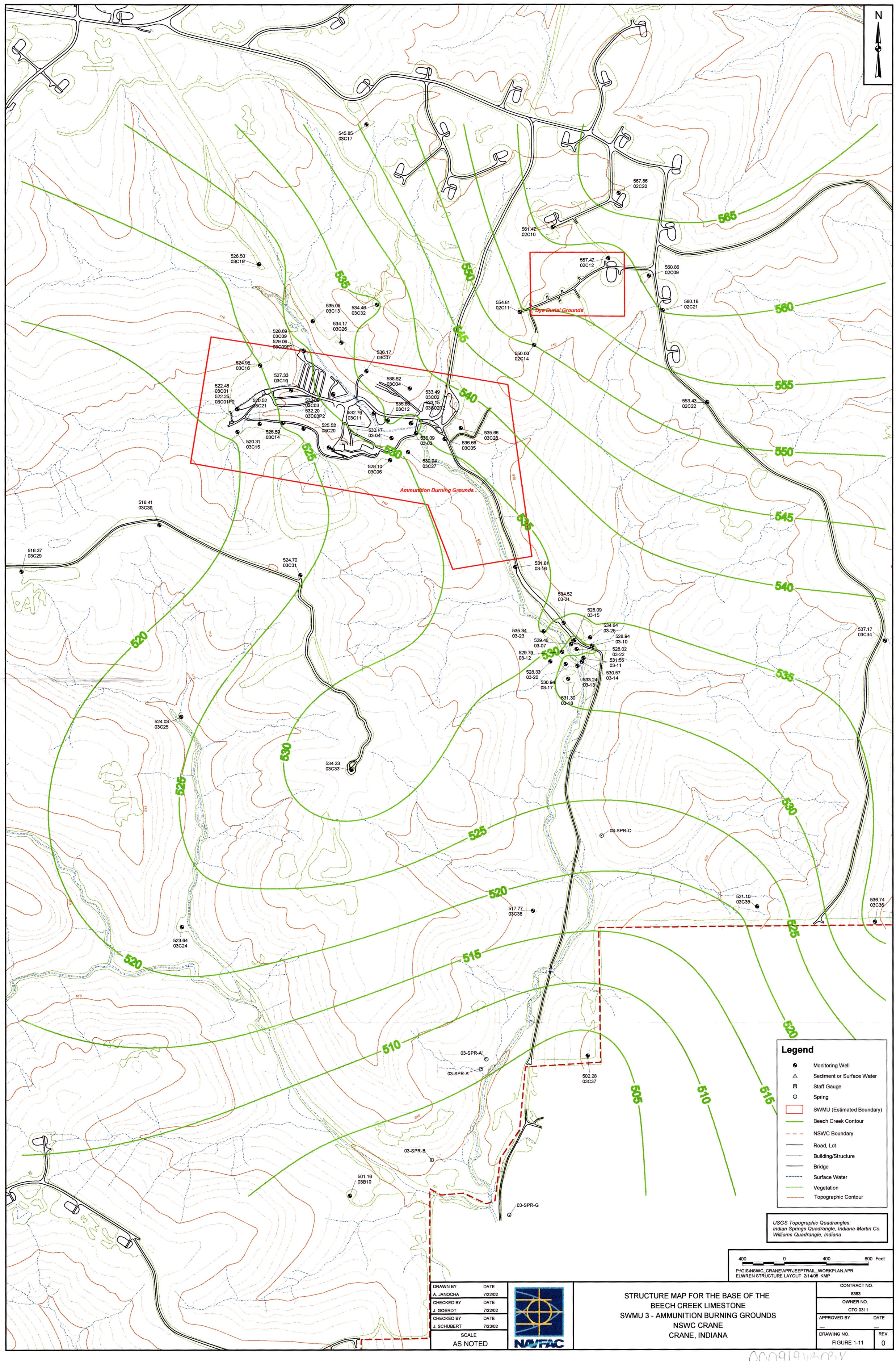

Legend

- Monitoring Well
- Sediment or Surface Water
- Staff Gauge
- Spring
- SWMU (Estimated Boundary)
- Beech Creek Contour
- NSWC Boundary
- Road, Lot
- Building/Structure
- Bridge
- Surface Water
- Vegetation
- Topographic Contour

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

400 0 400 800 Feet

P:\GIS\NSWC_CRANE\APR\JEEPTRAIL_WORKPLAN.APR
ELWREN STRUCTURE LAYOUT 2/14/05 KMP

DRAWN BY	DATE
A. JANOCHA	7/22/02
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J. GOERDT	7/22/02
CHECKED BY	DATE
J. SCHUBERT	7/23/02
SCALE	
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STRUCTURE MAP FOR THE BASE OF THE
BEECH CREEK LIMESTONE
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

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FIGURE 1-11	0

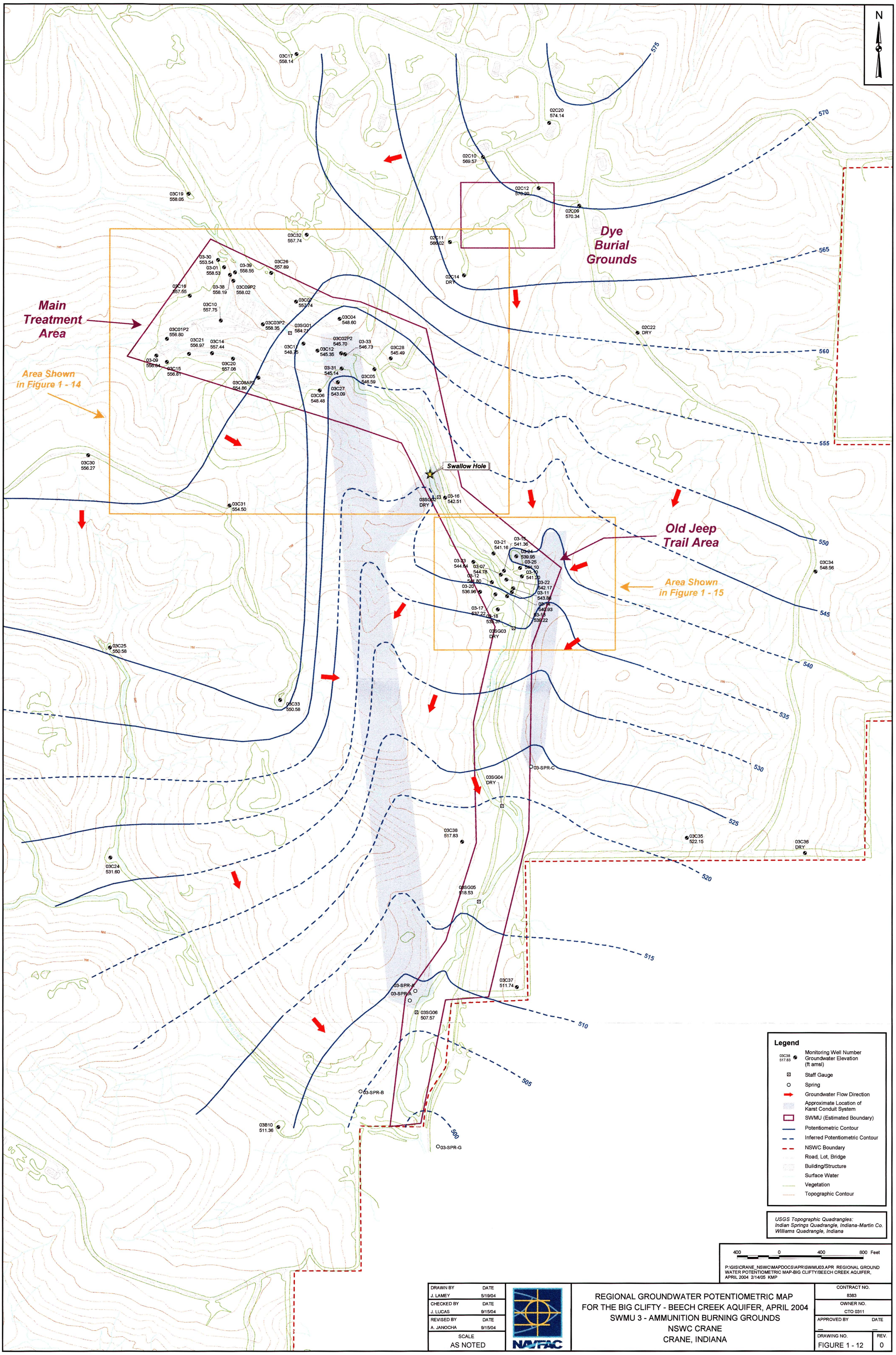
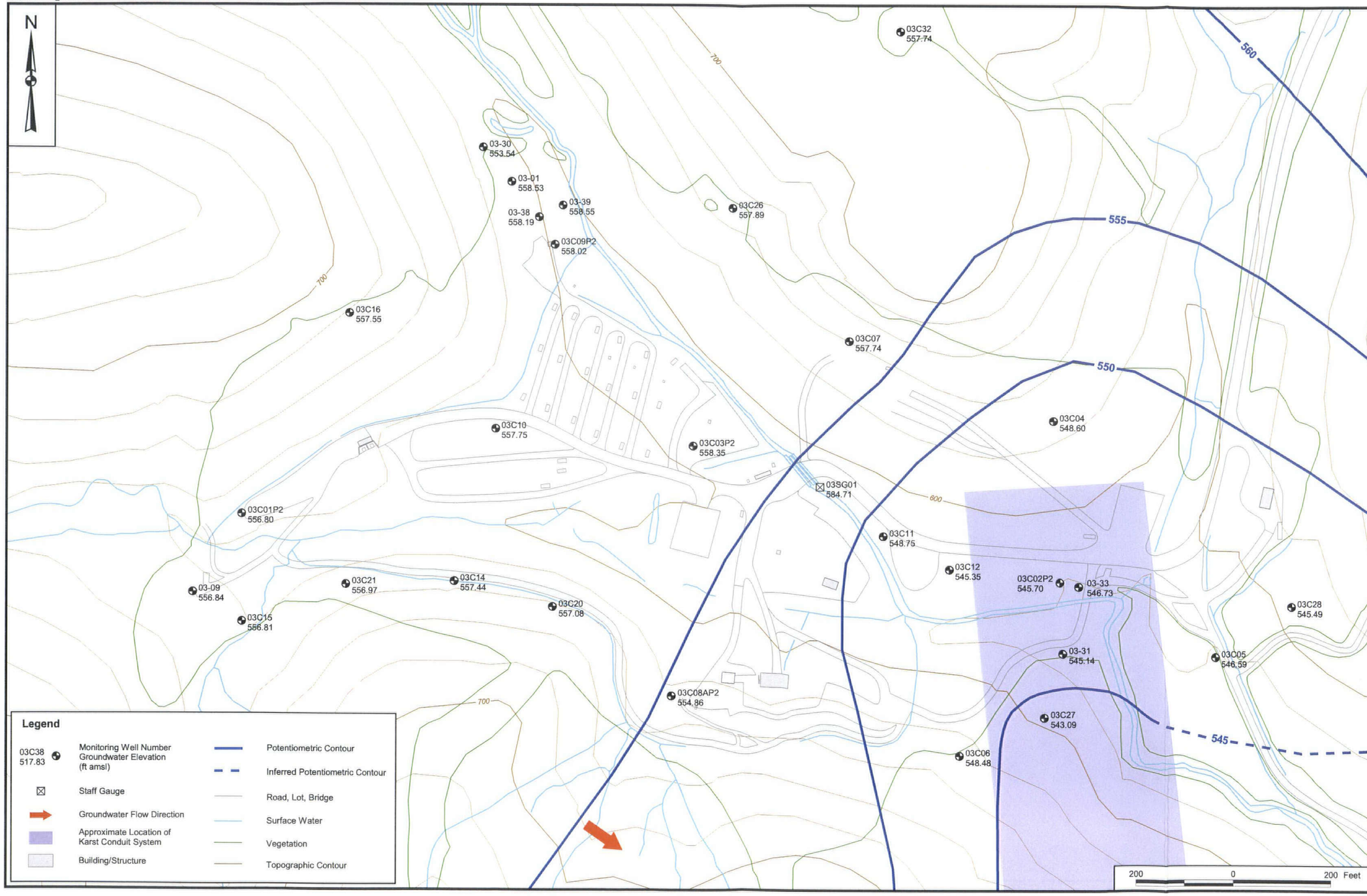

N
Dye Burial Grounds
Main Treatment Area
Area Shown in Figure 1 - 14
Old Jeep Trail Area
Area Shown in Figure 1 - 15
Swallow Hole
03C17 558.14
02C20 574.14
02C10 569.57
02C12 570.20
02C09 570.34
03C19 558.05
03C32 557.74
02C11 566.02
02C14 DRY
02C22 DRY
03-30 553.54
03-01 558.53
03-39 558.55
03C26 557.89
03C16 557.55
03-38 558.19
03C09P2 558.02
03C10 557.75
03C07 557.74
03C04 548.60
03C03P2 558.35
03SG01 584.73
03C01P2 556.80
03C21 556.97
03C14 557.44
03C02P2 545.70
03-33 546.73
03C11 548.75
03C12 545.35
03C28 545.49
03-09 556.84
03C15 556.81
03C20 557.08
03-31 545.14
03C05 546.59
03C08AP2 554.86
03C27 543.09
03C06 548.48
03C30 556.27
03C31 554.50
03SG02 DRY
03-16 542.51
03-21 541.16
03-15 541.36
03-24 539.95
03-25 541.10
03-23 544.64
03-07 544.78
03-10 541.20
03-12 541.80
03-22 542.17
03-20 536.96
03-11 543.86
03-14 540.93
03-17 537.22
03-18 535.37
03-13 539.22
03SG03 DRY
03C34 548.56
03C25 550.58
03C33 550.58
03-SPR-C
03SG04 DRY
03C38 517.83
03C35 522.15
03C36 DRY
03C24 531.60
03SG05 518.53
03C37 511.74
03-SPR-A
03-SPR-A
03SG06 507.57
03-SPR-B
03B10 511.36
03-SPR-G
575
570
565
560
555
550
545
540
535
530
525
520
515
510
505
500
Legend
03C38 517.83 Monitoring Well Number Groundwater Elevation (ft amsl)
Staff Gauge
Spring
Groundwater Flow Direction
Approximate Location of Karst Conduit System
SWMU (Estimated Boundary)
Potentiometric Contour
Inferred Potentiometric Contour
NSWC Boundary
Road, Lot, Bridge
Building/Structure
Surface Water
Vegetation
Topographic Contour
USGS Topographic Quadrangles:
Indian Springs Quadrangle, Indiana-Martin Co.
Williams Quadrangle, Indiana
400 0 400 800 Feet
P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU03.APR REGIONAL GROUND WATER POTENTIOMETRIC MAP-BIG CLIFTY/BEECH CREEK AQUIFER, APRIL 2004 2/14/05 KMP
DRAWN BY J. LAMEY DATE 5/19/04
CHECKED BY J. LUCAS DATE 9/15/04
REVISED BY A. JANOCHA DATE 9/15/04
SCALE AS NOTED
NAVFAC
REGIONAL GROUNDWATER POTENTIOMETRIC MAP
FOR THE BIG CLIFTY - BEECH CREEK AQUIFER, APRIL 2004
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA
CONTRACT NO. 8383
OWNER NO. CTO 0311
APPROVED BY —
DATE —
DRAWING NO. FIGURE 1 - 12
REV. 0

FIGURE 1-13
DISTRIBUTION OF ESTIMATED HYDRAULIC CONDUCTIVITY VALUES IN THE BEECH CREEK/BIG CLIFTY AQUIFER (ft/day)
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU03.APR MAIN TREATMENT AREA INSET LAYOUT 2/14/05 KMP



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APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 1 - 14

REV 0

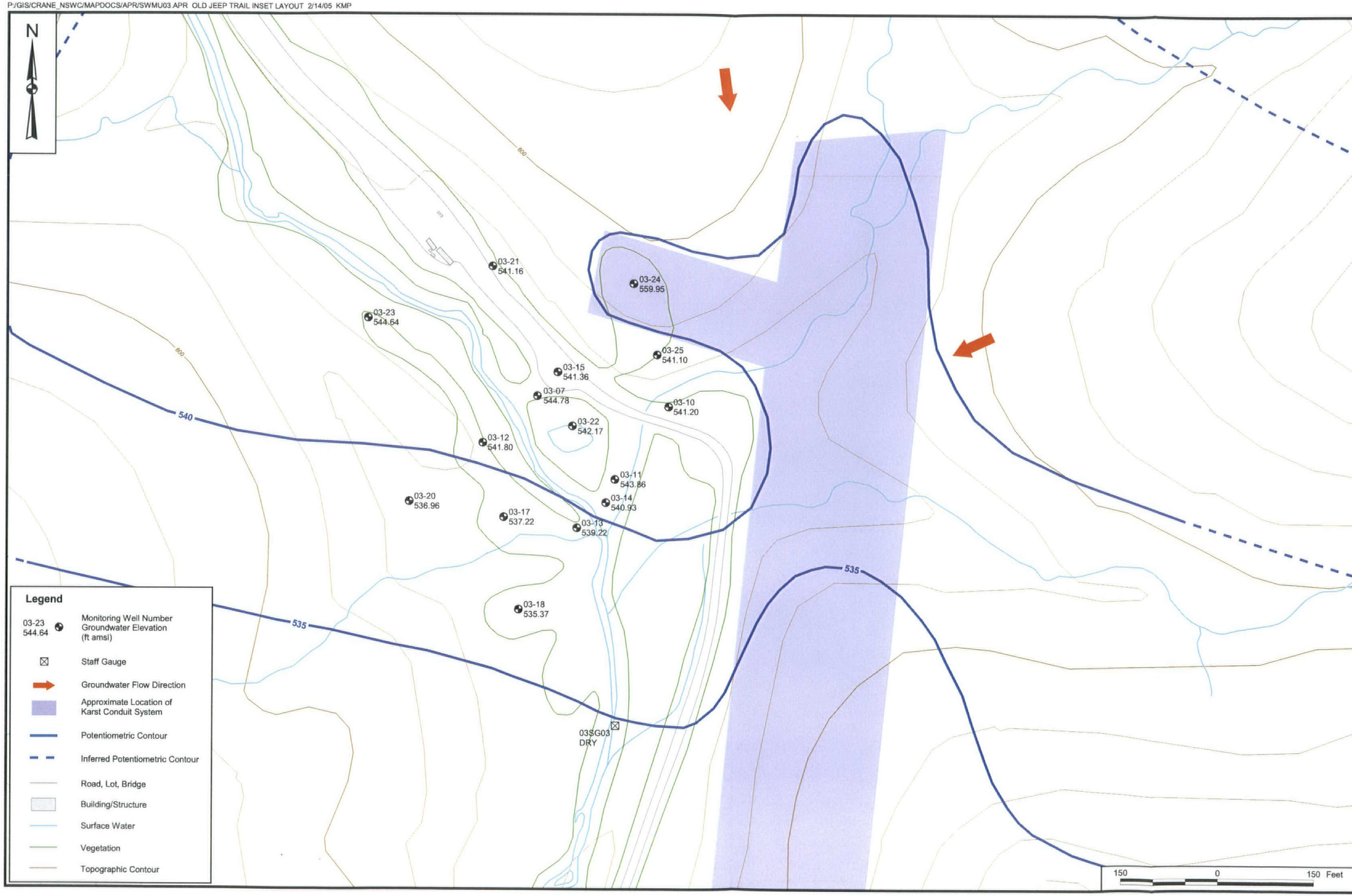
GROUNDWATER POTENTIOMETRIC MAP
FOR THE BIG CLIFTY - BEECH CREEK AQUIFER, APRIL 2004
MAIN TREATMENT AREA INSET
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

NAVFAC

	DATE
DRAWN BY A. JANOCHA	8/11/04
CHECKED BY J. LUCAS	9/16/04
COST/SCHED-AREA	

SCALE
AS NOTED

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU03.APR OLD JEEP TRAIL INSET LAYOUT 2/14/05 KMP



CONTRACT NO. 8383

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APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 1 - 15

REV 0

GROUNDWATER POTENTIOMETRIC MAP
FOR THE BIG CLIFTY - BEECH CREEK AQUIFER, APRIL 2004
OLD JEEP TRAIL INSET
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

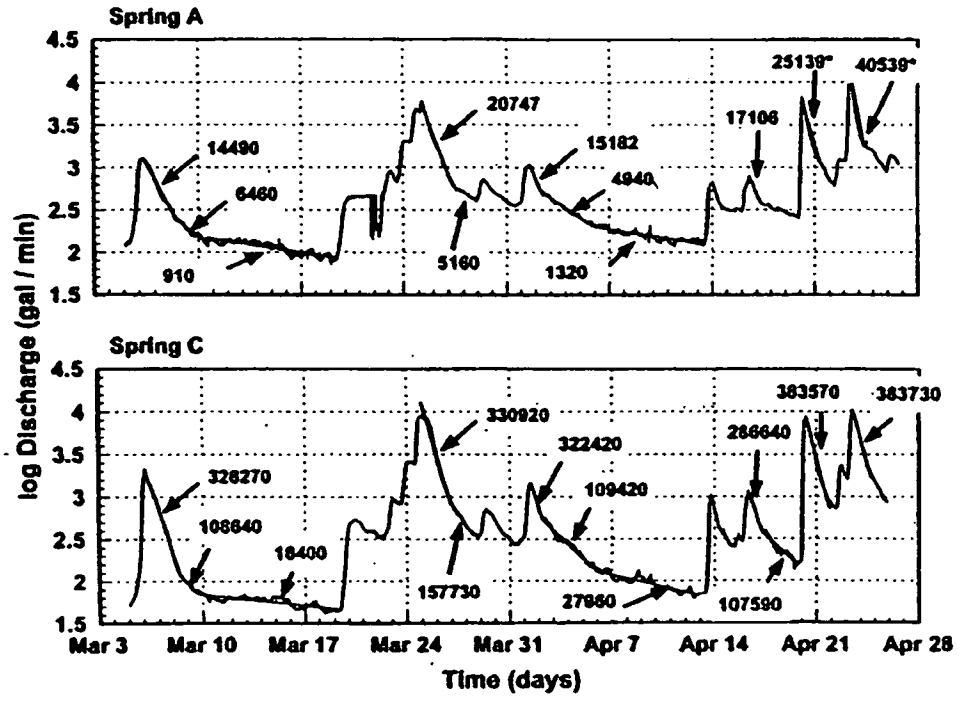
NAVFAC

DRAWN BY A. JANOCHA DATE 8/11/04

CHECKED BY J. LUCAS DATE 9/16/04

COST/SCHED-AREA

SCALE AS NOTED



Two-month hydrographs for Springs A and C (thin lines) during March – April 1996. Heavy lines show the conduit-, mixed-, and diffuse-flow systems. Numbers correspond to the ratio of T/Sy calculated from the corresponding segment of the hydrograph. An * next to the values of T/Sy indicates that discharges exceeded the calibrated range of the weir and pressure transducers for the rain event

SOURCE: JOCK AND KROTHE, 2002

DRAWN BY A. JANOCHA DATE 7/21/02	NAVFAC	FLOW HYDROGRAPHS FOR SPRINGS A AND C, MARCH-APRIL 1996	CONTRACT NUMBER 8383
CHECKED BY J. SCHUBERT DATE 7/21/02		SWMU 3 - AMMUNITION BURNING GROUNDS	APPROVED BY — DATE —
COST/SCHEDULE-AREA		NSWC CRANE	APPROVED BY — DATE —
SCALE AS NOTED		CRANE, INDIANA	DRAWING NO. FIGURE 1-16 REV 0

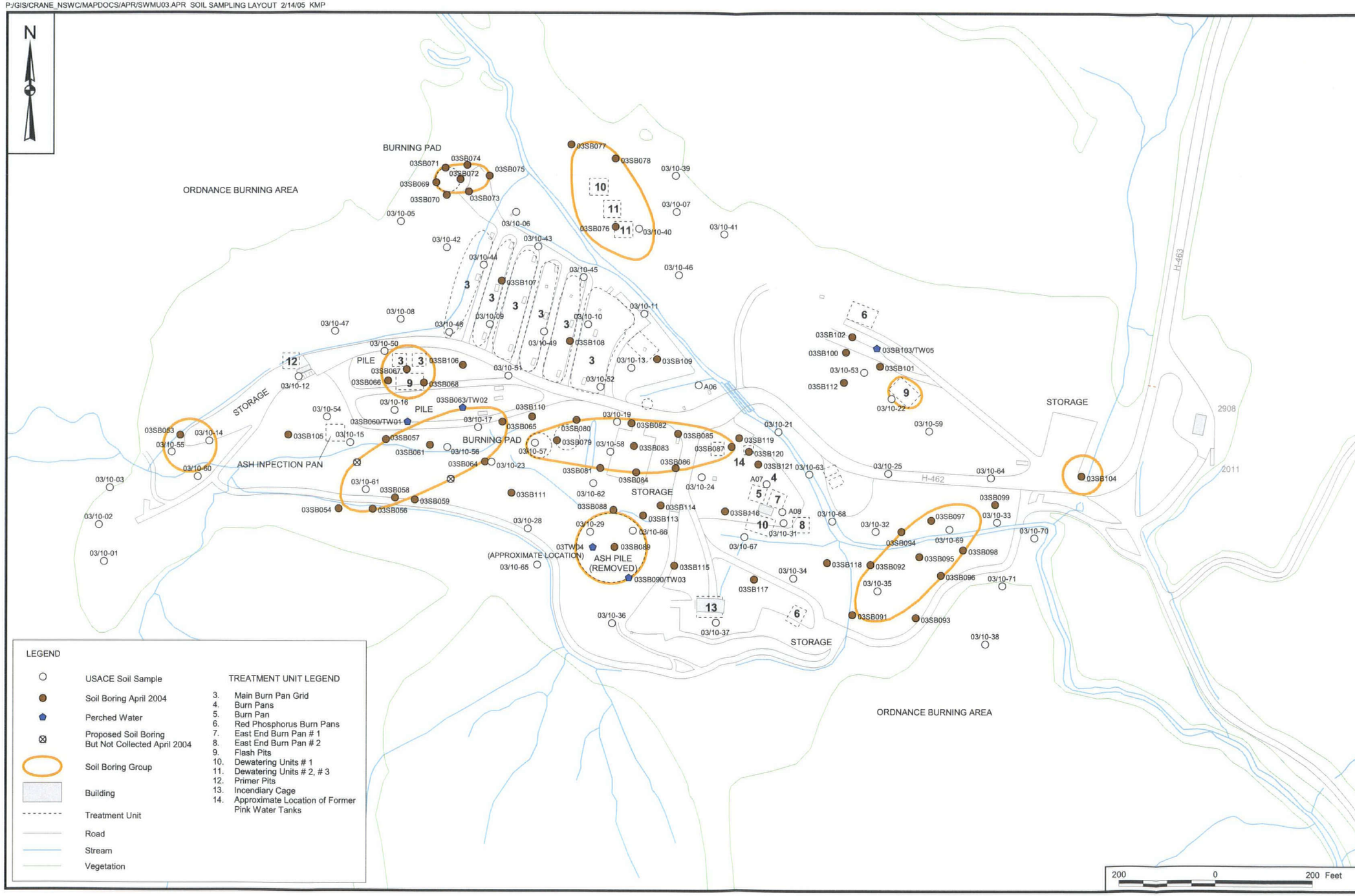
P:\GIS\NSWC_CRANE\APR\JEEPTRAIL_WORKPLAN.APR FLOW HYDROGRAPHS FOR SPRINGS A AND C, MARCH-APRIL 1996 LAYOUT 2/14/05 KMP

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

DRAWN BY J. LAMEY DATE 6/1/00	NAVFAC	LOCATION OF AMMUNITION BURNING GROUNDS, OLD JEEP TRAIL, LITTLE SULPHUR CREEK, AND MAJOR DRAINAGE BASINS SWMU 3 - AMMUNITION BURNING GROUNDS NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER 8383
CHECKED BY J. SCHUBERT DATE 8/22/02			APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 1-17 REV 0

P:\GIS\NSWC_CRANE\7651.APR AOC LOCATIONS AND DRAINAGE BASINS 2/14/05 KMP

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU03.APR SOIL SAMPLING LAYOUT 2/14/05 KMP



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APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 1 - 18

REV 0

SOIL SAMPLING LOCATIONS APRIL 2004
AMMUNITION BURNING GROUNDS MAIN TREATMENT AREA
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

NAVFAC

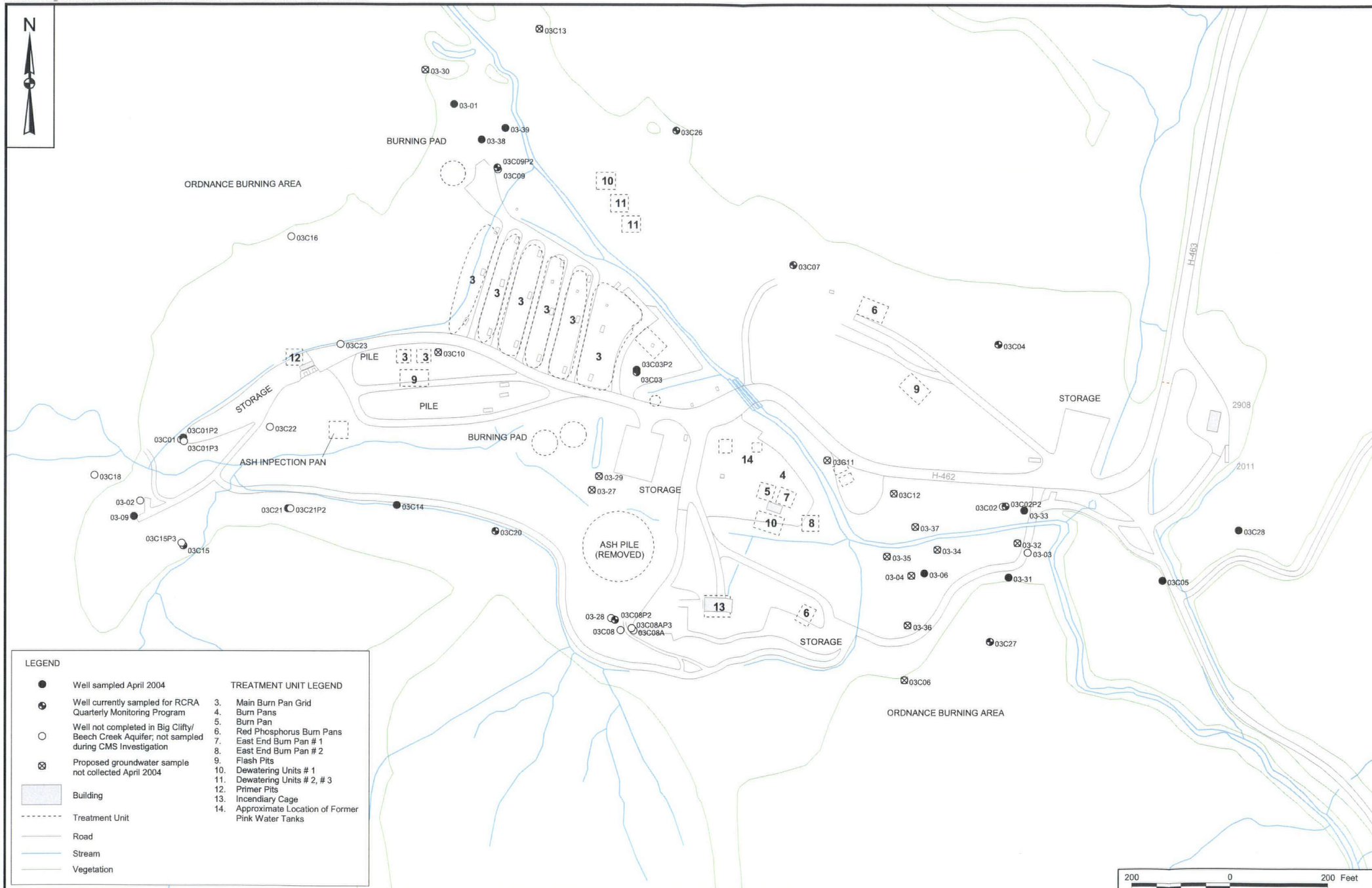
DRAWN BY A. JANOCHA DATE 9/14/04

CHECKED BY J. LUCAS DATE 9/15/04

COST/SCHED-AREA

SCALE AS NOTED

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU03.APR GROUNDWATER SAMPLING LAYOUT 2/14/05 KMP



CONTRACT NO. 8383

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APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 1 - 19

REV 0

GROUNDWATER SAMPLING LOCATIONS APRIL 2004
AMMUNITION BURNING GROUNDS MAIN TREATMENT AREA
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

NAVFAC

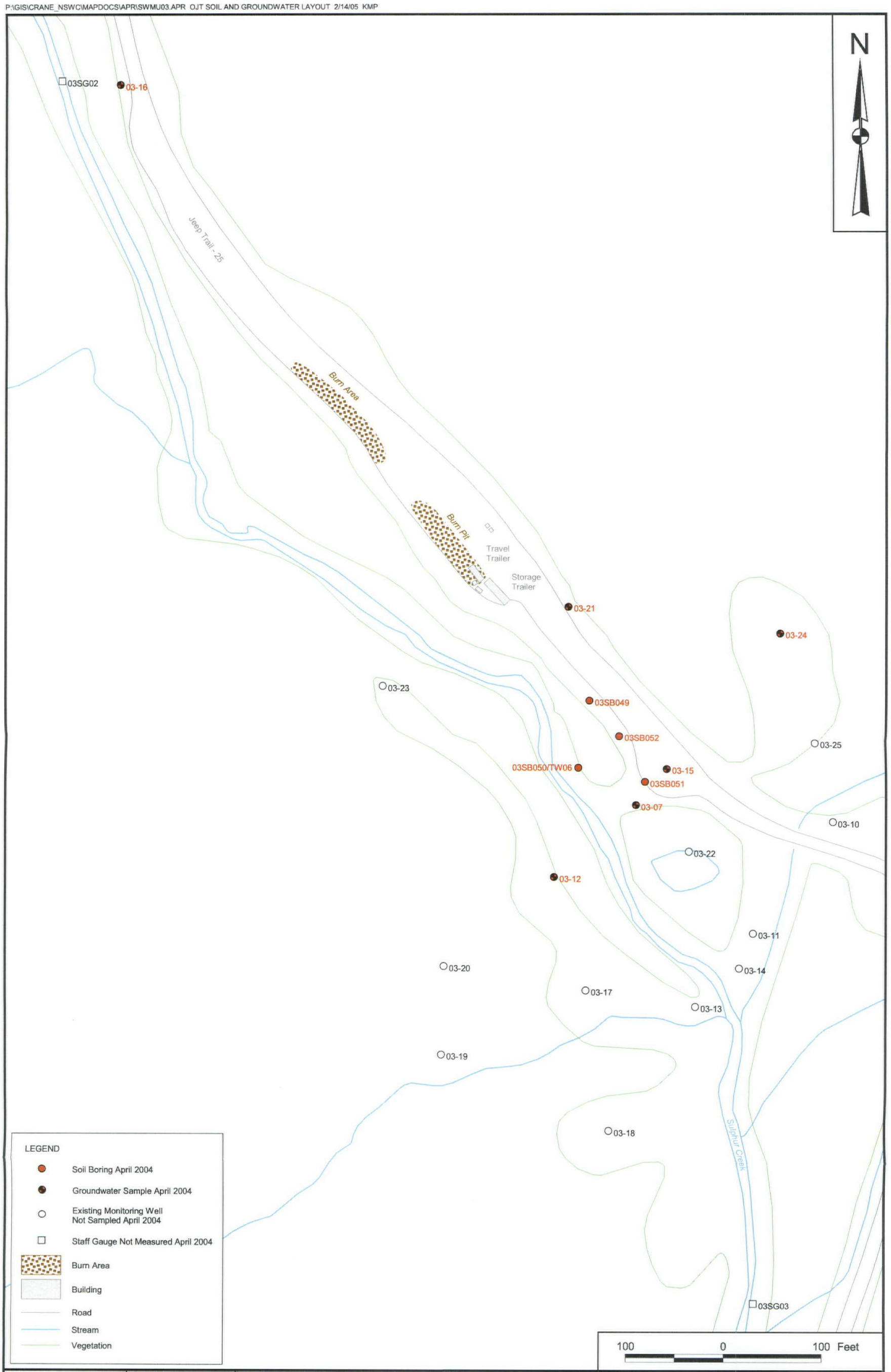
DRAWN BY A. JANOCHA DATE 9/14/04

CHECKED BY J. LUCAS DATE 9/15/04

COST/SCHED-AREA

SCALE AS NOTED

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU03.APR OJT SOIL AND GROUNDWATER LAYOUT 2/14/05 KMP



DRAWN BY	DATE
A. JANOCHA	9/15/04
CHECKED BY	DATE
J. LUCAS	9/15/04
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

NAVFAC

SOIL AND GROUNDWATER SAMPLING LOCATIONS APRIL 2004
OLD JEEP TRAIL AREA
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

CONTRACT NUMBER	
8383	
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APPROVED BY	DATE
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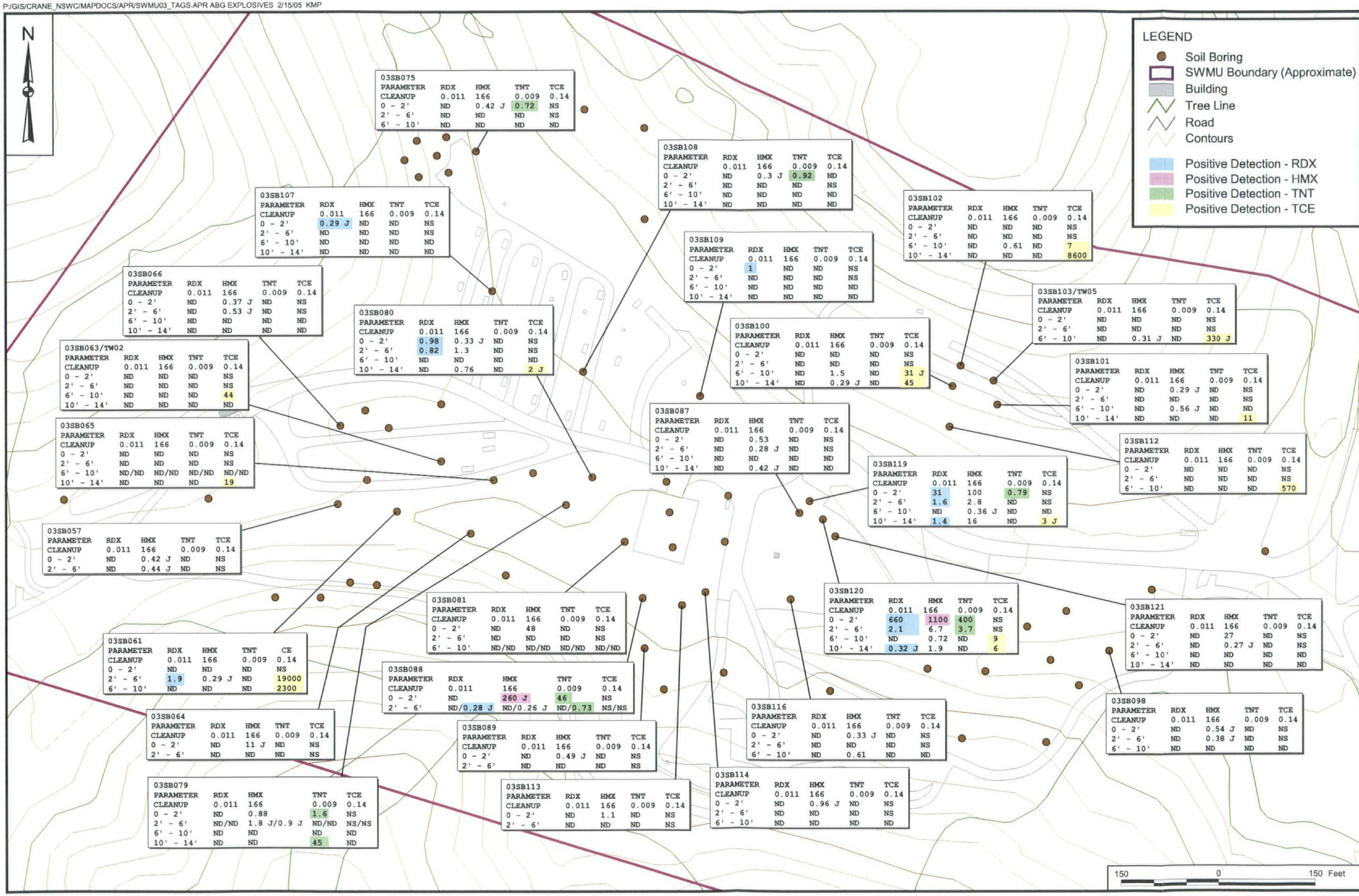
FIGURE 1 - 20	0

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU03_TAGS.APR ABG EXPLOSIVES 2/15/05 KMP



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APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 1 - 21

REV 0

SOIL SAMPLING LOCATIONS APRIL 2004
AMMUNITION BURNING GROUNDS MAIN TREATMENT AREA
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

NAVFAC

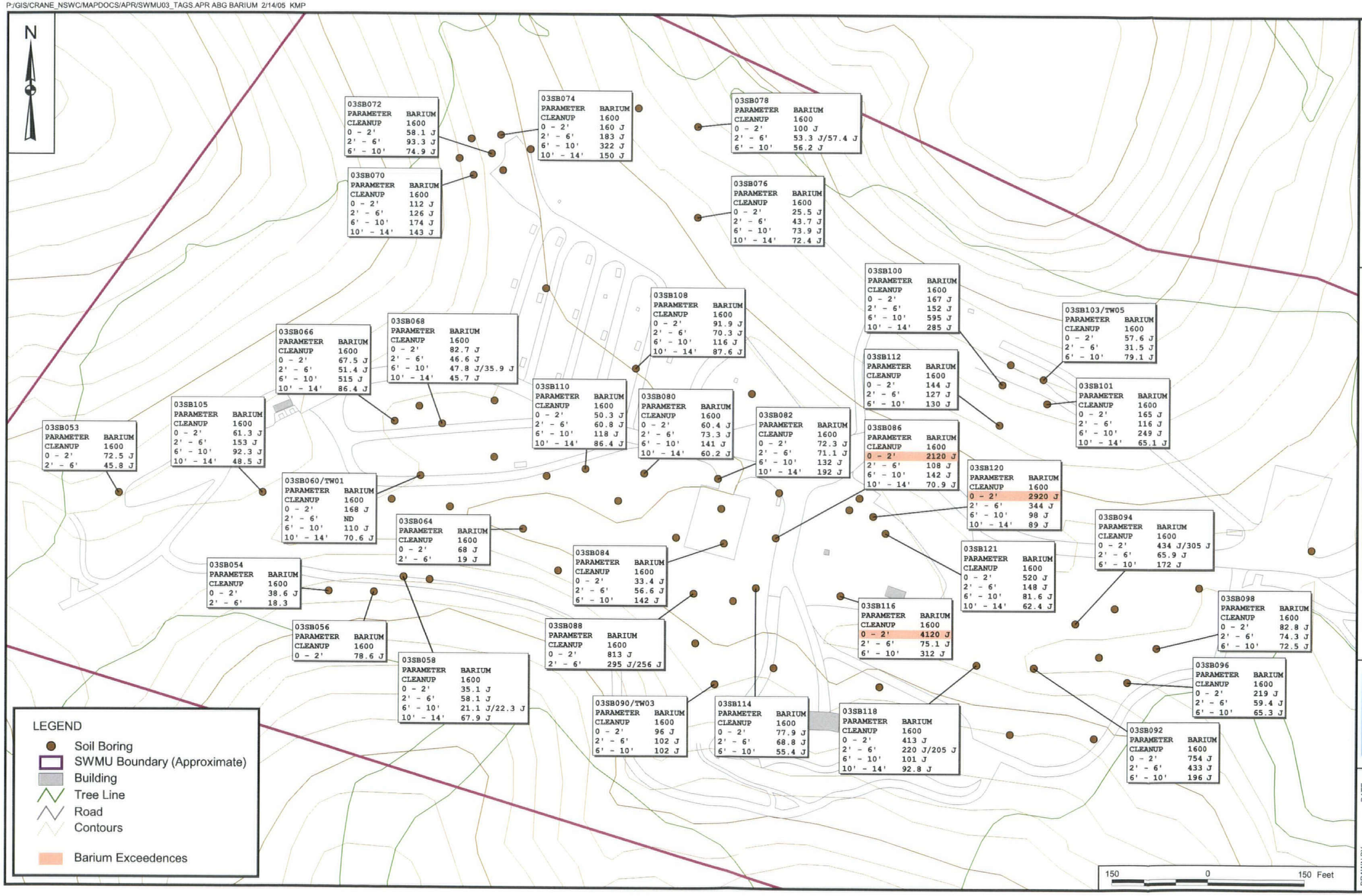
DRAWN BY A. JANOCHA DATE 9/14/04

CHECKED BY J. LUCAS DATE 9/15/04

COST/SCHED-AREA

SCALE AS NOTED

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU03_TAGS.APR ABG BARIUM 2/14/05 KMP



CONTRACT NO. 8383

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REV 0

MAIN TREATMENT AREA BARIUM
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

NAVFAC

DRAWN BY A. JANOCHA DATE 9/14/04

CHECKED BY J. LUCAS DATE 9/15/04

COST/SCHED-AREA

SCALE AS NOTED

FIGURE 1-23
RDX CONCENTRATIONS IN THE BIG CLIFTY/BEECH CREEK AQUIFER IN 1990
SWMU 3 – AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

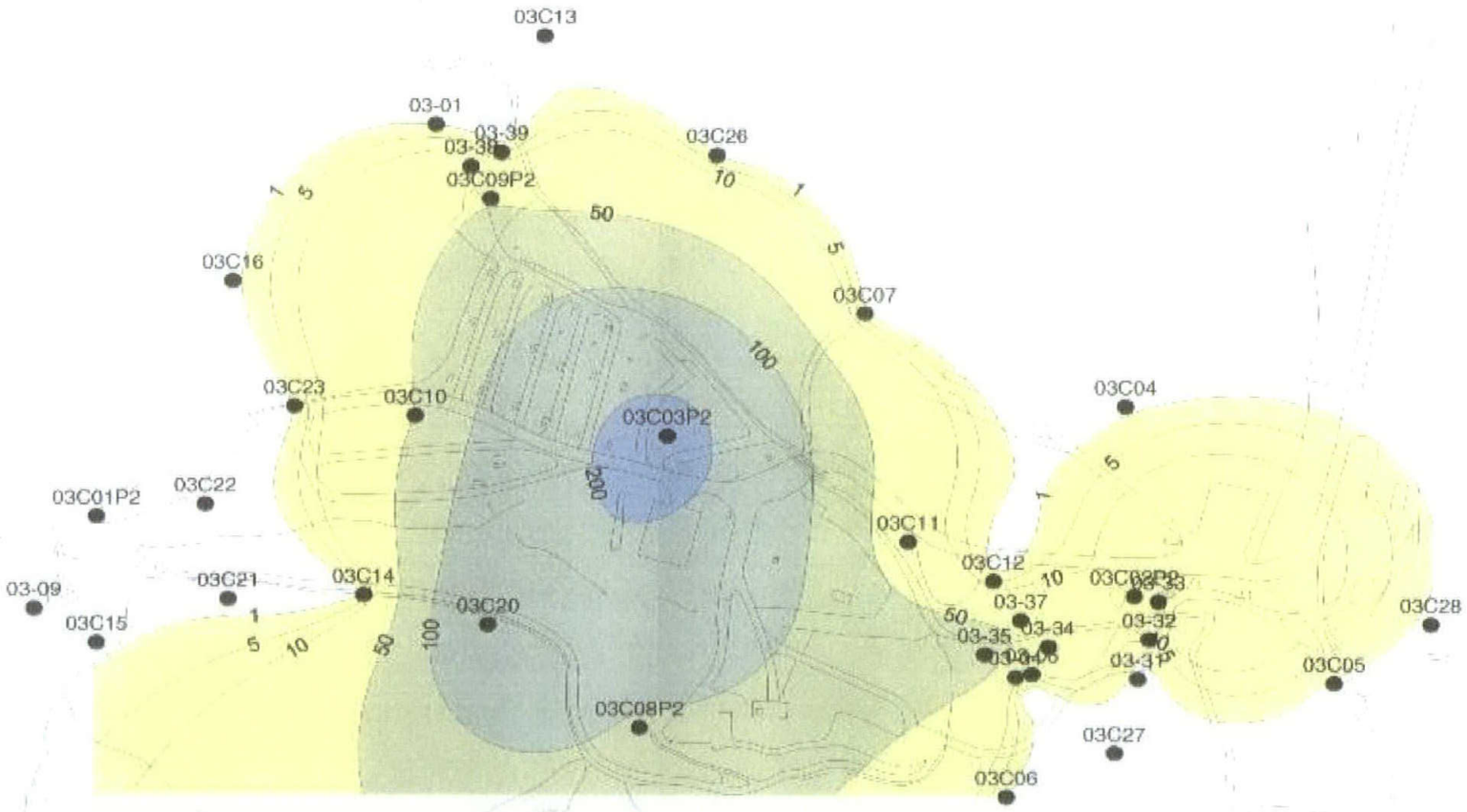


FIGURE 1-24
RDX CONCENTRATIONS IN THE BIG CLIFTY/BEECH CREEK AQUIFER IN 2004
SWMU 3 – AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

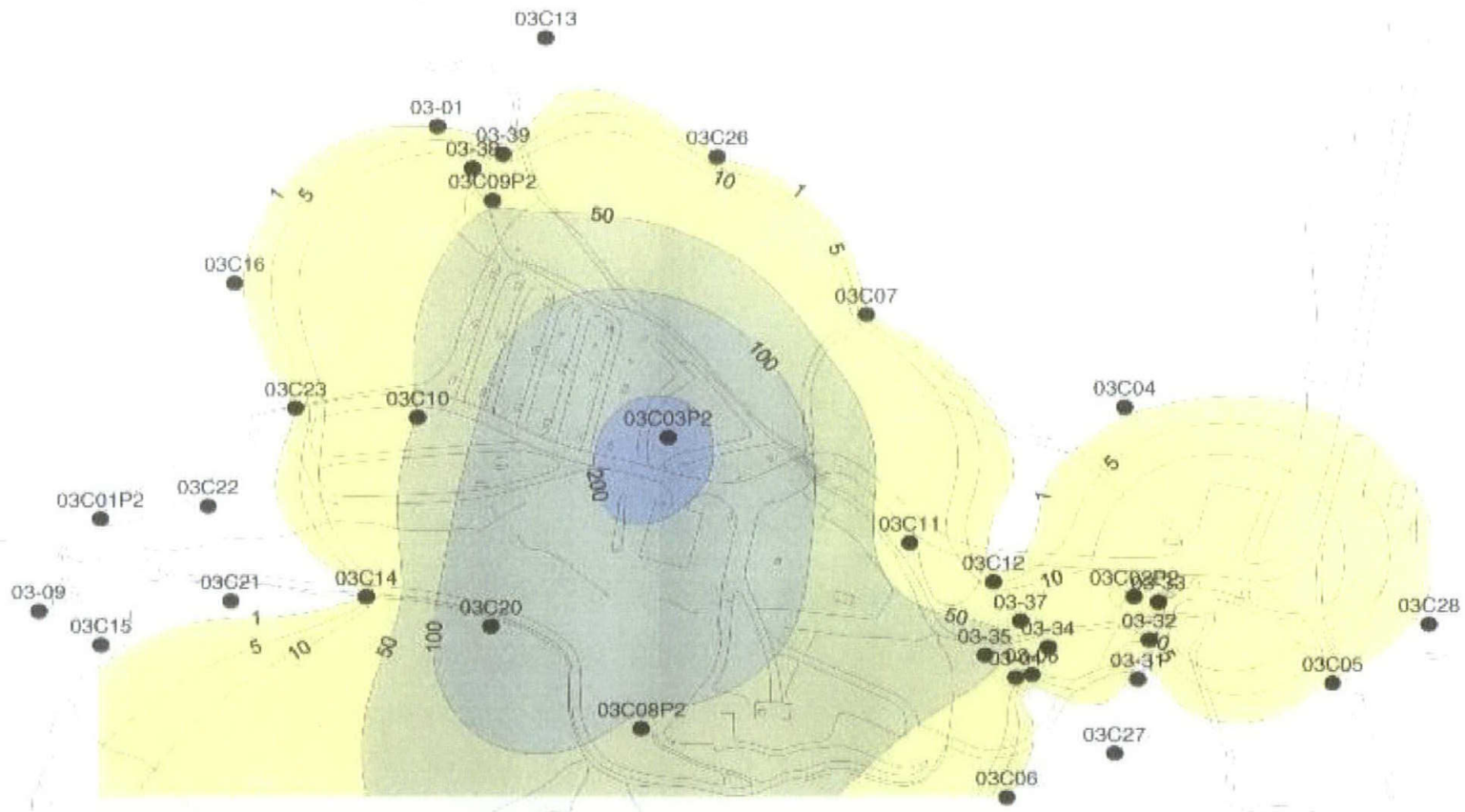


FIGURE 1-25
TCE CONCENTRATIONS IN THE BIG CLIFTY/BEECH CREEK AQUIFER IN 1990
SWMU 3 – AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

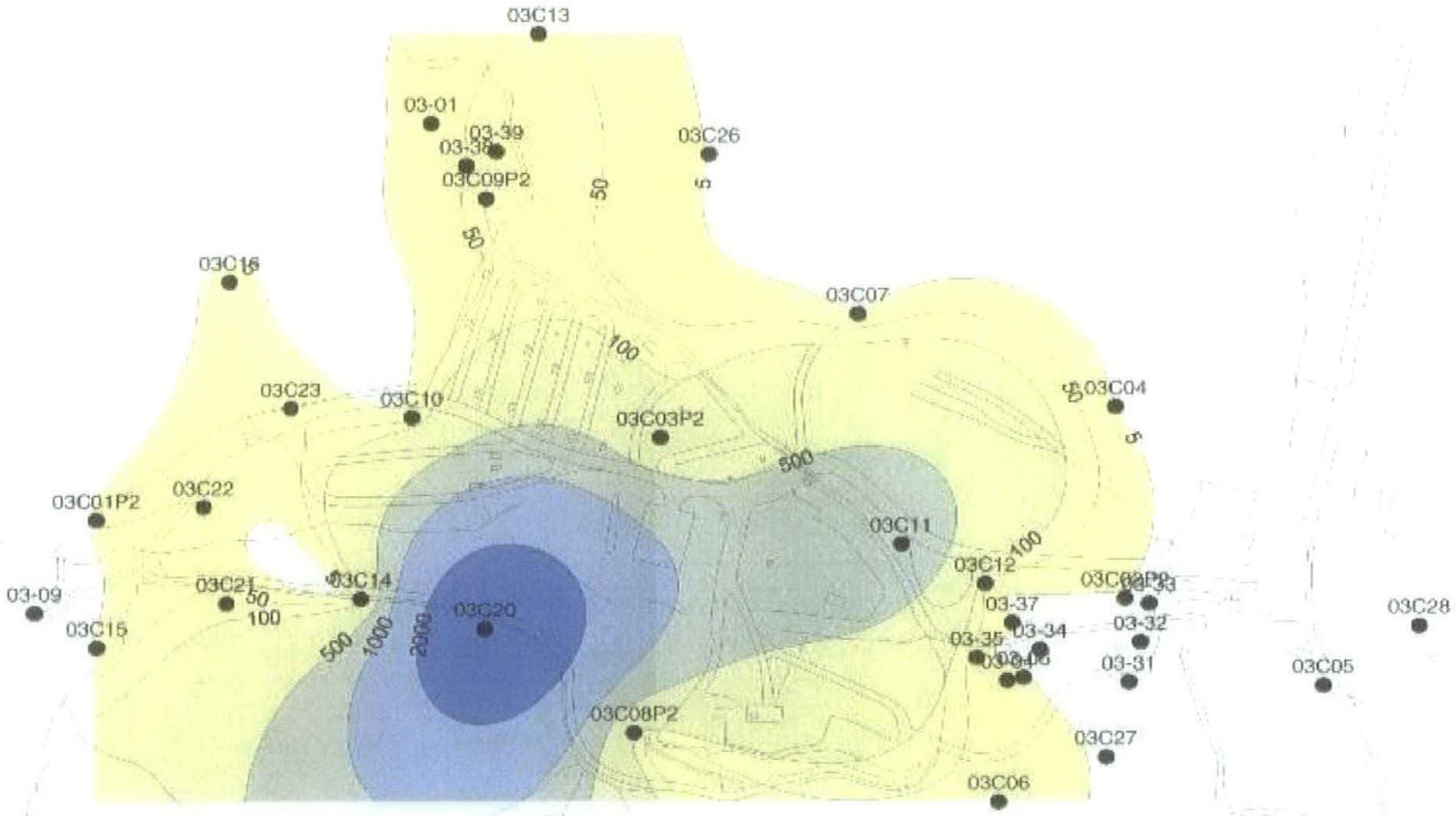
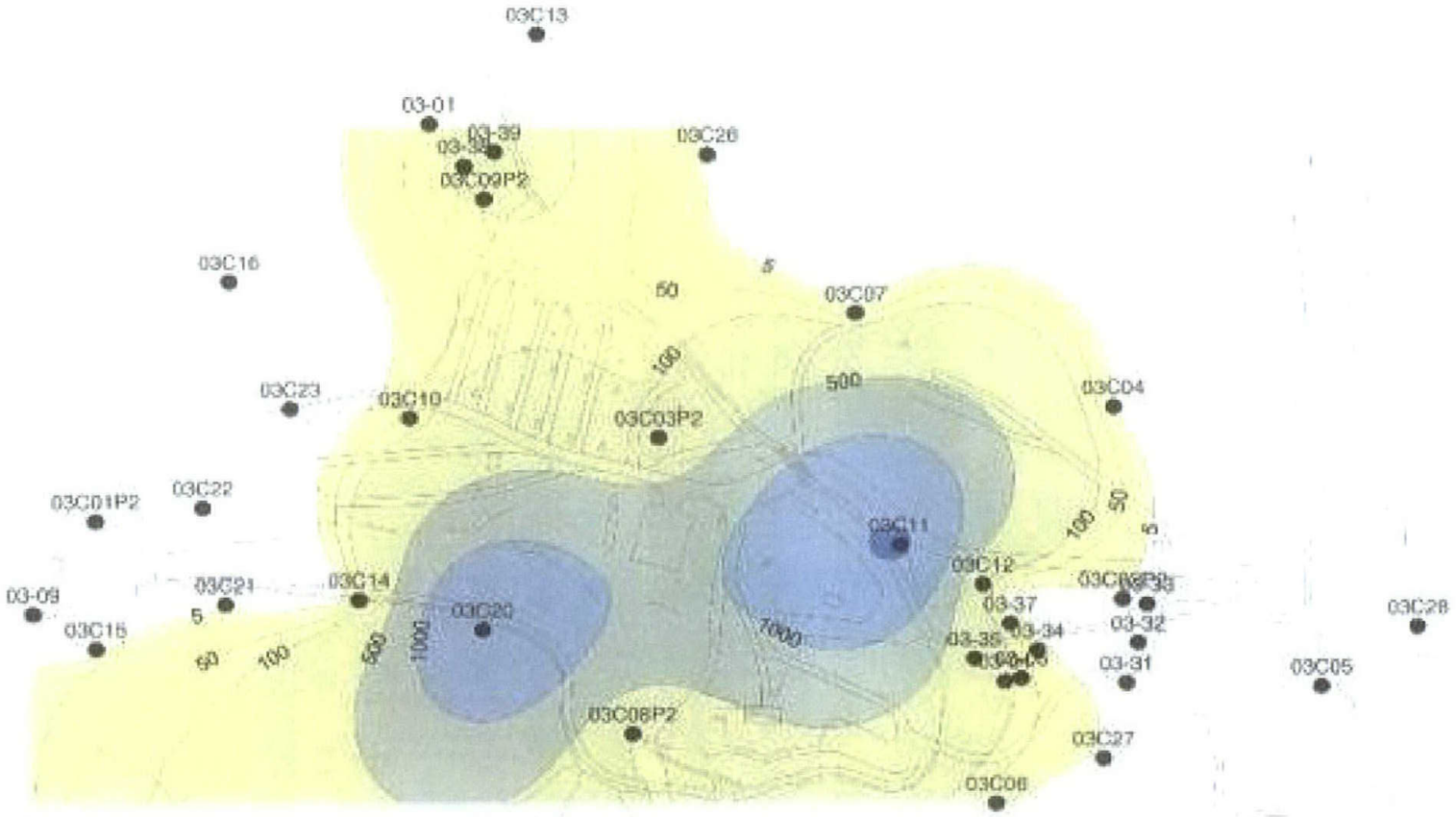


FIGURE 1-26
TCE CONCENTRATIONS IN THE BIG CLIFTY/BEECH CREEK AQUIFER IN 2004
SWMU 3 – AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA



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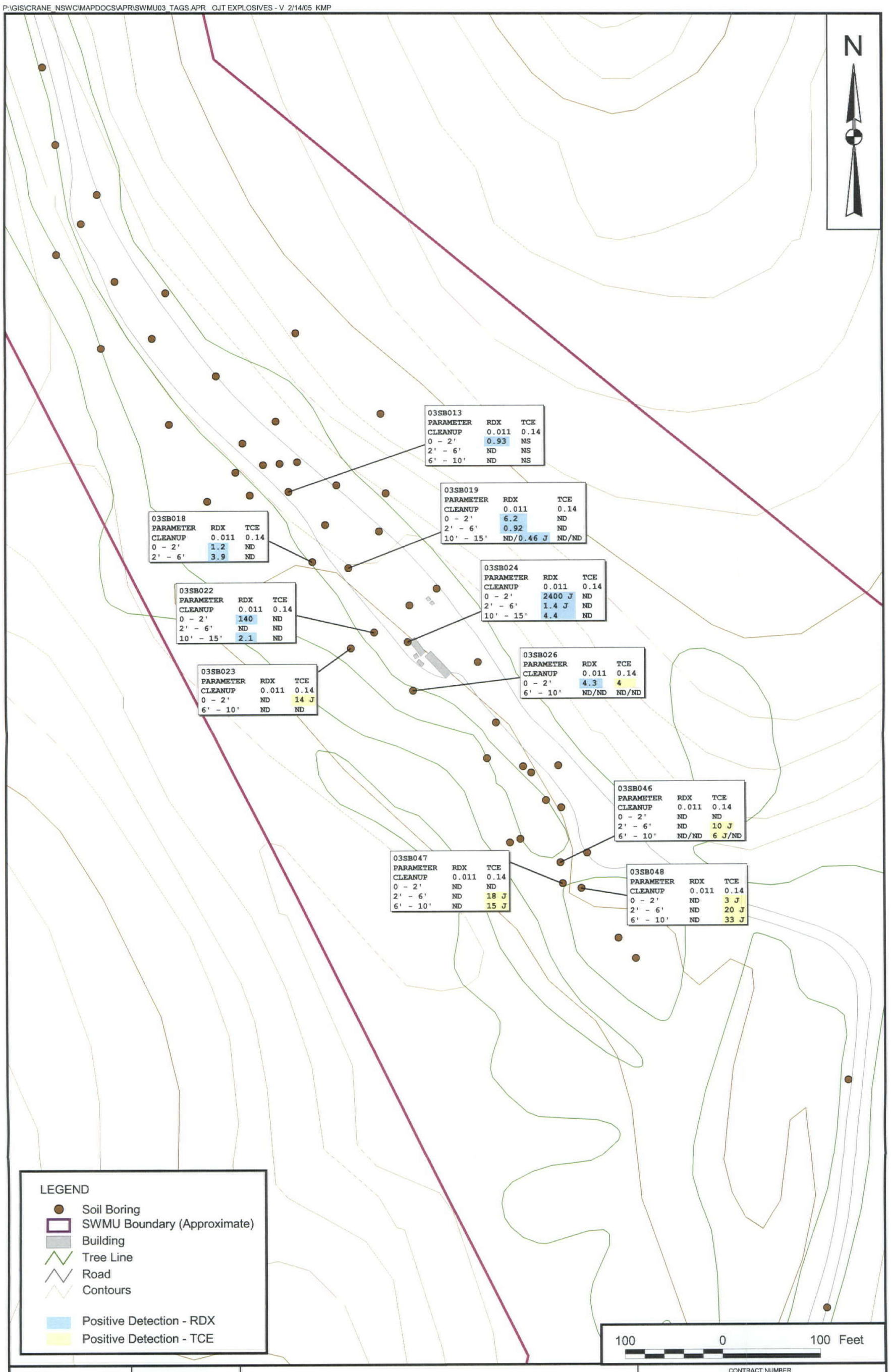
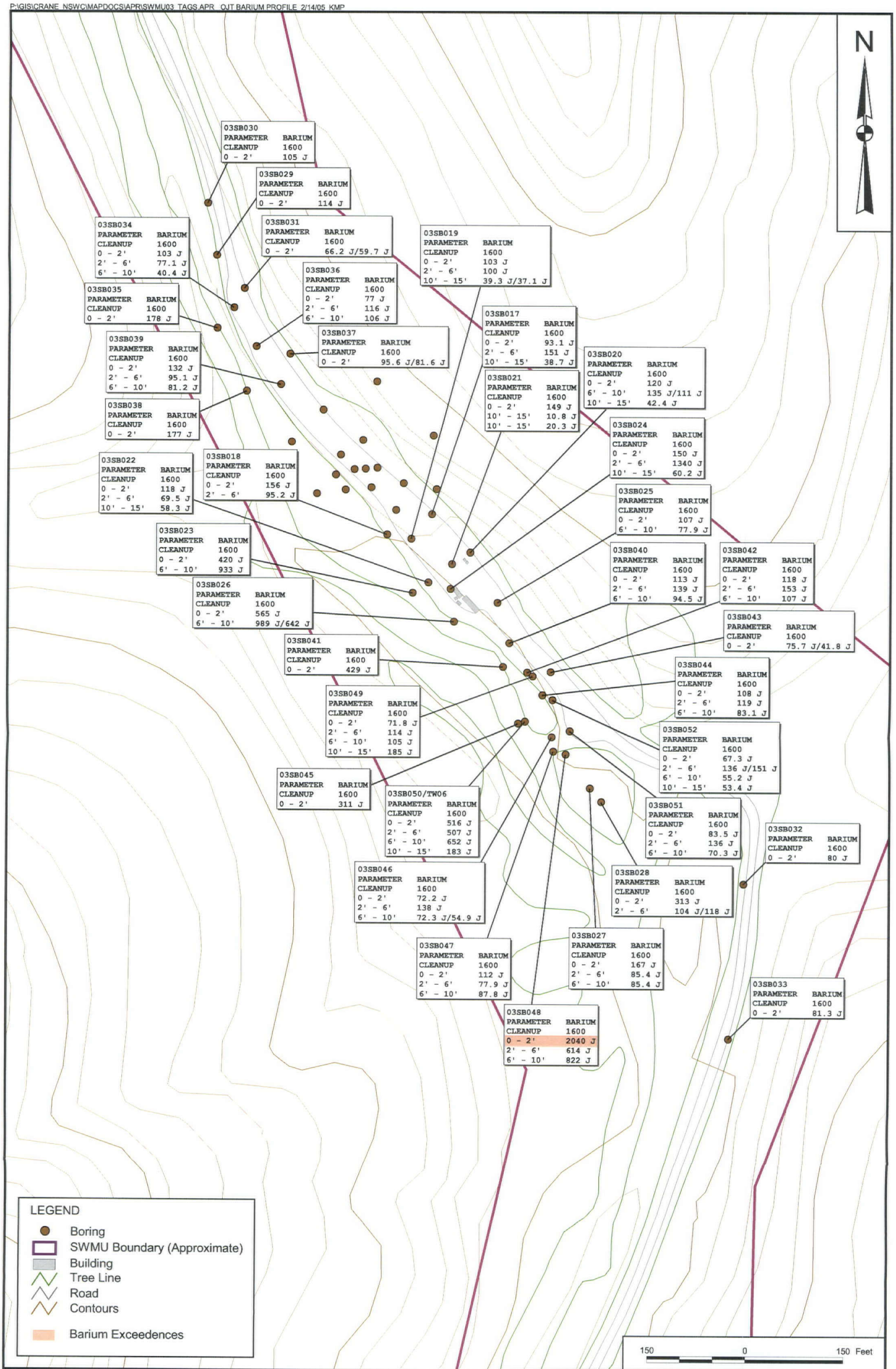


DRAWN BY C. FOSTER	DATE 11/22/04	OLD JEEP TRAIL EXPLOSIVES	CONTRACT NUMBER 8383
CHECKED BY R. BASINSKI	DATE 01/28/05	SWMU 3 - AMMUNITION BURNING GROUNDS	APPROVED BY — DATE —
COST/SCHEDULE-AREA		NSWC CRANE	APPROVED BY — DATE —
SCALE AS NOTED	NAVFAC	CRANE, INDIANA	DRAWING NO. FIGURE 1 - 27 REV 0

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU03_TAGS.APR OJT BARIUM PROFILE 2/14/05 KMP



DRAWN BY C. FOSTER	DATE 11/08/04	OLD JEEP TRAIL BARIUM SWMU 3 - AMMUNITION BURNING GROUNDS NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER 8383
CHECKED BY R. BASINSKI	DATE 01/28/05		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED	NAVFAC		DRAWING NO. FIGURE 1 - 28 REV 0

2.0 FIELD INVESTIGATION

This section presents sampling activities, procedures, and documentation utilized during field operations performed for NSWC Crane SWMU 3 – ABG. The objective of this field investigation was designed to fill data gaps for the development of the CMS.

2.1 OVERVIEW

Field activities were conducted from March through April 2004. All work performed was done in accordance with the procedures and methodologies described in the U.S. EPA-approved QAPP Addendum No. 1 (TtNUS, 2004). Appropriate referenced standard operating procedures (SOPs) are included in Appendix A of the approved QAPP (TtNUS, 2004). Surveyed sample locations of SWMU 3, copies of all field forms, records, and field logbooks associated with the April 2004 field investigations are provided in Appendices B through E of this document (Volume 2 of 2) as follows:

- Appendix B Surveyed Sample Locations
- Appendix C Boring Logs and Related Materials
- Appendix D Sample Log Sheets and Other Field Forms
- Appendix E Site Logbook, Field Notebook, and Survey Data

2.2 MOBILIZATION / DEMOBILIZATION

Following approval of the QAPP Addendum No. 1, TtNUS began mobilization activities. All field team members reviewed the approved QAPP Addendum No. 1, associated appendices, and the revised OJT Health and Safety Plan (HASP) prior to the start of project activities. In addition, the field operations leader (FOL) held field team orientation meetings to ensure that personnel were familiar with the scope of the field activities.

Prior to the initiation of fieldwork, the FOL arrived at the site and began on-site mobilization activities. These activities included coordination with base personnel and utility clearance of all proposed boring locations through the NSWC Crane Publics Works Office. The equipment required for the field activities was shipped to the site. Field sampling activities, drilling activities, and site characterization work were performed from March through April 2004. At the conclusion of the field activities, the FOL completed the decontamination and demobilization of all equipment.

2.3 SUBSURFACE INVESTIGATION METHODOLOGIES AND PROCEDURES

2.3.1 Drilling

Seventy-one borings for soil sampling were drilled using direct-push technology (DPT). All borings were drilled in accordance with SOP CTO126-04 and logged in accordance with SOP CTO126-07. Boring logs can be found in Appendix C.

2.3.1.1 Direct-Push Technology Borings

The DPT method involves pushing sampling tools hydraulically and/or mechanically downward into the ground to the desired depth. Soil samples were collected from borings for chemical analyses and for lithologic logging. All samples obtained from the boreholes were screened with a Photo Ionization Detector (PID) immediately upon opening. All PID readings were recorded on the boring logs. Soil sample collection information is provided in Section 2.5.1.

The DPT method was used to complete 71 soil borings at SWMU 3. Figure B-1 in Appendix B shows the locations of all soil borings completed as part of the RFI (e.g., the April 2004 sampling) at SWMU 3. DPT soil borings at SWMU 3 were advanced down to the bedrock surface or refusal, whichever occurred first in each boring. Detailed information regarding soil sampling is presented in Section 2.5.1.

2.3.2 Borehole and Sample Logging

A TtNUS geologist maintained a log for each boring in accordance with SOP CTO126-07 (Borehole and Soil Sample Logging). At a minimum, the boring logs contain the following information:

- Boring number
- Name of geologist logging the boring
- Name of drilling contractor
- Sample number and type
- Sample depth
- Sample recovery and sample interval
- Soil density or cohesiveness
- Soil color
- Unified Soil Classification System (USCS) material descriptions
- Rock type and description, recovery, and rock quality designation (RQD)
- Drilling problems or deviations from the project-specific approved QAPP

- Date(s) of drilling
- Screening instrument readings

In addition, depths of changes in lithology, sample moisture observations, depth to water, drilling methods, and total depth of each borehole were included on each log, as well as any other pertinent observations. Logs for the borings drilled, as part of the RFI, are included in Appendix C of this document.

2.3.3 Borehole Abandonment

All DPT soil borings at the ABG and OJT were backfilled with the soil cuttings and/or bentonite chips, which were hydrated in accordance with the manufacturer's specifications. The ground surface at all boring locations was restored to its original condition.

2.4 MONITORING WELL REPAIR AND DEVELOPMENT

Prior to beginning the groundwater monitoring well sampling, each of the 11 wells were developed by surging and pumping methods in accordance with SOP CTO126-10. The water removed from wells during the development process were stored in temporary containers and then transferred to a designated man-hole for treatment at the NSWC Crane water treatment facility. Each well was also inspected and repaired as needed. Inspection reports are included in Appendix D of this document.

Water-quality parameters (pH, specific conductivity, temperature, and turbidity), pumping rates, volume of groundwater removed, recharge rates, and water levels were recorded on monitoring well development records. Monitoring well development records can be found in Appendix D of this document.

2.5 SAMPLING OPERATIONS

This section discusses the sampling methodology for all soil, surface water, and groundwater sampling activities at SWMU 3 at NSWC Crane, Indiana. All sample locations for SWMU 3 are depicted on Figure 1-5. Tables 2-1 and 2-2 present a summary of analyses for proposed vs. actual samples collected for both soil and groundwater, respectively.

2.5.1 Soil Sampling

Two hundred thirty-eight soil samples were collected during the field investigation from 71 soil borings. Soil samples were collected in accordance with SOP CTO126-08. Soil sample log sheets are included in

Appendix D of this document. Table 2-4 presents boring depth, drilling method, date drilled, and sample depth intervals.

Samples for VOC analyses were collected first from the interval that had the greatest PID reading using 5-gram EnCore™ samplers. The remaining soil core material was then homogenized and soil to be analyzed for other parameters was placed into the required containers.

Although previous intrusive activities at the SWMU did not encounter any unexploded ordnance (UXO), as a precautionary measure each soil boring was monitored for UXO at 2-foot intervals down to a depth of 6 feet. No UXO was encountered during this field effort.

2.5.1.1 Surface Soil Sampling

Seventy-one of the proposed 73 surface soil samples were collected at SWMU 3 from the ground surface to a maximum depth of 2 feet bgs or until refusal was reached using the DPT method. Table 2-3 lists the samples that were not collected and the reasoning. Upon retrieval, all surface soil samples were monitored for the presence of VOCs using a PID. VOC analyses were not planned for surface soil samples unless an elevated PID measurement was observed (i.e.: sample 03SS1080002). Samples to be analyzed for VOCs were collected using 5-gram EnCore™ samplers. The results of this screening were recorded on the boring logs and/or soil sample log sheets (found in Appendix C and D, respectively of this document).

2.5.1.2 Subsurface Soil Sampling

One hundred sixty-seven of the proposed 219 subsurface soil samples were collected at SWMU 3 from 2-feet down to bedrock, refusal, or 14 feet. Table 2-3 lists the samples that were not collected and the reasoning. Upon retrieval, all subsurface soil samples were monitored for the presence of VOCs using a PID. As with surface soil, no subsurface soil samples in the 2 - 6 feet bgs interval were to have VOC analysis unless elevated PID measurements were recorded. Only samples 03SB0540206 and 03SB0610206 recorded elevated PID measurements and therefore were collected for VOC analysis. The results of this screening were recorded in the boring logs and/or on the soil sample log sheets (found in Appendix C and D, respectively, of this document).

2.5.2 Groundwater Purging and Sampling

A total of 26 groundwater samples were collected during the RFI activities at SWMU 3 from existing monitoring wells, DPT borings, and Spring A'. Purging and stabilization of wells prior to sampling was

accomplished using low-flow techniques in accordance with SOP CTO126-16 (Appendix A of the approved QAPP Addendum No. 1). Sampling was accomplished in accordance with SOP CTO126-05 (Appendix A of the approved QAPP Addendum No. 1).

Wells were purged prior to sampling using a peristaltic pump or bladder pump, depending on the static water level, well depth, and recharge information obtained during well development. In general, bladder pumps were used to sample wells with a water level greater than 28 feet bgs, and peristaltic pumps were used to sample wells having a water level less than 28 feet bgs. Disposable tubing was used with both pump types, and new, dedicated tubing was used for each well.

Groundwater quality parameters including pH, specific conductance, temperature, dissolved oxygen (DO), and oxidation-reduction potential (ORP) were measured during purging at 5- to 10-minute intervals using a YSI Model 600 series multi-parameter water-quality meter and flow-through cell. Longer intervals may have been used for slower pumping wells. Turbidity readings were measured using a LaMotte 2020 turbidity meter. Water levels and pumping rates were also measured during purging at 5- to 10-minute intervals. Purging continued until a minimum of one well volume was removed and the above parameters stabilized or for a maximum of 4 hours, in accordance with SOP CTO126-16 [Appendix A of the approved QAPP Addendum No. 1 (TtNUS, 2004)]. Copies of the monitoring well low-flow purge data sheets and groundwater sample log sheets are provided in Appendix D of this document.

To the extent possible, the pumping rates were adjusted to prevent drawdown from exceeding 0.3 foot during purging. Well purging continued until all parameters stabilized and the minimum purge volume (stabilized well volume plus the extraction tubing volume) was removed. If the water quality parameters did not stabilize within 4 hours of purging, sampling was initiated and this information was recorded on the well low-flow purge log sheet.

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

Sample containers were filled by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence. Samples for VOC analysis were collected by the straw method when using the peristaltic pump and were filled directly when using the bladder pump. These samples were immediately sealed in 40-mL vials so that no headspace existed. Samples for explosives, total metals, total mercury, perchlorate, dissolved metals, and dissolved mercury were collected next and in the order

given (when applicable). Samples with turbidity values greater than 10 nephelometric turbidity units (NTUs) were field filtered for dissolved metals analyses using a 0.45 µm in-line filter.

No new wells were installed at SWMU 3 during this field event. All sampled wells were existing wells. Initially, 26 monitoring wells at the ABG MTA and six monitoring wells at the OJT were scheduled to be sampled. However, due to the length of time since these wells were last sampled, some of the wells had been abandoned, had blocked screens, or the well had collapsed. 19 of the scheduled 32 monitoring wells were actually sampled. Table 2-3 presents the wells that were not sampled and the associated reason. Refer to Appendix D for monitoring well development, low-flow purge data, and groundwater sampling sheets.

Springs A and C and LSC are currently sampled for the RCRA Quarterly Monitoring Program and therefore not sampled during this field event. Spring A' is not part of the sampling program. As a result, a sample was collected from Spring A during this field event.

Six perched groundwater samples were collected during this field event at SWMU 3. The perched groundwater samples were collected from the bottom of DPT borings near the overburden/bedrock interface. These samples are identified in Table 2-4.

2.6 FIELD SAMPLE DOCUMENTATION

Sample documentation consisted of the completion of boring logs, matrix-specific sample log sheets, sample bottle tags, chain-of-custody records, field task modification request forms (FTMRs), equipment calibration log sheets, field logbooks, and health and safety documentation. Field documentation was completed as discussed in the approved QAPP Addendum No. 1 (TtNUS, 2004). Boring logs were completed as discussed in Section 2.3.2 and can be found in Appendix C of this document. The sample log sheets contain information such as sample location and sample ID, container requirements and analyses to be performed, sample type, time, date, and method of sample collection. Any unusual circumstances encountered during sample collection were noted on the form. Sample log sheets can be found in Appendix C of this document. Chain-of-custody (COC) records (see Appendix D) were used to track each sample from collection to receipt and analysis at the laboratory. Field Task Modification Records (FTMRs) (see Appendix D) were used to document deviations from the approved QAPP Addendum No. 1. Equipment calibration log sheets are discussed in Section 2.9.1 and can be found in Appendix D of this document. Copies of all field logbooks are contained in Appendix E. Copies of the health and safety logs are maintained in the project file. Upon completion of sample analyses, sample

bottle tags were forwarded by laboratory personnel to the NSWC Crane Environmental Protection Department for storage.

2.7 SAMPLE HANDLING, PACKAGING, AND SHIPPING

Sample handling activities included the field-related considerations concerning the selection of sample containers, preservatives, allowable holding times, sample custody, and maintaining samples at the appropriate storage temperature. Sampling containers were sealed in Ziploc® plastic bags, and glass containers were wrapped in plastic bubble wrap to minimize the possibility of breakage during transport. The sample containers were then placed in a cooler lined with a large plastic garbage bag. The cooler was packed with a cushioning material (bubble wrap) to prevent container breakage. Samples were cooled immediately after collection with ice placed over the sample containers. A temperature blank was placed in each cooler prior to shipment. The plastic garbage bag was sealed with a knot, and the COC form was sealed in a Ziploc® bag and taped to the inside of the cooler lid. A signed and dated custody seal was applied to each end of the cooler and then covered with strapping tape to provide a tamper-evident seal. A Federal Express® airbill was applied to the shipping cooler. TtNUS maintained custody of the samples until they were relinquished to Federal Express®. The Federal Express® tracking number (airbill number) was recorded on the COC form, and the sender's copy of the airbill was maintained for shipment tracking, if needed. All samples were shipped to the laboratories for overnight delivery and were received within sample holding times. The procedures for sample preservation, packing, and shipment can be found in Section 3.8 of the approved QAPP Addendum No. 1 (TtNUS, 2004). The procedure used for sample labeling can also be found in Section 3.8 and SOP CTO126-01 of the approved QAPP Addendum No. 1 (TtNUS, 2004). Likewise, the procedures used to maintain sample custody requirements are described in Section 3.8 and SOP CTO126-03 of the approved QAPP Addendum No. 1 (TtNUS, 2004). Sample bottle tags were removed from each sample bottle by laboratory personnel and forwarded to the NSWC Environmental Protection Department.

2.8 QUALITY CONTROL SAMPLES

Quality assurance/quality control (QA/QC) samples were collected and generated during sampling activities to monitor both field and laboratory procedures. These procedures are detailed in the approved QAPP Addendum No. 1. QA/QC samples included field duplicates, equipment rinsate blanks, trip blanks, source water blanks, and temperature blanks. These types of QA/QC samples are briefly described below:

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

- Equipment Rinsate Blanks - Equipment rinsate blanks were obtained under representative field conditions by collecting the rinse water generated by running analyte-free water through or over sample collection equipment after decontamination and before use. As a rule, 1 equipment rinsate blank per 10 samples per aqueous matrix and 20 samples per solid matrix was collected for each type of sampling equipment used (i.e., bladder pump) on a daily basis. However, when pre-cleaned, dedicated, or disposable (no decontamination was required) sampling equipment was used, one equipment rinsate blank was collected as a batch blank. Additionally, bladder pump equipment rinsate blanks were collected at a rate of one equipment rinsate blank for every five samples (See the FTMR form in Appendix D). Equipment rinsate blanks were analyzed for the same chemical constituents as the associated environmental samples.

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

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

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

2.9 FIELD INSTRUMENT MEASUREMENTS

Field measurements taken and recorded during field sampling operations included water temperature, pH, specific conductance, ORP, DO, turbidity, and groundwater level measurements. Ambient air

measurements included monitoring of organic vapors in the breathing zone during intrusive field investigation activities and monitoring of organic vapors emanating from site sources such as soil samples and well casings. Several instruments were used during field activities to obtain these measurements including the following:

- PID
- YSI Model 600 Series, Multi-Parameter Water Quality Meter
- LaMotte 2020 Turbidity Meter
- M-Scope Water Level Meter

2.9.1 Equipment Calibration

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

2.9.2 Field Investigation Preventive Maintenance Procedures/Schedule

The field instruments for this project included the PID, YSI water-quality meter, Lamotte 2020 turbidity meter, and water level indicator. The specific preventive maintenance procedures followed for field equipment were those recommended by the equipment manufacturers.

An appropriate maintenance check was performed daily on each piece of equipment. If damaged or defective parts were identified during the maintenance check, and it was determined that the damage could have an impact on the instrument's performance, the instrument was removed from service until the defective parts were repaired or replaced. Critical spare parts were kept on site to reduce downtime. Spare parts included batteries, a DO-probe membrane kit (membranes and a bottle of solution), and air particle filters for the PID. Back-up instruments and equipment were available on site or were shipped within 1 day via overnight courier to avoid delays in the field schedule.

2.10 SURVEYING

All existing monitoring wells, soil borings, and Spring A' were surveyed. The top of the riser pipe (where the uncapped well riser is marked), the top of the protective casing, and the ground surface elevation at each monitoring well location were surveyed to within 0.01-foot vertical accuracy. For all other locations, the ground surface elevation was surveyed to the nearest 0.10-foot. Vertical elevations were referenced to the 1988 North American Vertical Datum (NAVD88). Existing survey monuments at NSWC Crane were used as reference points. Horizontal locations of samples, borings, and wells were surveyed to Indiana

State Plane coordinates to the nearest 0.10 foot and referenced to the 1927 North American Datum (NAD27). All surveying was subcontracted to a State of Indiana professional licensed surveyor. Copies of the survey data can be found in Appendix E.

2.11 DECONTAMINATION

The nondedicated, nondisposable equipment involved in field sampling activities was decontaminated before beginning work, during drilling and sampling activities, and at the completion of the RFI activities in accordance with SOP CTO126-17 contained in Appendix A of the approved QAPP Addendum No.1. This equipment included drilling rigs, down-hole tools, augers, and soil and water sampling equipment.

2.11.1 Major Equipment

All down-hole equipment, including down-hole drilling tools, were steam cleaned with high-pressure hot water prior to beginning work and at the conclusion of work at the site. Between borings all drilling tools were cleaned with alconox and potable water.

Well riser pipe and screens were supplied at the site in certified clean packaging. All decontamination activities took place at a predetermined area within NSWC Crane.

2.11.2 Sampling Equipment

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

- Potable water and phosphate-free detergent wash (scrub if necessary)
- Potable water rinse
- Deionized (DI) water rinse
- Air dry (if possible)
- Wrap in aluminum foil (if not to be used immediately)

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

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

2.12 WATER LEVEL MEASUREMENTS AND AQUIFER TESTING

2.12.1 Groundwater Level Measurements

Water level measurements were obtained from each monitoring well prior to development and purging. Measurements were taken with an electrical water level indicator (M-scope), using the top of the riser pipe as the reference point to determine water depth for monitoring wells. All measurements were taken in accordance with SOP CTO 126-18 contained in Appendix A of the approved QAPP Addendum No. 1 (TtNUS, 2004). A mark was placed at the top of the riser pipe to ensure that measurements were taken from a consistent reference point. Water level measurements were collected on April 24 and 25, 2004 and were recorded to the nearest 0.01 foot on a groundwater level measurement form, provided in Appendix D of this document.

2.13 FIELD CORRECTIVE ACTION

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

Corrective action in the field resulted when substantive changes were made to the sampling network (i.e., more/fewer samples collected, sampling locations other than those specified, etc.) and when sampling procedures or field analytical procedures required modification. Project personnel reported all suspected technical or QA nonconformance or suspected deficiencies of any activity or issued document to the FOL or designee. The Task Order Manager (TOM) was responsible for assessing the suspected problems in consultation with the project QA/QC Manager and for making a decision based on the potential for the situation to affect the quality of the data. If it was determined that the situation warranted a reportable nonconformance requiring corrective action, a nonconformance report was initiated by the TOM. As identified in Table 2-3, boring locations 03SB055 and 03SB062 were abandoned due to the steep slope which would have compromised the safety of drilling. Boring 03SB058 was moved southwest, closer to the access road. Boring 03SB061 was moved north across the stream bed. Boring 03SB112 was moved south of the Burning Cage. Boring 03SB113 was moved near the sink hole in the Former Ash Pile area.

2.14 INVESTIGATION-DERIVED WASTE HANDLING

The field investigations generated several types of potentially contaminated wastes including Personal Protective Equipment (PPE), decontamination fluids from the drill rig, sampling equipment decontamination fluids, DPT plastic sleeves, development and purge water, and soil cuttings. Management of each residue was performed as follows:

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

Purge Water, Development Water, Drill and Sampling Equipment Decontamination Fluids – All well development and purge waters and equipment decontamination fluids were collected and discharged to the NSWC Crane permitted waste treatment plant.

Waste Cuttings and Rock Cores from Drilling Activities – For each boring, the cuttings/macro core samples produced were scanned for VOCs. A few VOC readings were slightly above background levels, however after exposure to air the readings were all below background levels and were used as backfill if the boring terminated above the water table. Any remaining cuttings were spread on the ground in the immediate vicinity of the boring.

Additional requirements for Investigation-Derived Waste (IDW) handling can be found in SOP CTO126-15 contained in Appendix A of the approved QAPP Addendum No. 1 (TtNUS, 2004).

2.15 SITE MANAGEMENT AND FACILITY SUPPORT

The FOL was designated as the lead in coordinating all day-to-day activities during the investigation. The FOL was responsible for ensuring that all field team members (including subcontractors) were familiar with the approved QAPP Addendum No. 1 and the revised OJT HASP. Additionally, the FOL was responsible for all sampling operations, QA/QC, field documentation requirements, and field change orders. The FOL reported to the TOM on a daily basis regarding the status of fieldwork.

All site preparation, mobilization/demobilization, and sampling activities were coordinated through NSWC Crane personnel.

2.16 RECORDKEEPING

Various hardcover, bound record books were maintained for each field activity in accordance with SOP CTO126-03. The Master Site Logbook served as the overall record of field activities. Information recorded daily in the Master Site Logbook included daily field activities, weather conditions, identity of and arrival and departure times of personnel, management issues, etc. Various field notebooks were also maintained. For example, the site geologist supervising soil boring operations maintained a field notebook. Copies of field log books are included in Appendix E.

The FOL was responsible for the maintenance and security of all field records. Eventually, all field records, COC forms, sample log sheets, field forms, logbooks, and notebooks were docketed and incorporated in the central project file for CTO 0311.

TABLE 2-1

SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSES - SURFACE/SUBSURFACE SOILS
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Soil Boring Group[1]	Boring Location	Sample Number[2,3]	VOCs[4]	Explosives[4]	RDX Degradation Products[4]	Target Analyte List Metals[4]	Perchlorate	Total Organic Carbon	pH	Cation Exchange Capacity
OJT	03SB049	03SS0490002	-	S	S	S	S	-	-	-
OJT	03SB049	03SB0490206	-	S	S	S	S	-	-	-
OJT	03SB049	03SB0490610	S	S	S	S	S	-	-	-
OJT	03SB049	03SB0491014	S	S	S	S	S	-	-	-
OJT	03SB050	03SS0500002	-	S	-	S	-	-	-	-
OJT	03SB050	03SB0500206	-	S	-	S	-	-	-	-
OJT	03SB050	03SB0500610	S	S	-	S	-	-	-	-
OJT	03SB050	03SB0501014	S	S	-	S	-	-	-	-
OJT	03SB051	03SS0510002	-	S	S	S	S	-	-	-
OJT	03SB051	03SB0510206	-	S	S	S	S	-	-	-
OJT	03SB051	03SB0510610	S	S	S	S	S	-	-	-
OJT	03SB051	03SB0511014	O	O	O	O	O	-	-	-
OJT	03SB052	03SS0520002	-	S	-	S	-	-	-	-
OJT	03SB052	03SB0520206	-	S	-	S	-	-	-	-
OJT	03SB052	03SB0520610	S	S	-	S	-	-	-	-
OJT	03SB052	03SB0521014	S	S	-	S	-	-	-	-
A	03SB053	03SS0530002	-	S	S	S	S	-	-	-
A	03SB053	03SB0530206	-	S	S	S	S	-	-	-
A	03SB053	03SB0530610	O	O	O	O	O	-	-	-
A	03SB053	03SB053xxxx	O	O	O	O	O	-	-	-
B	03SB054	03SS0540002	-	S	-	S	-	-	-	-
B	03SB054	03SB0540206	E	S	-	S	-	-	-	-
B	03SB054	03SB0540610	O	O	-	O	-	-	-	-
B	03SB054	03SB054xxxx	O	O	-	O	-	-	-	-
B	03SB055	03SS0550002	-	O	O	-	O	-	-	-
B	03SB055	03SB0550206	-	O	O	-	O	-	-	-
B	03SB055	03SB0550610	O	O	O	-	O	-	-	-
B	03SB055	03SB055xxxx	O	O	O	-	O	-	-	-
B	03SB056	03SS0560002	-	S	-	S	-	-	-	-
B	03SB056	03SB0560206	-	O	-	O	-	-	-	-
B	03SB056	03SB0560610	O	O	-	O	-	-	-	-
B	03SB056	03SB056xxxx	O	O	-	O	-	-	-	-
B	03SB057	03SS0570002	-	S	-	-	-	-	-	-
B	03SB057	03SB0570206	-	S	-	-	-	-	-	-
B	03SB057	03SB0570610	O	O	-	-	-	-	-	-
B	03SB057	03SB057xxxx	O	O	-	-	-	-	-	-
B	03SB058	03SS0580002	-	S	-	S	-	-	-	-
B	03SB058	03SB0580206	-	S	-	S	-	-	-	-
B	03SB058	03SB0580610	S	S	-	S	-	-	-	-

TABLE 2-1

SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSES - SURFACE/SUBSURFACE SOILS
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Soil Boring Group[1]	Boring Location	Sample Number[2,3]	VOCs[4]	Explosives[4]	RDX Degradation Products[4]	Target Analyte List Metals[4]	Perchlorate	Total Organic Carbon	pH	Cation Exchange Capacity
B	03SB058	03SB0581012	S	S	-	S	-	-	-	-
B	03SB059	03SS0590002	-	S	S	-	S	-	-	-
B	03SB059	03SB0590206	-	S	S	-	S	-	-	-
B	03SB059	03SB0590610	O	O	O	-	O	-	-	-
B	03SB059	03SB059xxxx	O	O	O	-	O	-	-	-
B	03SB060	03SS0600002	-	S	-	S	-	-	-	-
B	03SB060	03SB0600206	-	S	-	S	-	-	-	-
B	03SB060	03SB0600610	S	S	-	S	-	-	-	-
B	03SB060	03SB0601014	S	S	-	S	-	-	-	-
B	03SB061	03SS0610002	-	S	S	-	S	-	-	-
B	03SB061	03SB0610206	E	S	S	-	S	-	-	-
B	03SB061	03SB0610610	S	S	S	-	S	-	-	-
B	03SB061	03SB061xxxx	O	O	O	-	O	-	-	-
B	03SB062	03SS0620002	-	O	-	O	-	-	-	-
B	03SB062	03SB0620206	-	O	-	O	-	-	-	-
B	03SB062	03SB0620610	O	O	-	O	-	-	-	-
B	03SB062	03SB062xxxx	O	O	-	O	-	-	-	-
B	03SB063	03SS0630002	-	S	-	-	-	-	-	-
B	03SB063	03SB0630206	-	S	-	-	-	-	-	-
B	03SB063	03SB0630610	S	S	-	-	-	-	-	-
B	03SB063	03SB0631014	S	S	-	-	-	-	-	-
B	03SB064	03SS0640002	-	S	-	S	-	-	-	-
B	03SB064	03SB0640206	-	S	-	S	-	-	-	-
B	03SB064	03SB0640610	O	O	-	O	-	-	-	-
B	03SB064	03SB064xxxx	O	O	-	O	-	-	-	-
B	03SB065	03SS0650002	-	S	S	-	S	-	-	-
B	03SB065	03SB0650206	-	S	S	-	S	-	-	-
B	03SB065	03SB0650610	S	S	S	-	S	-	-	-
B	03SB065	03SB0651014	S	S	S	-	S	-	-	-
C	03SB066	03SS0660002		S	-	S	-	-	-	-
C	03SB066	03SB0660206		S	-	S	-	-	-	-
C	03SB066	03SB0660610	S	S	-	S	-	-	-	-
C	03SB066	03SB0661014	S	S	-	S	-	-	-	-
C	03SB067	03SS0670002	-	S	S	-	S	-	-	-
C	03SB067	03SB0670206	-	S	S	-	S	-	-	-
C	03SB067	03SB0670610	S	S	S	-	S	-	-	-
C	03SB067	03SB0671012	S	S	S	-	S	-	-	-
C	03SB068	03SS0680002	-	S	-	S	-	-	-	-
C	03SB068	03SB0680206	-	S	-	S	-	-	-	-

TABLE 2-1

SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSES - SURFACE/SUBSURFACE SOILS
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Soil Boring Group[1]	Boring Location	Sample Number[2,3]	VOCs[4]	Explosives[4]	RDX Degradation Products[4]	Target Analyte List Metals[4]	Perchlorate	Total Organic Carbon	pH	Cation Exchange Capacity
C	03SB068	03SB0680610	S	S	-	S	-	-	-	-
C	03SB068	03SB0681013	S	S	-	S	-	-	-	-
D	03SB069	03SS0690002	-	S	-	-	-	-	-	-
D	03SB069	03SB0690206	-	S	-	-	-	-	-	-
D	03SB069	03SB0690610	S	S	-	-	-	-	-	-
D	03SB069	03SB069xxxx	O	O	-	-	-	-	-	-
D	03SB070	03SS0700002	-	S	-	S	-	-	-	-
D	03SB070	03SB0700206	-	S	-	S	-	-	-	-
D	03SB070	03SB0700610	S	S	-	S	-	-	-	-
D	03SB070	03SB0701012	S	S	-	S	-	-	-	-
D	03SB071	03SS0710002	-	S	S	-	S	-	-	-
D	03SB071	03SB0710206	-	S	S	-	S	-	-	-
D	03SB071	03SB0710610	O	O	O	-	O	-	-	-
D	03SB071	03SB071xxxx	O	O	O	-	O	-	-	-
D	03SB072	03SS0720002	-	S	-	S	-	-	-	-
D	03SB072	03SB0720206	-	S	-	S	-	-	-	-
D	03SB072	03SB0720610	S	S	-	S	-	-	-	-
D	03SB072	03SB072xxxx	O	O	-	O	-	-	-	-
D	03SB073	03SS0730002	-	S	S	-	S	-	-	-
D	03SB073	03SB0730206	-	S	S	-	S	-	-	-
D	03SB073	03SB0730610	S	S	S	-	S	-	-	-
D	03SB073	03SB0731013	S	S	S	-	S	-	-	-
D	03SB074	03SS0740002	-	S	-	S	-	-	-	-
D	03SB074	03SB0740206	-	S	-	S	-	-	-	-
D	03SB074	03SB0740610	S	S	-	S	-	-	-	-
D	03SB074	03SB0741014	S	S	-	S	-	-	-	-
D	03SB075	03SS0750002	-	S	-	-	-	-	-	-
D	03SB075	03SB0750206	-	S	-	-	-	-	-	-
D	03SB075	03SB0750610	S	S	-	-	-	-	-	-
D	03SB075	03SB075xxxx	O	O	-	-	-	-	-	-
E	03SB076	03SS0760002	-	S	-	S	-	-	-	-
E	03SB076	03SB0760206	-	S	-	S	-	-	-	-
E	03SB076	03SB0760610	S	S	-	S	-	-	-	-
E	03SB076	03SB0761014	S	S	-	S	-	-	-	-
E	03SB077	03SS0770002	-	S	S	-	S	-	-	-
E	03SB077	03SB0770206	-	S	S	-	S	-	-	-
E	03SB077	03SB0770610	S	S	S	-	S	-	-	-
E	03SB077	03SB077xxxx	O	O	O	-	O	-	-	-
E	03SB078	03SS0780002	-	S	-	S	-	S	S	S

TABLE 2-1

SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSES - SURFACE/SUBSURFACE SOILS
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Soil Boring Group[1]	Boring Location	Sample Number[2,3]	VOCs[4]	Explosives[4]	RDX Degradation Products[4]	Target Analyte List Metals[4]	Perchlorate	Total Organic Carbon	pH	Cation Exchange Capacity
E	03SB078	03SB0780206	-	S	-	S	-	S	S	S
E	03SB078	03SB0780610	S	S	-	S	-	S	S	S
E	03SB078	03SB078xxxx	O	O	-	O	-	O	O	O
F	03SB079	03SS0790002	-	S	S	-	S	-	-	-
F	03SB079	03SB0790206	-	S	S	-	S	-	-	-
F	03SB079	03SB0790610	S	S	S	-	S	-	-	-
F	03SB079	03SB0791012	S	S	S	-	S	-	-	-
F	03SB080	03SS0800002	-	S	-	S	-	-	-	-
F	03SB080	03SB0800206	-	S	-	S	-	-	-	-
F	03SB080	03SB0800610	S	S	-	S	-	-	-	-
F	03SB080	03SB0801013	S	S	-	S	-	-	-	-
F	03SB081	03SS0810002	-	S	-	-	-	-	-	-
F	03SB081	03SB0810206	-	S	-	-	-	-	-	-
F	03SB081	03SB0810610	S	S	-	-	-	-	-	-
F	03SB081	03SB081xxxx	O	O	-	-	-	-	-	-
F	03SB082	03SS0820002	-	S	-	S	-	-	-	-
F	03SB082	03SB0820206	-	S	-	S	-	-	-	-
F	03SB082	03SB0820610	S	S	-	S	-	-	-	-
F	03SB082	03SB0821013	S	S	-	S	-	-	-	-
F	03SB083	03SS0830002	-	S	S	-	S	-	-	-
F	03SB083	03SB0830206	-	S	S	-	S	-	-	-
F	03SB083	03SB0830610	S	S	S	-	S	-	-	-
F	03SB083	03SB0831014	O	O	O	-	O	-	-	-
F	03SB084	03SS0840002	-	S	-	S	-	-	-	-
F	03SB084	03SB0840206	-	S	-	S	-	-	-	-
F	03SB084	03SB0840610	S	S	-	S	-	-	-	-
F	03SB084	03SB084xxxx	O	O	-	O	-	-	-	-
F	03SB085	03SS0850002	-	S	-	-	-	-	-	-
F	03SB085	03SB0850206	-	S	-	-	-	-	-	-
F	03SB085	03SB0850610	S	S	-	-	-	-	-	-
F	03SB085	03SB0851013	S	S	-	-	-	-	-	-
F	03SB086	03SS0860002	-	S	-	S	-	-	-	-
F	03SB086	03SB0860206	-	S	-	S	-	-	-	-
F	03SB086	03SB0860610	S	S	-	S	-	-	-	-
F	03SB086	03SB0861014	S	S	-	S	-	-	-	-
F	03SB087	03SS0870002	-	S	S	-	S	-	-	-
F	03SB087	03SB0870206	-	S	S	-	S	-	-	-
F	03SB087	03SB0870610	S	S	S	-	S	-	-	-
F	03SB087	03SB0871013	S	S	S	-	S	-	-	-

TABLE 2-1

SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSES - SURFACE/SUBSURFACE SOILS
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Soil Boring Group[1]	Boring Location	Sample Number[2,3]	VOCs[4]	Explosives[4]	RDX Degradation Products[4]	Target Analyte List Metals[4]	Perchlorate	Total Organic Carbon	pH	Cation Exchange Capacity
G	03SB088	03SS0880002	-	S	-	S	-	-	-	-
G	03SB088	03SB0880206	-	S	-	S	-	-	-	-
G	03SB088	03SB0880610	O	O	-	O	-	-	-	-
G	03SB088	03SB088xxxx	O	O	-	O	-	-	-	-
G	03SB089	03SS0890002	-	S	S	-	S	-	-	-
G	03SB089	03SB0890206	-	S	S	-	S	-	-	-
G	03SB089	03SB0890610	O	O	O	-	O	-	-	-
G	03SB089	03SB089xxxx	O	O	O	-	O	-	-	-
G	03SB090	03SS0900002	-	S	-	S	-	-	-	-
G	03SB090	03SB0900206	-	S	-	S	-	-	-	-
G	03SB090	03SB0900610	S	S	-	S	-	-	-	-
G	03SB090	03SB090xxxx	O	O	-	O	-	-	-	-
H	03SB091	03SS0910002	-	S	S	-	S	-	-	-
H	03SB091	03SB0910206	-	S	S	-	S	-	-	-
H	03SB091	03SB0910610	S	S	S	-	S	-	-	-
H	03SB091	03SB091xxxx	O	O	O	-	O	-	-	-
H	03SB092	03SS0920002	-	S	-	S	-	-	-	-
H	03SB092	03SB0920206	-	S	-	S	-	-	-	-
H	03SB092	03SB0920610	S	S	-	S	-	-	-	-
H	03SB092	03SB092xxxx	O	O	-	O	-	-	-	-
H	03SB093	03SS0930002	-	S	-	-	-	-	-	-
H	03SB093	03SB0930206	-	S	-	-	-	-	-	-
H	03SB093	03SB0930610	S	S	-	-	-	-	-	-
H	03SB093	03SB0931014	S	S	-	-	-	-	-	-
H	03SB094	03SS0940002	-	S	-	S	-	-	-	-
H	03SB094	03SB0940206	-	S	-	S	-	-	-	-
H	03SB094	03SB0940610	S	S	-	S	-	-	-	-
H	03SB094	03SB094xxxx	O	O	-	O	-	-	-	-
H	03SB095	03SS0950002	-	S	S	-	S	-	-	-
H	03SB095	03SB0950206	-	S	S	-	S	-	-	-
H	03SB095	03SB0950610	S	S	S	-	S	-	-	-
H	03SB095	03SB095xxxx	O	O	O	-	O	-	-	-
H	03SB096	03SS0960002	-	S	-	S	-	-	-	-
H	03SB096	03SB0960206	-	S	-	S	-	-	-	-
H	03SB096	03SB0960610	S	S	-	S	-	-	-	-
H	03SB096	03SB096xxxx	O	O	-	O	-	-	-	-
H	03SB097	03SS0970002	-	S	S	-	S	-	-	-
H	03SB097	03SB0970206	-	S	S	-	S	-	-	-
H	03SB097	03SB0970610	S	S	S	-	S	-	-	-

TABLE 2-1

SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSES - SURFACE/SUBSURFACE SOILS
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Soil Boring Group[1]	Boring Location	Sample Number[2,3]	VOCs[4]	Explosives[4]	RDX Degradation Products[4]	Target Analyte List Metals[4]	Perchlorate	Total Organic Carbon	pH	Cation Exchange Capacity
H	03SB097	03SB097xxxx	O	O	O	-	O	-	-	-
H	03SB098	03SS0980002	-	S	-	S	-	-	-	-
H	03SB098	03SB0980206	-	S	-	S	-	-	-	-
H	03SB098	03SB0980610	S	S	-	S	-	-	-	-
H	03SB098	03SB098xxxx	O	O	-	O	-	-	-	-
H	03SB099	03SS0990002	-	S	-	-	-	-	-	-
H	03SB099	03SB0990206	-	S	-	-	-	-	-	-
H	03SB099	03SB0990610	S	S	-	-	-	-	-	-
H	03SB099	03SB099xxxx	O	O	-	-	-	-	-	-
I	03SB100	03SS1000002	-	S	-	S	-	-	-	-
I	03SB100	03SB1000206	-	S	-	S	-	-	-	-
I	03SB100	03SB1000610	S	S	-	S	-	-	-	-
I	03SB100	03SB1001014	S	S	-	S	-	-	-	-
I	03SB101	03SS1010002	-	S	S	S	S	-	-	-
I	03SB101	03SB1010206	-	S	S	S	S	-	-	-
I	03SB101	03SB1010610	S	S	S	S	S	-	-	-
I	03SB101	03SB1011014	S	S	S	S	S	-	-	-
I	03SB102	03SS1020002	-	S	-	-	-	-	-	-
I	03SB102	03SB1020206	-	S	-	-	-	-	-	-
I	03SB102	03SB1020610	S	S	-	-	-	-	-	-
I	03SB102	03SB1021013	S	S	-	-	-	-	-	-
I	03SB103	03SS1030002	-	S	S	S	S	-	-	-
I	03SB103	03SB1030206	-	S	S	S	S	-	-	-
I	03SB103	03SB1030610	S	S	S	S	S	-	-	-
I	03SB103	03SB1031011	S	O	O	O	O	-	-	-
J	03SB104	03SS1040002	-	S	-	-	-	-	-	-
J	03SB104	03SB1040206	-	S	-	-	-	-	-	-
J	03SB104	03SB1040610	S	S	-	-	-	-	-	-
J	03SB104	03SB1041014	S	S	-	-	-	-	-	-
MISC	03SB105	03SS1050002	-	S	S	S	S	-	-	-
MISC	03SB105	03SB1050206	-	S	S	S	S	-	-	-
MISC	03SB105	03SB1050610	S	S	S	S	S	-	-	-
MISC	03SB105	03SB1051012	S	S	S	S	S	-	-	-
MISC	03SB106	03SS1060002	-	S	-	-	-	-	-	-
MISC	03SB106	03SB1060206	-	S	-	-	-	-	-	-
MISC	03SB106	03SB1060610	S	S	-	-	-	-	-	-
MISC	03SB106	03SB1061014	S	S	-	-	-	-	-	-
MISC	03SB107	03SS1070002	-	S	S	-	S	-	-	-
MISC	03SB107	03SB1070206	-	S	S	-	S	-	-	-

TABLE 2-1

SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSES - SURFACE/SUBSURFACE SOILS
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Soil Boring Group[1]	Boring Location	Sample Number[2,3]	VOCs[4]	Explosives[4]	RDX Degradation Products[4]	Target Analyte List Metals[4]	Perchlorate	Total Organic Carbon	pH	Cation Exchange Capacity
MISC	03SB107	03SB1070610	S	S	S	-	S	-	-	-
MISC	03SB107	03SB1071014	S	S	S	-	S	-	-	-
MISC	03SB108	03SS1080002	E	S	-	S	-	-	-	-
MISC	03SB108	03SB1080206	-	S	-	S	-	-	-	-
MISC	03SB108	03SB1080610	S	S	-	S	-	-	-	-
MISC	03SB108	03SB1081014	S	S	-	S	-	-	-	-
MISC	03SB109	03SS1090002	-	S	-	-	-	-	-	-
MISC	03SB109	03SB1090206	-	S	-	-	-	-	-	-
MISC	03SB109	03SB1090610	S	S	-	-	-	-	-	-
MISC	03SB109	03SB1091013	S	S	-	-	-	-	-	-
MISC	03SB110	03SS1100002	-	S	-	S	-	-	-	-
MISC	03SB110	03SB1100206	-	S	-	S	-	-	-	-
MISC	03SB110	03SB1100610	S	S	-	S	-	-	-	-
MISC	03SB110	03SB1101013	S	S	-	S	-	-	-	-
MISC	03SB111	03SS1110002	-	S	S	-	S	-	-	-
MISC	03SB111	03SB1110206	-	S	S	-	S	-	-	-
MISC	03SB111	03SB1110610	S	S	S	-	S	-	-	-
MISC	03SB111	03SB111xxxx	O	O	O	-	O	-	-	-
MISC	03SB112	03SS1120002	-	S	-	S	-	-	-	-
MISC	03SB112	03SB1120206	-	S	-	S	-	-	-	-
MISC	03SB112	03SB1120610	S	S	-	S	-	-	-	-
MISC	03SB112	03SB112xxxx	O	O	-	O	-	-	-	-
MISC	03SB113	03SS1130002	-	S	S	-	S	-	-	-
MISC	03SB113	03SB1130206	-	S	S	-	S	-	-	-
MISC	03SB113	03SB1130610	O	O	O	-	O	-	-	-
MISC	03SB113	03SB113xxxx	O	O	O	-	O	-	-	-
MISC	03SB114	03SS1140002	-	S	-	S	-	-	-	-
MISC	03SB114	03SB1140206	-	S	-	S	-	-	-	-
MISC	03SB114	03SB1140610	S	S	-	S	-	-	-	-
MISC	03SB114	03SB114xxxx	O	O	-	O	-	-	-	-
MISC	03SB115	03SS1150002	-	S	-	-	-	-	-	-
MISC	03SB115	03SB1150206	-	S	-	-	-	-	-	-
MISC	03SB115	03SB1150610	S	S	-	-	-	-	-	-
MISC	03SB115	03SB115xxxx	O	O	-	-	-	-	-	-
MISC	03SB116	03SB1160002	-	S	-	S	-	S	S	S
MISC	03SB116	03SB1160206	-	S	-	S	-	S	S	S
MISC	03SB116	03SB1160610	S	S	-	S	-	S	S	S
MISC	03SB116	03SB116xxxx	O	O	-	O	-	O	O	O
MISC	03SB117	03SS1170002	-	S	S	-	S	-	-	-

TABLE 2-1

SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSES - SURFACE/SUBSURFACE SOILS
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Soil Boring Group[1]	Boring Location	Sample Number[2,3]	VOCs[4]	Explosives[4]	RDX Degradation Products[4]	Target Analyte List Metals[4]	Perchlorate	Total Organic Carbon	pH	Cation Exchange Capacity
MISC	03SB117	03SB1170206	-	S	S	-	S	-	-	-
MISC	03SB117	03SB1170610	S	S	S	-	S	-	-	-
MISC	03SB117	03SB1171013	S	S	S	-	S	-	-	-
MISC	03SB118	03SS1180002	-	S	-	S	-	-	-	-
MISC	03SB118	03SB1180206	-	S	-	S	-	-	-	-
MISC	03SB118	03SB1180610	S	S	-	S	-	-	-	-
MISC	03SB118	03SB1181012	S	S	-	S	-	-	-	-
MISC	03SB119	03SS1190002	-	S	-	-	-	-	-	-
MISC	03SB119	03SB1190206	-	S	-	-	-	-	-	-
MISC	03SB119	03SB1190610	S	S	-	-	-	-	-	-
MISC	03SB119	03SB1191014	S	S	-	-	-	-	-	-
MISC	03SB120	03SS1200002	-	S	S	S	S	-	-	-
MISC	03SB120	03SB1200206	-	S	S	S	S	-	-	-
MISC	03SB120	03SB1200610	S	S	S	S	S	-	-	-
MISC	03SB120	03SB1201012	S	S	S	S	S	-	-	-
MISC	03SB121	03SS1210002	-	S	-	S	-	-	-	-
MISC	03SB121	03SB1210206	-	S	-	S	-	-	-	-
MISC	03SB121	03SB1210610	S	S	-	S	-	-	-	-
MISC	03SB121	03SB1211013	S	S	-	S	-	-	-	-

VOC Volatile organic compound.
MISC Miscellaneous.
S Sample collected as proposed in the approved QAPP Addendum No. 1 (TtNUS, 2004).
O Sample NOT collected as proposed in the approved QAPP Addendum No. 1 (TtNUS, 2004) (See Table 2-3).
E Sample collected due to elevated PID readings in soil core.

1 Soil Boring Groups correspond to Figure 3-1. "OJT" indicates borings located at the OJT; "MISC" indicates borings located in the spaces between soil boring groups on Figure 3-1.
2 Borings ending in xxxx were not collected as described in Table 2-3.
3 For sample numbers ending in 0002 or 0206 VOC samples were collected at the highest PID reading if a reading higher than background was obtained. See Section 3.5.1 of the text of QAPP Addendum No. 1.
4 See Table 1-3 of QAPP Addendum No. 1 for specific analysis requirements and analyte list.

TABLE 2-2

SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSIS – GROUNDWATER
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Location	Sample Number	VOCs[1]	Explosives[1]	Metals[1][2]	Perchlorate[1]
Ammunition Burning Grounds Main Treatment Area					
03-01	03GW0101	S	S	S	-
03-04	03GW0401	O	O	O	-
03-06	03GW0601	O	O	O	-
03-09	03GW0901	S	S	S	S
03-27	03GW2701	O	O	O	-
03-29	03GW2901	O	O	O	-
03-30	03GW3001	O	O	O	O
03-31	03GW3101	S	S	S	-
03-32	03GW3201	O	O	O	-
03-33	03GW3301	S	S	S	S
03-34	03GW3401	O	O	O	-
03-35	03GW3501	O	O	O	-
03-36	03GW3601	O	O	O	-
03-37	03GW3701	O	O	O	-
03-38	03GW3801	S	S	S	S
03-39	03GW3901	S	S	S	-
03C01P2	03GWC01P201	S	S	S	-
03C03P2	03GWC03P201	S	S	S	-
03C05	03GWC0501	S	S	S	S
03C06	03GWC0601	S	S	S	-
03C10	03GWC1001	O	O	O	O
03C11	03GWC1101	O	O	O	O
03C13	03GWC1301	O	O	O	O
03C14	03GWC1401	S	S	S	-
03C21	03GWC2101	S	S	S	-
03C28	03GWC2801	S	S	S	-
03TW01[3]	03GWTW01[3]	S	S	S	S
03TW02[3]	03GWTW02[3]	S	S	S	-
03TW03[3]	03GWTW03[3]	S	S	S	-
03TW04[3]	03GWTW04[3]	S	S	S	-
03TW05[3]	03GWTW05[3]	S	S	S	-
Old Jeep Trail					
03-07	03GW0702	S	S	S	S
03-12	03GW1202	S	S	S	-
03-15	03GW1502	S	S	S	S

TABLE 2-2

SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSIS – GROUNDWATER
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Location	Sample Number	VOCs(1)	Explosives(1)	Metals(1)(2)	Perchlorate(1)
03-16	03GW1602	S	S	S	-
03-21	03GW2102	S	S	S	-
03-24	03GW2402	S	S	S	-
03TW06(3)	03GWTW06(3)	S	S	S	-
Spring A'					
03SPA'	03SPAp01	S	S	S	-

1 See Table 1-3 of the QAPP Addendum No. 1 for specific analysis requirements and analyte list.
2 Unfiltered samples were analyzed for total metals if turbidity of water was greater than 10 nephelometric turbidity units, a filtered sample was also collected and analyzed for dissolved metals.
3 "TW" refers to temporary wells, which were actually DPT borings from which ground water (perched sample) was extracted from near the bedrock-overburden interface.

VOCs = Volatile Organic Compounds.
S= Sample collected as proposed in the approved QAPP Addendum No. 1 (TtNUS, 2004).
O = Sample NOT collected as proposed in the approved QAPP Addendum No.1 (TtNUS, 2004) (See Table 2-3).

TABLE 2-3

SUMMARY OF SOIL AND GROUND WATER SAMPLES NOT COLLECTED AS PROPOSED
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Soil Boring Group[1]	Soil Boring or Monitoring Well Location	Sample Number	Reason Not Collected
SURFACE SOIL			
B	03SB055	03SS0550002	Abandoned due to steep slope
B	03SB062	03SS0620002	Abandoned due to steep slope
SUBSURFACE SOIL			
OJT	03SB051	03SB051xxxx	Refusal at 10.5 feet
A	03SB053	03SB0530610	Refusal at 4.5 feet
A	03SB053	03SB053xxxx	Refusal at 4.5 feet
B	03SB054	03SB0540610	Refusal at 4.0 feet
B	03SB054	03SB054xxxx	Refusal at 4.0 feet
B	03SB055	03SB0550206	Abandoned due to steep slope
B	03SB055	03SB0550610	Abandoned due to steep slope
B	03SB055	03SB055xxxx	Abandoned due to steep slope
B	03SB056	03SB0560206	Refusal at 2.0 feet
B	03SB056	03SB0560610	Refusal at 2.0 feet
B	03SB056	03SB056xxxx	Refusal at 2.0 feet
B	03SB057	03SB0570610	Refusal at 5.5 feet
B	03SB057	03SB057xxxx	Refusal at 5.5 feet
B	03SB059	03SB0590610	Refusal at 4.5 feet
B	03SB059	03SB059xxxx	Refusal at 4.5 feet
B	03SB061	03SB061xxxx	Refusal at 7.0 feet
B	03SB062	03SB0620206	Abandoned due to steep slope
B	03SB062	03SB0620610	Abandoned due to steep slope
B	03SB062	03SB062xxxx	Abandoned due to steep slope
B	03SB064	03SB0640610	Refusal at 4.5 feet
B	03SB064	03SB064xxxx	Refusal at 4.5 feet
D	03SB069	03SB069xxxx	Refusal at 9.0 feet
D	03SB071	03SB0710610	Refusal at 5.0 feet
D	03SB071	03SB071xxxx	Refusal at 5.0 feet
D	03SB072	03SB072xxxx	Refusal at 10.0 feet
D	03SB075	03SB075xxxx	Refusal at 9.5 feet
E	03SB077	03SB077xxxx	Refusal at 10.0 feet
E	03SB078	03SB078xxxx	Refusal at 8.0 feet
F	03SB081	03SB081xxxx	Refusal at 9.0 feet
F	03SB083	03SB083xxxx	Refusal at 10.0 feet
F	03SB084	03SB084xxxx	Refusal at 8.5 feet
G	03SB088	03SB0880610	Refusal at 6.0 feet
G	03SB088	03SB088xxxx	Refusal at 6.0 feet
G	03SB089	03SB0890610	Refusal at 6.0 feet
G	03SB089	03SB089xxxx	Refusal at 6.0 feet
G	03SB090	03SB090xxxx	Refusal at 10.0 feet
H	03SB091	03SB091xxxx	Refusal at 10.0 feet

TABLE 2-3

SUMMARY OF SOIL AND GROUND WATER SAMPLES NOT COLLECTED AS PROPOSED
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Soil Boring Group[1]	Soil Boring or Monitoring Well Location	Sample Number	Reason Not Collected
SUBSURFACE SOIL (cont'd)			
H	03SB092	03SB092xxxx	Refusal at 8.5 feet
H	03SB094	03SB094xxxx	Refusal at 9.5 feet
H	03SB095	03SB095xxxx	Refusal at 7.5 feet
H	03SB096	03SB096xxxx	Refusal at 8.5 feet
H	03SB097	03SB097xxxx	Refusal at 9.5 feet
H	03SB098	03SB098xxxx	Refusal at 7.5 feet
H	03SB099	03SB099xxxx	Refusal at 8.0 feet
I	03SB103[2]	03SB103xxxx	Refusal at 11.0 feet
MISC	03SB111	03SB111xxxx	Refusal at 9.0 feet
MISC	03SB112	03SB112xxxx	Refusal at 10.0 feet
MISC	03SB113	03SB1130610	Refusal at 4.5 feet
MISC	03SB113	03SB113xxxx	Refusal at 4.5 feet
MISC	03SB114	03SB114xxxx	Refusal at 9.0 feet
MISC	03SB115	03SB115xxxx	Refusal at 8.0 feet
MISC	03SB116	03SB116xxxx	Refusal at 9.5 feet
GROUNDWATER			
MTA	03-04	03GW0401	Abandoned
MTA	03-06	03GW0601	Abandoned
MTA	03-27	03GW2701	Damaged and Abandoned
MTA	03-29	03GW2901	Damaged and Abandoned
MTA	03-30	03GW3001	No Recharge
MTA	03-32	03GW3201	Abandoned
MTA	03-34	03GW3401	Abandoned
MTA	03-35	03GW3501	Abandoned
MTA	03-36	03GW3601	Abandoned
MTA	03-37	03GW3701	Abandoned
MTA	03C10	03GWC1001	Not Needed
MTA	03C11	03GWC1101	Not Needed
MTA	03C13	03GWC1301	Collapsed Well Casing w/ Lodged Bladder Pump

MISC Miscellaneous.
MTA Main Treatment Area.
OJT Old Jeep Trail.
1 Soil Boring Groups correspond to Figure 3-1 of the approved QAPP Addendum No. 1 (TtNUS, 2004).
"OJT" indicates borings located at the OJT;
"MISC" indicates borings located in the spaces between soil boring groups on Figure 3-1.
2 Sample was collected for VOCs, but not for explosives or TAL Metals.
xxxx Indicates soil depths greater than 10 feet.

TABLE 2-4

DATES AND DEPTHS OF SOIL BORINGS AND SOIL SAMPLES COLLECTED
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Boring No.	Total Depth (feet bgs)	Drilling Method[1]	Date Drilled	Depth Interval(s) of Soil Samples (feet bgs)
03SB049	14.0	DPT	23-Apr-04	0-2, 2-6, 6-10, 10-14
03SB050	13.5	DPT	22-Apr-04	0-2, 2-6, 6-10, 10-13.5
03SB051	10.5	DPT	23-Apr-04	0-2, 2-6, 6-10
03SB052	13.5	DPT	23-Apr-04	0-2, 2-6, 6-10, 10-13.5
03SB053	4.5	DPT	16-Apr-04	0-2, 2-4.5
03SB054	3.0	DPT	22-Apr-04	0-2, 2-3
03SB055	NC	NC	NC	NC
03SB056	2.0	DPT	22-Apr-04	0-2
03SB057	5.5	DPT	16-Apr-04	0-2, 2-5.5
03SB058	11.5	DPT	22-Apr-04	0-2, 2-6, 6-10, 10-11.5
03SB059	4.5	DPT	22-Apr-04	0-2, 2-4.5
03SB060	14.0	DPT	16-Apr-04	0-2, 2-6, 6-10, 10-14
03SB061	7.0	DPT	22-Apr-04	0-2, 2-6, 6-7
03SB062	NC	NC	NC	NC
03SB063	14.0	DPT	17-Apr-04	0-2, 2-6, 6-10, 10-14
03SB064	4.5	DPT	17-Apr-04	0-2, 2-4.5
03SB065	14.0	DPT	17-Apr-04	0-2, 2-6, 6-10, 10-14
03SB066	13.5	DPT	16-Apr-04	0-2, 2-6, 6-10, 10-13.5
03SB067	11.5	DPT	16-Apr-04	0-2, 2-6, 6-10, 10-11.5
03SB068	13.0	DPT	16-Apr-04	0-2, 2-6, 6-10, 10-13
03SB069	9.0	DPT	19-Apr-04	0-2, 2-6, 6-9
03SB070	11.5	DPT	19-Apr-04	0-2, 2-6, 6-10, 10-11.5
03SB071	5.0	DPT	19-Apr-04	0-2, 2-5
03SB072	10.0	DPT	19-Apr-04	0-2, 2-6, 6-10
03SB073	13.0	DPT	19-Apr-04	0-2, 2-6, 6-10, 10-13
03SB074	14.0	DPT	22-Apr-04	0-2, 2-6, 6-10, 10-14
03SB075	9.5	DPT	22-Apr-04	0-2, 2-6, 6-9.5
03SB076	14.0	DPT	20-Apr-04	0-2, 2-6, 6-10, 10-14
03SB077	10.0	DPT	20-Apr-04	0-2, 2-6, 6-10
03SB078	8.0	DPT	20-Apr-04	0-2, 2-6, 6-8
03SB079	12.0	DPT	17-Apr-04	0-2, 2-6, 6-10, 10-12
03SB080	12.5	DPT	17-Apr-04	0-2, 2-6, 6-10, 10-12.5
03SB081	9.0	DPT	17-Apr-04	0-2, 2-6, 6-9
03SB082	13.0	DPT	18-Apr-04	0-2, 2-6, 6-10, 10-13
03SB083	10.0	DPT	18-Apr-04	0-2, 2-6, 6-10
03SB084	8.5	DPT	18-Apr-04	0-2, 2-6, 6-8.5
03SB085	13.0	DPT	18-Apr-04	0-2, 2-6, 6-10, 10-13
03SB086	14.0	DPT	18-Apr-04	0-2, 2-6, 6-10, 10-14
03SB087	13.0	DPT	18-Apr-04	0-2, 2-6, 6-10, 10-13
03SB088	6.0	DPT	18-Apr-04	0-2, 2-6

TABLE 2-4

DATES AND DEPTHS OF SOIL BORINGS AND SOIL SAMPLES COLLECTED
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Boring No.	Total Depth (feet bgs)	Drilling Method[1]	Date Drilled	Depth Interval(s) of Soil Samples (feet bgs)
03SB089	6.0	DPT	18-Apr-04	0-2, 2-6
03SB090	10.0	DPT	18-Apr-04	0-2, 2-6, 6-10
03SB091	10.0	DPT	23-Apr-04	0-2, 2-6, 6-10
03SB092	8.5	DPT	19-Apr-04	0-2, 2-6, 6-8.5
03SB093	14.0	DPT	19-Apr-04	0-2, 2-6, 6-10, 10-14
03SB094	9.5	DPT	21-Apr-04	0-2, 2-6, 6-9.5
03SB095	7.5	DPT	19-Apr-04	0-2, 2-6, 6-7.5
03SB096	8.5	DPT	19-Apr-04	0-2, 2-6, 6-8.5
03SB097	9.5	DPT	21-Apr-04	0-2, 2-6, 6-9.5
03SB098	7.5	DPT	19-Apr-04	0-2, 2-6, 6-7.5
03SB099	8.0	DPT	21-Apr-04	0-2, 2-6, 6-8
03SB100	14.0	DPT	20-Apr-04	0-2, 2-6, 6-10, 10-14
03SB101	14.0	DPT	20-Apr-04	0-2, 2-6, 6-10, 10-14
03SB102	13.0	DPT	20-Apr-04	0-2, 2-6, 6-10, 10-13
03SB103	11.0	DPT	20-Apr-04	0-2, 2-6, 6-10, 10-11
03SB104	14.0	DPT	21-Apr-04	0-2, 2-6, 6-10, 10-14
03SB105	11.5	DPT	16-Apr-04	0-2, 2-6, 6-10, 10-11.5
03SB106	14.0	DPT	17-Apr-04	0-2, 2-6, 6-10, 10-14
03SB107	13.5	DPT	22-Apr-04	0-2, 2-6, 6-10, 10-13.5
03SB108	13.5	DPT	22-Apr-04	0-2, 2-6, 6-10, 10-13.5
03SB109	13.0	DPT	22-Apr-04	0-2, 2-6, 6-10, 10-13
03SB110	12.5	DPT	17-Apr-04	0-2, 2-6, 6-10, 10-12.5
03SB111	9.0	DPT	17-Apr-04	0-2, 2-6, 6-9
03SB112	10.0	DPT	23-Apr-04	0-2, 2-6, 6-10
03SB113	4.5	DPT	23-Apr-04	0-2, 2-4.5
03SB114	9.0	DPT	18-Apr-04	0-2, 2-6, 6-9
03SB115	8.0	DPT	21-Apr-04	0-2, 2-6, 6-8
03SB116	9.5	DPT	21-Apr-04	0-2, 2-6, 6-9.5
03SB117	13.0	DPT	21-Apr-04	0-2, 2-6, 6-10, 10-13
03SB118	11.5	DPT	19-Apr-04	0-2, 2-6, 6-10, 10-11.5
03SB119	13.5	DPT	21-Apr-04	0-2, 2-6, 6-10, 10-13.5
03SB120	12.0	DPT	21-Apr-04	0-2, 2-6, 6-10, 10-12
03SB121	12.5	DPT	21-Apr-04	0-2, 2-6, 6-10, 10-12.5

bgs = below ground surface.
DPT = Direct-push technology.
NC = Not collected due to steep slope.

3.0 CONCEPTUAL SITE MODEL

3.1 INTRODUCTION

This section presents the conceptual site model for the NSWC Crane SWMU 3 (Ammunition Burning Grounds). The conceptual site model presents the representation of the environmental system. It provides a tool for identifying contamination sources, contaminant migration pathways, and potential receptors. Uncertainties are identified. The conceptual site model provides a framework for development of the Corrective Measures Study (CMS), so that the study can be focused on identification and evaluation of practical and cost-effective remedial actions. Figure 3-1 presents a schematic of the conceptual site model for the Main Treatment Area (MTA). Figure 3-2 presents a schematic of the conceptual site model for the Old Jeep Trail (OJT). Both conceptual site models are discussed in detail in Sections 3.3 and 3.4, respectively. Section 3.5 summarizes the conceptual site models for the MTA and OJT.

3.2 SUMMARY OF SITE INFORMATION

Figures 1-1 through 1-17 show the locations of various physiographic features and operational facilities, surface and subsurface geologic features, and hydrogeological conditions of SWMU 3 and the Little Sulphur Creek (LSC) watershed. Section 1.3 provides a detailed description of those features. The site operational history, which describes the types of materials treated and hence potentially released at the MTA and OJT, is described in Section 1.3.1. The operational history, physical features, and environmental data collected to date are developed below into a conceptual site model that explains how and where site operations and physical features resulted in the existence and movement of various contaminants at SWMU 3. The model also supports inferences about future site conditions and potential routes of exposure to site contaminants for humans and ecological receptors. Tables located in Appendix A summarize the detections of chemicals investigated at SWMU 3 for each environmental media, which may be related to site activities. RDX (a common high explosive) and TCE (a commonly used chlorinated organic solvent) are the most significant organic chemicals that have been detected at SWMU 3. Barium (a naturally occurring metal and part of barium sulfate, which is used as an inert filler in projectiles and flares), is the most significant inorganic chemical that has been detected at SWMU 3.

3.3 MAIN TREATMENT AREA

Treatment Operations

The MTA is an active RCRA-Permitted open burning facility for the treatment of reactive hazardous wastes. Large-scale open burning of waste propellant, explosives, and explosive–contaminated materials has taken place at the MTA since the 1940s. The materials burned range from pure propellant and explosives to chlorinated and non-chlorinated solvents and packaging materials that are contaminated with propellants and explosives. Prior to the initiation of the use of containment facilities (steel pans and concrete pads), open burning typically took place directly on the ground surface. Often these operations took place directly on the ground surface in pits, which were dug into the ground. Until the early 1990's, unlined surface impoundments were used to dewater sludges, which contained explosives, propellants, and solvents. Until removed in the late 1980s an unlined waste pile was used to store residuals from burning operations at the OJT and the MTA. Up until the early 1990s, the MTA was kept devoid of vegetation which resulted in significant erosion and transport of surface soils to LSC. During the period that these practices took place a direct pathway existed for contamination of surface and subsurface soils. All treatment operations currently take place in containment facilities and tanks. The waste pile and surface impoundments have been decommissioned. Therefore, contamination is no longer being released to soils or into LSC from the routine MTA treatment operations. Any accidental releases would be immediately cleaned up in compliance with provisions of the RCRA Permit.

Soil Contamination

Historical treatment practices have resulted in the release of explosives and solvents to the soils. Investigations were conducted to determine the locations of soil sources of explosives (RDX), chlorinated organics (TCE), and metals (barium) contamination at the MTA. In general, the highest RDX contamination was observed in the upper 2 feet of the soil horizon and was observed to decrease with depth. Samples collected during the April 2004 field investigation did not provide evidence that a continuing source of RDX contamination is present in soils. Samples collected during the April 2004 field event showed evidence of a direct link between the soil overburden and the bedrock for TCE at some isolated locations. Figure 1-21 is a tag map which shows the locations where soil samples were collected and all positive detections for RDX and TCE. Barium was found in significant concentrations only in surface soils samples. No evidence was found of a direct link between soil barium sources and the bedrock. Figure 1-22 is a tag map which the locations where soil samples were collected and all positive detections.

Groundwater Flow and Contamination

The groundwater flow direction at SWMU 3 is generally toward LSC. Dissolved contaminants move in groundwater along the bedrock surface until they find an opening that allows them to migrate deeper, into bedrock and groundwater. As groundwater migrates along the fractures, dissolved contamination will diffuse into the rock matrix. The back-diffusion of contaminated water from the matrix into the open fractures will provide a long-term source of contamination and will slow the rate of plume migration. RDX, TCE, and barium contamination released as the result of historical practices, have migrated into the bedrock and serve as a continuing source of groundwater contamination. If the bedrock surface tilts in a direction other than the direction of groundwater, the contaminants will move in unexpected directions along the bedrock surface. Nevertheless, the contaminants will assume the groundwater flow direction if they migrate down into the Big Clifty-Beech Creek aquifer.

Spring Discharges of Groundwater and Contamination

The MTA is underlain by a karst system in the Beech Creek Formation that leads southward along the west side of the valley toward Springs A and A' (shown schematically in Figure 1-12). After making its way through saturated overburden and bedrock, MTA groundwater, and hence the MTA contaminants, are conveyed through the karst conduit to LSC via Springs A and A' (shown on Figure 1-12). RDX concentrations ranged from 0 to 140 µg/L at Spring A between 1998 and 2004, with an approximate average concentration of 36 µg/L. These concentrations are less than the average RDX concentration in groundwater underlying the MTA (71 µg/L). As expected, clean groundwater (and/or relatively clean groundwater) enters the conduit all along its path from the MTA to the location of Spring A. This results in dilution of contaminants between the MTA and Springs A and A'. Spring A' is part of the same conduit system which drains the MTA and discharges to LSC. The RDX concentration in Spring A' was 7.4 µg/L in April 2004, which is well below the average groundwater RDX concentration in the MTA.

The hydrographs for Spring A and C in Figure 1-16 illustrates the wide variation in water flow rates that occur in the springs, depending on whether base flow is observed or it is supplemented with varying degrees of precipitation. Precipitation increases the infiltration of water into the conduits. This not only affects transport and dilution in the conduits, but also causes corresponding increases in spring water flow rates.

TCE

When the karst conduit system is only partially full (i.e., some air space exists in the conduit), the conduit acts as open channel flow and a significant amount of VOCs could potentially volatilize out of the

groundwater during transit. This seems to be the situation in the conduit between the MTA and Springs A and A', because even though TCE is more concentrated in the MTA groundwater than is RDX, the TCE concentrations are generally discharging from the springs at a much lower concentration (commonly not detected) than RDX. Any TCE which is not volatized in the karst system would be expected to volatize in LSC.

Natural Attenuation

It is evident that natural attenuation process are slowing plume migration and are reducing the contaminant concentrations between the MTA and Springs A and A'. In summary:

- Matrix diffusion is reducing the rate of plume migration in fractured bedrock before groundwater enters the karst system.
- Dilution is reducing the concentration of RDX, TCE, and barium in the karst system before the groundwater discharges through Springs A and A' into LSC.
- TCE is volatizing within the karst system before discharge through the springs.

In addition to dilution and volatilization, other natural attenuation processes such as biotic and abiotic degradation may also operate to reduce the contaminant concentrations during storage and migration within the MTA before entering the karst conduit system. Breakdown products of RDX (MNX, DNX, and TNX) were found to be present during monitoring conducted during 1999 through 2002. Based on the concentration-time graphs for wells (see Appendix F); there is little indication that natural attenuation is rapidly reducing groundwater contaminant concentrations within the MTA area. However, the relatively stable trends indicate that monitored as natural attenuation processes are acting to stabilize the plume and slow migration.

Groundwater Contamination Sources

As noted previously, historical practices which resulted in the release of contamination to soils and groundwater have not been utilized since the early 1990's and all treatment operations now take place in containment devices. Contamination is no longer being released as the result of routine operation practices. The lack of decreasing concentrations of the RDX and TCE in groundwater within the MTA implies that the sources resulting from historical operations have not been depleted. Based on the April 2004 soil and groundwater data, it is difficult to identify a single primary source contributing to

groundwater contamination. The heterogeneous distribution of soil contamination indicates that multiple treatment areas were responsible for the observed groundwater contamination. Based on the April 2004 soil and groundwater data and groundwater data collected during the routine RCRA groundwater monitoring program, the sources appear to be present in a combination of the overburden soils, the bedrock, and the karst system. The April 2004 investigation did not provide evidence of RDX and barium contamination in soils immediately above the bedrock except in isolated locations. No evidence was found of barium contamination immediately above the bedrock. Therefore, it is probable that significant sources of RDX and barium are also located in the bedrock or karst system or some combination of the two. The April 2004 investigation did provide evidence of subsurface soils with TCE contamination directly above the bedrock in isolated locations. It is likely that TCE has also migrated into the bedrock and/or the karst system. It is not possible to determine the relative distributions of TCE among the soils, bedrock, and karst system.

Migration of Contamination

In summary, all contaminated MTA groundwater is discharged into LSC, primarily at Springs A and A'. Except during periods of extensive precipitation, LSC is dry between the MTA and Spring C. LSC is a loosing stream with surface waters infiltrating into the karst system. LSC becomes a perennial stream at the location where Spring C discharges into LSC. The LSC surface waters flow off-site. LSC surface waters do not generally contain any TCE because, as discussed previously, the TCE appears to volatize in the karst system and from LSC. The LSC surface waters generally contain RDX in concentrations above the RBTL established in the RCRA Permit.

Chemicals and Media of Concern

Human health and ecological risk assessments (Current Contamination Conditions Risk Assessment (CCCRA)) for existing contamination conditions were conducted in 1999 (TtNUS 1999a) as part of the hazardous waste permitting process for the open burning treatment operations at the MTA. The operating RCRA Permit issued by US EPA Region 5 established requirements for groundwater monitoring including RBTLs for hazardous constituents. The Permit requires the Navy to develop a Corrective Action Plan for groundwater when statistically significant concentrations of hazardous constituents also exceed RBTLs for point-of-compliance wells at the MTA. Annual groundwater monitoring reports for the years 2000, 2001, 2002, and 2003, which were prepared by the Navy (SAIC 2002a, SAIC 2002b, SAIC 2003, and SAIC 2004), have identified hazardous constituents, which were detected in statistically significant concentrations and above RBTLs. The following summarizes the chemical of concern (COCs) and media in which they are found as described in these documents.

- Groundwater: The CCCRA identified RDX, TCE, various degradation products of TNT and TCE, and metals (principally barium) as COCs for future residents or workers ingesting groundwater at the MTA. The annual groundwater monitoring reports have identified RDX, TCE, and barium as the principal contaminants present in statistically significant concentrations and above RBTLs in point-of-compliance wells at the MTA. Any risks to receptors for groundwater at the MTA are currently controlled because contaminated groundwater at the ABG is not used as a drinking water source. Open burning treatment operations prevent use of the MTA for residences.

- Springs A and A': The CCCRA did not identify any COCs for Springs A or A'. The annual groundwater monitoring reports have identified RDX and barium as the principal contaminants present in statistically significant concentrations and above RBTLs at Spring A. Any risks to receptors from these COCs are controlled because the Navy controls the property where Springs A and A' discharge.

- Surface Waters: The CCCRA identified RDX and arsenic as COCs for off-site residents using LSC surface waters as drinking water sources. The annual groundwater monitoring reports have not identified any COCs for LSC surface waters. However, it should be noted that reported concentrations of RDX are in excess of the RBTL that was established in the RCRA Permit for protection of groundwater. Any risks to offsite receptors are not currently controlled.

- Soils: The CCCRA identified arsenic, zinc, PCDD, and TCDD as COCs for future residents ingesting home grown fruits, vegetables, beef, or milk. Any risks to receptors for home grown agricultural products at the MTA are currently controlled because the MTA is not used for any agricultural purposes. Open burning treatment operations prevent use of the MTA for residences or agriculture. Reasonable future land use for the MTA does not include residential or agricultural use.

- Ecological - Soils: The CCCRA did not identify any significant ecological risks or COCs within the MTA. In addition, open burning treatment operations preclude the use of the MTA for ecological habitat.

- Ecological – LSC: The CCCRA did not identify any significant ecological risks or COCs in LSC.

3.4 OLD JEEP TRAIL

The OJT is an inactive area that is adjacent to and down-valley (southeast) of the MTA. The OJT was used to burn out bomb casing (burn area) and open burn explosive-contaminated materials in a pit (burn pit). Treatment operations took place from the mid-1970's through 1983. Figure 1-2 shows the approximate locations of these areas. At the burn area, bomb casings, from which the bulk explosives had been removed, were filled with initiating powder, tilted on-end toward a hillside east of the OJT in the direction of the adjacent hillside, and flashed to complete the demilitarization process. The burn pit was a trench or natural depression, approximately 100 feet long, 30 feet wide, and 10 to 12 feet deep, located just south-southeast of the burn area (Figure 1-2). Powder was flashed and explosives-contaminated materials were burned in this pit. The area has not been used for any operations since 1983 at which time it was filled with clean fill material and revegetated. The area is now overgrown with brush, trees, and grasses.

Historical treatment practices have resulted in the release of explosives, solvents, and metals to the soils and groundwater underlying the OJT. Investigations were conducted to determine the locations of soil sources of explosives (RDX), chlorinated organics (TCE), and metals (barium) contamination at the OJT. In general, RDX contamination decreased with depth. Samples collected during the June 2001 and April 2004 field investigations did not provide direct evidence that the source of RDX contamination in soils have been located. Samples collected during these field events showed evidence of a direct link between the soil overburden and the bedrock for TCE. Figure 1-27 is a tag map which shows the locations were soil samples were collected and all positive detections for RDX and TCE.

In general, similar physical site conditions and hydrologic processes exist for the OJT area as those which were discussed for the MTA:

- RDX and TCE have been released to the soils and groundwater as the result of historical site operations.
- Contaminants are leaching down and impacting groundwater.
- Contaminated groundwater is migrating eastward toward a karst conduit.
- From the OJT, groundwater enters the karst conduit and flows rapidly southward.

- Unlike the western conduit system, the eastern conduit system transmits the groundwater to Spring C (rather than Springs A or A').

- An extensive amount of dilution takes place within the conduit before the groundwater reaches Spring C.

The hydrographs for Spring A and C in Figure 1-16 illustrates the wide variation in water flow rates that occur in the springs, depending on whether base flow is observed or it is supplemented with varying degrees of precipitation. Precipitation increases the infiltration of water into the conduits. This not only affects transport and dilution in the conduits but also causes corresponding increases in spring water flow rates.

Chemicals and Media of Concern

An RFI was conducted was conducted for the OJT and LSC. The RFI report (TtNUS January 2005) included health and ecological risk assessments for the OJT and LSC. The Permit required groundwater monitoring program for the MTA includes monitoring of Spring C. The following summarizes the COCs and media in which they are found as described in the risk assessments, which are contained in the RFI Report and for Spring C in the Annual Groundwater Monitoring Reports.

- Groundwater: TCE, 1,1,2,2-TCA, and 4-A-2,6-DNT were identified as COCs for future residents or workers ingesting of groundwater at the OJT. Any risks to receptors for groundwater at the OJT are currently controlled because the OJT is under control of the Navy and is not used as a drinking water source.

- Spring C: The RFI did not include a separate evaluation of Spring C. The annual groundwater monitoring reports have identified barium as the principal contaminants present in statistically significant concentrations and above RBTLs at Spring C. Data for RDX contained in the RFI Report shows that RDX is generally present above the RBTL established in the Permit.

- Soils: TNT, RDX, and lead were identified as COCs for future residents exposed to soils. Risk to residential receptors is currently controlled, because the OJT is under control of the Navy and is not used for residences.

- Surface Waters: 2-A-4,6-DNT, 4-A-2,6-DNT, and RDX were identified as COCs for future residents ingesting surface water. Any risks to receptors from ingestion of surface water at the OJT are

currently controlled, because the portion of LSC that is within the boundary of NSWC Crane is under control of the Navy.

- Ecological – Soils: No significant ecological risks or COCs were identified for the OJT.

- Ecological – LSC: No significant ecological risks or COCs were identified in LSC. .

3.5 SUMMARY OF CONCEPTUAL SITE MODEL

Figure 3-1 is a schematic drawing of the conceptual site model for the MTA. It shows, in principle, that contaminants were released through surface/subsurface soils and spread toward downgradient locations from those releases to deeper soils, groundwater, springs, and LSC. The following is a summary of the conceptual site model for the MTA.

- The relative distribution of RDX, TCE, and barium contamination sources between the overburden, bedrock, and karst system is not known.

- The distribution of RDX, TCE, and barium contamination sources in the overburden soil, bedrock, and karst system appears to be heterogeneous in nature.

- Groundwater underlying the MTA is contaminated with RDX, TCE, degradation products of RDX and TCE, and barium.

- MTA groundwater discharges through the karst system into LSC through Springs A and A'.

- TCE is volatized in the karst system and is not present in LSC surface waters.

- RDX is present above RBTLs in LSC surface waters and unknown risk to off-site receptors exists.

- Excess risk is presented only to future residents ingesting groundwater; there is no current risk to on-site receptors. Reasonable future uses for the MTA do not include residential housing.

Figure 3-2 is a schematic drawing of the conceptual site model for the OJT. It shows, in principle, that contaminants were released through surface/subsurface soils and spread toward downgradient locations from those releases to deeper soils, groundwater, springs, and LSC. Exposure to the contaminants could

result in unacceptable health risks to humans. The following is a summary of the conceptual site model for the OJT:

- Groundwater underlying the OJT is contaminated with RDX and TCE.
- Excess risk is presented only to future residents ingesting groundwater.
- RDX, TCE, and barium contamination sources appear to be distributed among the overburden soil, bedrock, and kart system.
- The relative distribution of RDX, TCE and barium contamination sources between the overburden, bedrock, and karst system is not known due to the heterogeneous distribution of contamination at the OJT.
- OJT groundwater discharges through the karst system into LSC at Spring C.
- TCE is volatized in the karst system and is not present in LSC surface waters.

3.6 RECOMMENDATIONS FOR CORRECTIVE MEASURES STUDY

Following are recommendations for consideration in development of the CMS for the ABG. These recommendations are based on the conceptual site model which has been presented in this section.

- Contaminated groundwater from the MTA and OJT are discharged through Springs A, A', and C. Off-site impacts to surface waters quality can be controlled at the locations where groundwater discharges into these springs.
- The distribution of sources of explosives (RDX), chlorinated solvents (TCE), and metals (barium) among the soils, bedrock, and karst system, within both the MTA and the OJT, is very heterogeneous due to the nature of the previous burning operations at the MTA. Although the April 2004 soil sampling identified isolated areas of RDX, TCE, and barium contamination, the characterization study failed to identify a significant persistent source of contamination in soil. Therefore, it is highly probable that soil remediation would be ineffective in eliminating sources of these contaminants and in improving the quality of groundwater in the MTA and surface water leaving the base through Springs A, A', C, and LSC. Therefore, remediation of soils to address RDX, TCE, and barium contamination should not be extensively evaluated.

- In-situ alternatives for remediation of contaminated groundwater within the MTA and OJT should be evaluated at locations before the groundwater has entered the karst systems.

- TCE does not present any off-site impacts because it volatizes within the karst system and LSC. Therefore, evaluations of remedial alternatives for surface water and groundwater should focus on explosives rather than TCE.

FIGURE 3-1
CONCEPTUAL SITE MODEL SCHEMATIC DIAGRAM
MAIN TREATMENT AREA
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

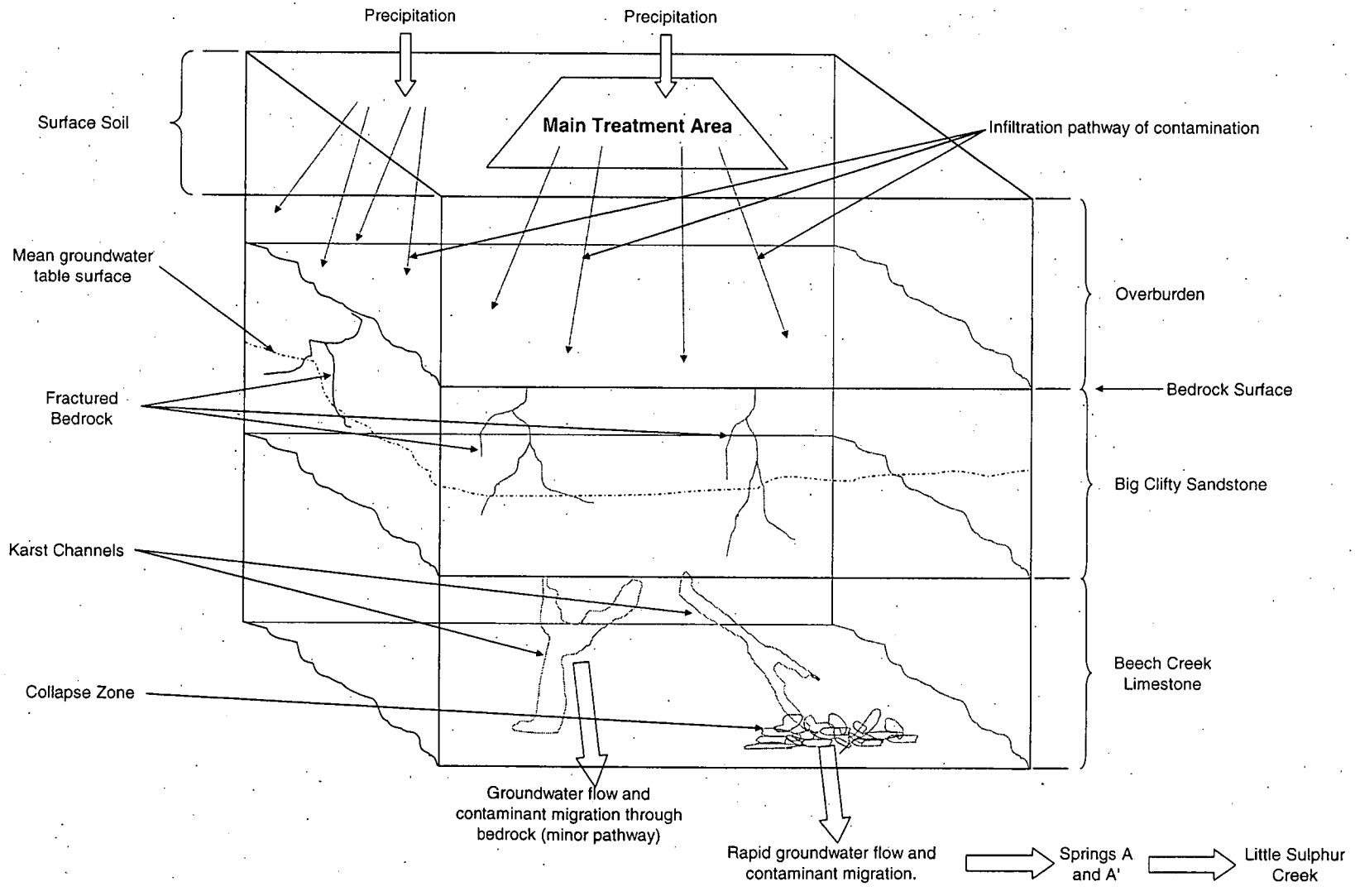
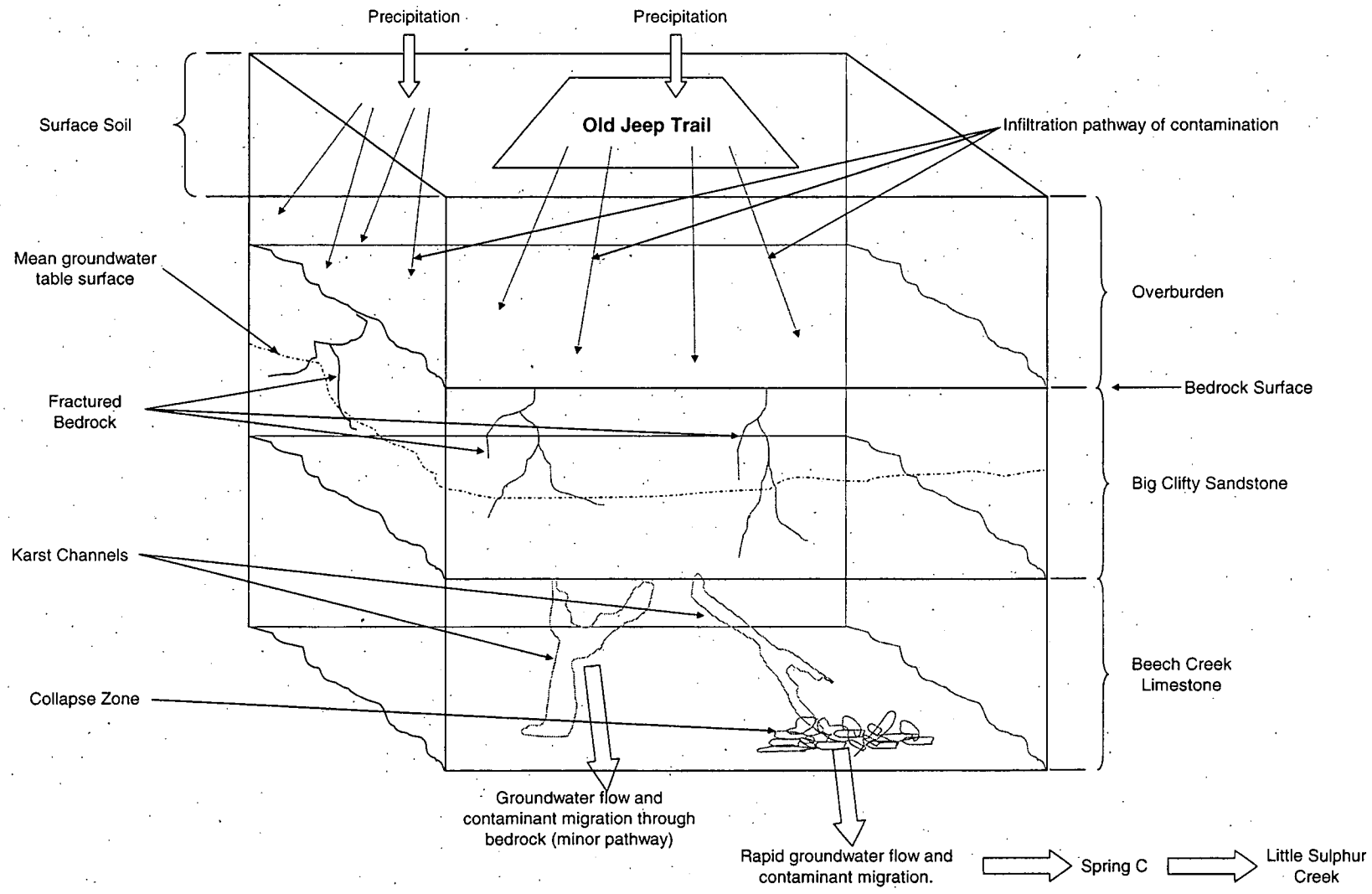


FIGURE 3-2
CONCEPTUAL SITE MODEL SCHEMATIC DIAGRAM
OLD JEEP TRAIL
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA



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