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October 19, 2009

U.S. Army Engineer District, Nashville
ATTN: CELRN-EC-R (Ms. Kathy McClanahan)
110 Ninth Avenue South, Room 682
U.S. Court House Annex
Nashville, Tennessee 37203

Submittal of the Final Decision Document for TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio
Contract No. W912DR-05-D-0026: Shaw Project Number 119268

Dear Ms. McClanahan:

In accordance with the requirements of Delivery Order No. DX02 of Contract No. DACA62-00-D-0002, Shaw is pleased to submit this Final Decision Document for TNT Area C at the Former Plum Brook Ordnance Works located in Sandusky, Ohio.

Enclosed are four copies of this Decision Document for your records. Copies have also been sent as indicated to those on the attached distribution list. As requested, the Decision Document was sent to the Center of Expertise and Mr. Mark Bohne in electronic format only. This Decision Document incorporates pertinent comments that were received on the March 26, 2009 Draft Decision Document. If this Decision Document is approved by the Department of Defense, copies of the signed pages will be provided by Mr. Rick Meadows.

Should you have any questions or require additional information regarding this submittal, please do not hesitate to contact me at (865) 694-7496.

Sincerely,

Steven T. Downey, PE, PMP
Project Manager

Enclosures

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Distribution List

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Final
Decision Document for
TNT Area C
Former Plum Brook Ordnance Works
Sandusky, Ohio

Issued By: U.S. Army Corps of Engineers

October 2009

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List of Acronyms

2-ADNT	2-amino-4,6-dinitrotoluene
4-ADNT	4-amino-2,6-dinitrotoluene
AR	Administrative Record
ARAR	applicable or relevant and appropriate requirement
BERA	baseline ecological risk estimation
bgs	below ground surface
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	chemical of concern
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
cy	cubic yards
D&M	Dames & Moore, Inc.
DERP	Defense Environmental Restoration Program
DNT	dinitrotoluene
DoD	U.S. Department of Defense
DSMOA	Defense and State Memorandum of Agreement
EHI	ecological hazard index
EHQ	ecological hazard quotient
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
FFS	focused feasibility study
FS	feasibility study
FUDS	Formerly Used Defense Sites
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
ICI	International Consultants, Inc.
ILCR	incremental lifetime cancer risk
IRIS	Integrated Risk Information System
IT	IT Corporation
LD_{50}	dose at which 50 percent of test organisms died

List of Acronyms *(Continued)*

LDR	land disposal restriction
LOAEL	lowest-observed-adverse-effects level
LRD	Great Lakes and Rivers Division
MDC	maximum detected concentration
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram of body weight per day
MK	Morrison-Knudsen Corporation
NASA	National Aeronautics and Space Administration
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NOAEL	no-observed-adverse-effects level
NTCRA	non-time-critical removal action
Ohio EPA	Ohio Environmental Protection Agency
PA	preliminary assessment
PAH	polynuclear aromatic hydrocarbon
PBOW	former Plum Brook Ordnance Works
PCB	polychlorinated biphenyl
PRRWP	Pentolite Road Red Water Ponds
RAB	Restoration Advisory Board
RAO	remedial action objective
RBRC	risk-based remediation concentration
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RG	remedial goal
RI	remedial investigation
RTV	reference toxicity value
SARA	Superfund Amendments and Reauthorization Act of 1986
SF	slope factor
Shaw	Shaw Environmental, Inc.
SI	site investigation
SLERA	screening level ecological risk assessment
TAPP	Technical Assistance for Public Participation
TCLP	toxicity characteristic leaching procedure
TNT	trinitrotoluene
TNTA	TNT Area A
TNTB	TNT Area B

List of Acronyms *(Continued)*

TNTC	TNT Area C
TSDF	transportation, storage, and disposal facility
USACE	U.S. Army Corps of Engineers

1.0 Declaration

1.1 Site Name and Location

TNT Area C
Former Plum Brook Ordnance Works
Sandusky, Ohio

1.2 Statement of Basis and Purpose

This Decision Document presents the selected final remedy for contaminated soil and sediment attributable to releases associated with historical operations at TNT Area C (TNTC), located on the former Plum Brook Ordnance Works (PBOW), Sandusky, Ohio. No action is recommended for TNTC surface water. PBOW is an Army Defense Environmental Restoration Program (DERP) project under the Great Lakes and Rivers Division (LRD) Formerly Used Defense Site (FUDS) program. The Louisville District Office of the U.S. Army Corps of Engineers (USACE) is the LRD program management district for the LRD FUDS program. Management support and technical support for PBOW are provided to the Louisville District Office by the USACE Huntington, West Virginia District Office and technical oversight is provided by the Nashville, Tennessee USACE District Office. The remedy selection has been made in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan under CERCLA (NCP) (EPA, 1990). The investigation, reporting, and project decision process were conducted consistent with *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (U.S. Environmental Protection Agency [EPA], 1988) and subsequent guidance materials, including *Guidance on Implementation of the Superfund Accelerated Cleanup Model (SACM) under CERCLA and the NCP* (EPA, 1992). This decision is based on the Administrative Record (AR) file for TNTC.

This document has been prepared for the U.S. Department of the Army, the lead agency for response actions at the PBOW. The remedy for this site has been selected by the USACE. The State of Ohio concurs with this remedy.

1.3 Assessment of Site

The response action selected in this Decision Document is necessary to protect public health, public welfare, or the environment from actual or threatened releases of hazardous substances

into the environment or from actual or threatened releases of pollutants or contaminants from this site which may present an imminent and substantial endangerment to public health or welfare.

1.4 Description of the Selected Remedy

The remedy selected in this Decision Document addresses the contamination associated with TNTC soil and sediment. The soil and sediment remedy includes excavation, alkaline hydrolysis, windrow composting, ex situ chemical stabilization, and on-site/off-site disposal. It was estimated that a total of 9,205 cubic yards (cy) of contaminated soil and sediment will need to be excavated, 2,310 cy of which are anticipated to be hazardous. Of the 2,310 cy of hazardous materials, most is classified based solely on 2,4-dinitrotoluene (DNT) concentrations that would otherwise exceed alternate land disposal restriction (LDR) treatment standards for underlying hazardous constituents in contaminated soil (40 Code of Federal Regulations [CFR] Parts 261.24 and 268.49). However, it is anticipated that alkaline hydrolysis, coupled if necessary with windrow composting, will reduce the 2,4-DNT concentrations to below LDR requirements, soil cleanup criteria (Section 2.8.1), and sediment cleanup criteria (Section 2.8.2). Alternatively, windrow composting alone may be used to treat nitroaromatic-contaminated soil. Windrow composting treats 2,4,6-trinitrotoluene (TNT) and DNTs by reducing them to less toxic and less mobile compounds which bind to the soil matrix. Alkaline hydrolysis effectively treats nitroaromatics in contaminated soils, especially TNT, by reducing them to less toxic constituents.

The expectation is that a combination of alkaline hydrolysis and windrow composting, or alternatively alkaline hydrolysis alone or windrow composting alone, will reduce the concentrations of chemicals of concern (COC) to meet the remedial goals (RG) for on-site disposal. Windrow composting will permanently treat the nitroaromatic-contaminated soil, which represents the principal threat, by reducing its toxicity and mobility, and alkaline hydrolysis will permanently treat the nitroaromatic-contaminated soil by reducing its toxicity. Lead-contaminated (400 cy) materials will be segregated, stabilized, and taken to a nonhazardous waste landfill. Polychlorinated biphenyl (PCB)-contaminated materials, where RGs for on-site disposal are exceeded, will be segregated and taken to a nonhazardous waste landfill. The PCB- and lead-contaminated materials would only be disposed of at a nonhazardous waste landfill provided that they meet all LDR and permit requirements for the disposal facility. The Army has no knowledge of any Resource Conservation and Recovery Act (RCRA) listed hazardous waste in TNTC soils or sediments.

1.5 Determinations

The selected remedy is protective of human health and the environment, complies with federal and State of Ohio requirements that are either applicable or relevant and appropriate to the remedial action, is cost effective, utilizes permanent solutions and treatment or resource recovery technologies to the maximum extent practicable, and satisfies the requirement for treatment as a principal element of the remedy. No soil or sediment contaminants will be left at levels to which direct exposure would be considered unacceptable by the Ohio Environmental Protection Agency (Ohio EPA). This remedy does not directly address contamination in underlying groundwater. A separate Decision Document will address groundwater for the three former TNT manufacturing areas and the two former Red Water Pond Areas. However, the remediation of soil and sediment addressed by this Decision Document represents the removal of a potential source of future groundwater contamination.

1.6 Decision Document Data Certification Checklist

The following information is included in the Decision Summary (Chapter 2.0) of this Decision Document.

- COCs and their respective concentrations
- Baseline risk represented by the COCs
- Cleanup levels established for COCs and the basis for these levels
- How source materials constituting principal threats are addressed
- Current and reasonable anticipated future land use assumptions used in the baseline risk assessment and Decision Document
- Potential land use that will be available at the site as a result of the Selected Remedy
- Estimated capital, annual operation and maintenance, and total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected
- Key factors that led to selecting the remedy.

Additional information can be found in the AR file for this site.

1.7 Authorizing Signatures

The Selected Remedy includes excavation, alkaline hydrolysis, windrow composting, ex situ chemical stabilization, and on-site/off-site disposal as described in this Declaration. The undersigned acknowledges approval of the Selected Remedy for TNT Area C soil and sediment.

STACEY K. HIRATA, P.E.
Chief, Department of Defense Team
Environmental Programs

7 Dec 2009
Date

Lead Regulator Concurrence

The Ohio Environmental Protection Agency is the lead regulator at the Plum Brook Ordnance Works FUDS property. Agency concurrence with the Selected Remedy is provided by separate letter. The Ohio EPA concurrence letter is provided on the following page of this document.

OhioEPA
State of Ohio Environmental Protection Agency

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January 15, 2010

Stacey K. Hirata, P.E.
Chief, Department of Defense Team
Environmental Programs
U. S. Army Corps of Engineers
441 G. Street, NW
Washington, D.C. 20314

RE: Ohio EPA Concurrence on Decision Document for Soils and Sediments, TNT Area C, NASA Plum Brook Ordnance Works, Sandusky, Ohio.

Dear Mr. Hirata:

Ohio EPA has reviewed the October 2009 Decision Document for Soils and Sediments, TNT Area C, Plum Brook Ordnance Works. The site is located within the NASA Plum Brook Station, four miles south of Sandusky, Ohio. Ohio EPA has been involved in the investigation of this Area of Concern, reviewing and concurring in work plans, Analytical data, and investigation reports.

The former TNT Area C manufacturing site consisted of an area approximately 119 acres in size and is currently overgrown with brush and is less than 10 percent wooded. Structures include roads, fire hydrants, water valves, railroad beds, and former building pad foundations. Several below ground features are also present, including manholes, drains, and underground lines. Soil and other media were contaminated by nitroaromatic compounds and associated chemical such as lead, PCBs and PAHs as secondary contaminants involved in the former manufacturing processes.

Results of the surface water sampling indicated low levels of nitroaromatics, but not at concentrations that would adversely affect TNT Area C surface water; thus, no surface water chemicals of concern were identified. Contamination in sediment was found at concentrations that may potentially affect human or ecological receptors at one location.

A Focused Feasibility Study for soils and sediments was completed in 2003. A public meeting and comment period in 2004 generated no substantive comments. Subsequently, for administrative reasons, a revised preferred remedial alternative was presented in a 2009 Proposed Plan, based on a Focused Feasibility Study Addendum. This Proposed Plan was public noticed in February 2009 with a public meeting on March 12, 2009 and a comment period from March 12 through April 13, 2009.

The selected remedy is Alternative 5, Excavation, Alkaline Hydrolysis, Windrow Composting, Ex Situ Chemical Stabilization and On-Site/Off-Site Disposal. This alternative meets the NCP statutory preference for treatment technologies that permanently reduce the toxicity and mobility through treatment, and (with the exception of the No Action alternative) is estimated to be the least expensive alternative. The community has expressed a preference for windrow composting and other treatment technologies over those remedial approaches that rely primarily on landfill disposal, and NASA has expressed the desire to use composted materials on site if these materials meet the remediation goals. The expected outcome represents a permanent remedy which appears to meet community acceptance. Therefore, the Ohio Environmental Protection Agency concurs with the October 2009 Decision Document for Soils and Sediments, TNT Area C, at the NASA Plum Brook Ordnance Works.

If you have any questions regarding this letter, please contact Paul Jayko (DERR/NWDO) at (419) 373-3038.

Sincerely,

Chris Korleski
Director, Ohio EPA

/csl

pc: File, DERR, NASA-PBOW

ec: Cindy Hafner, Chief, DERR, CO
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Bonnie Buthker, DERR, FFS, SWDO
Richard Meadows, USACE, Richard.L.Meadows@USACE.army.mil

2.0 Decision Summary

2.1 Site Name, Location, and Description

This Decision Document describes the determination that remedial action is required at PBOW TNTC. Only TNTC soil and sediment are covered by this Decision Document. The Decision Summary provides an overview of information presented in greater detail in the Report of Findings (IT Corporation [IT], 2001a), Human Health Risk Assessment (HHRA) (IT, 2001b), Ecological Risk Assessment (ERA) (IT, 2001c), Focused Feasibility Study (FFS) (Shaw Environmental, Inc. [Shaw], 2003), FFS Addendum (Shaw, 2009a), and other documents on file as part of the AR for PBOW TNTC. A summary of pertinent documents which are part the AR for TNTC is provided in the text box on the following page.

TNTC comprises 1 of 16 U.S. Department of Defense (DoD) projects at PBOW; the other 15 DoD projects are identified in Section 2.4. A recommendation for remediation of TNTC soil and sediment was prepared and presented to the public on May 10, 2004. This remediation had been planned as part of an interim non-time critical removal action (NTCRA). However, it was subsequently decided that this action would not be performed as a NTRCA. The preferred remedial alternative, as described in the Proposed Plan (Shaw, 2009b), was presented to the public on March 12, 2009 during a public meeting at the Bowling Green State University Firelands Campus Library in Huron, Ohio. The remedial decision is recorded in this Decision Document in consultation with the Ohio EPA and the community. The goal for this remedial action is to enable the TNTC property to meet unrestricted land use criteria.

This Decision Document is being issued by the USACE in partnership with, and supported by, the State of Ohio and is consistent with EPA (1999a) guidance. As the lead agency for DoD environmental response actions at PBOW, the USACE is responsible for planning and implementing remedial action at the site. The partner support agencies provide regulatory review, comment, and oversight. The environmental restoration of PBOW is being pursued by the USACE under the *LRD* DERP—FUDS. The Louisville District Office of the USACE is the LRD program management district for the LRD FUDS program. Management support and technical support for PBOW are provided to the Louisville District Office by the USACE Huntington, West Virginia District Office, and technical oversight is provided by the Nashville, Tennessee USACE District Office.

The FUDS program was established under DERP to clean up properties that were under the jurisdiction of the Secretary of Defense and owned by, leased to, or otherwise possessed by the United States at the time of actions leading to contamination or safety hazards caused by DoD.

The Army is the executive agent for the FUDS program, and the USACE executes the program. The cleanup mission for the FUDS program is to perform appropriate, cost-effective cleanup of contamination caused by DoD and to protect human health, public safety, and the environment (U.S. Army Environmental Center, 2004).

2.1.1 Site Location

PBOW is located approximately 4 miles south of Sandusky, Ohio, and 59 miles west of Cleveland (Figure 2-1). The former PBOW facility property is currently used by the National Aeronautics and Space Administration (NASA) as the Glenn Research Center, Plum Brook Station and is the home of the center's four world class test facilities. None of these test facilities is located in TNTC, and NASA has not conducted any known activities in this area to contribute to the environmental contamination resulting from the former Department of Defense actions on the property. Although located primarily in Perkins and Oxford Townships, the eastern edge of the site extends into Huron and Milan Townships. PBOW is bounded on the north by Bogart Road, on the south by Mason Road, on the west by Patten Tract Road, and on the east by U.S. Highway 250. The area surrounding PBOW is mostly agricultural and residential (IT, 2001a).

2.1.2 Site Description

NTC occupies approximately 119 acres of land in the western portion of PBOW, as shown on Figure 2-2. Currently, the area is mostly overgrown with trees and brush. Several aboveground features that indicate former PBOW facilities were present are still evident at TNTC. These include roads, fire hydrants, water valves, a water valve control well, railroad beds, and former building pad foundations. Below-ground features are also present, including manholes, drains, and underground lines (indicated by aboveground water valves). NASA does not currently and is not known to have ever used the TNTC area; no records suggest that NASA ever constructed any buildings on TNTC. One building present on the site was constructed and used by the EPA to perform noise abatement testing in the 1980s. This building is located near a former Wash House (Building 606) along former Process Line 10. Based on this use, there is no reason to expect that EPA contributed in any way to contamination at TNTC. Former buildings and other site features are shown on Figure 2-3.

Currently, TNTC consists mostly of early and late old field combined with shrubby thicket vegetation and is less than 10 percent wooded. Some wetland vegetation was found along TNTC drainage ditches and streams. During rain events, drainage from the ditches flows into any of three small streams that eventually flow to Pipe Creek, located northwest of TNTC. Areas east of TNTC are primarily old field and shrub, while to the south, southeast, northeast, north, and west, it is primarily forested, and to the southwest, it is old field and early shrub thicket.

2.2 Site History and Statutory Authority

2.2.1 Site History

The 9,009-acre PBOW facility was built in early 1941 as a manufacturing plant for TNT, 2,4-DNT, and pentolite (ICI, 1995). Production of explosives at PBOW began in December 1941 and continued until 1945. It is estimated that more than 1 billion pounds of nitroaromatic explosives were manufactured during the 4-year operating period. The three explosive manufacturing areas were designated TNT Area A (TNTA), TNT Area B (TNTB), and TNTC. Twelve process lines were used in the manufacture of TNT, four lines at TNTA, three lines at TNTB, and five lines at TNTC.

The TNTC manufacturing site consisted of widely scattered buildings of wood frame construction with asbestos and sheet metal coverings. It also included a series of buried and/or

Primary Background Documents for TNTC

Dames & Moore, Inc. (D&M), 1997, ***TNT Areas Site Investigation Final Report, Plum Brook Ordnance Works, Plum Brook Station/NASA, Sandusky, Ohio,*** prepared for U.S. Army Corps of Engineers, Nashville District/Huntington District, April.

International Consultants Inc. (ICI), 1999, ***Community Relations Plan, Plum Brook Ordnance Works, Sandusky, Ohio,*** September.

International Consultants Inc. (ICI), 1995, ***Site Management Plan, Plum Brook Ordnance Works, Sandusky, Ohio,*** September.

IT Corporation (IT), 2001a, ***TNT Areas A and C Remedial Investigation, Volume 1 – Report of Findings***, Final, Former Plum Brook Ordnance Works, Sandusky, Ohio, November.

IT Corporation (IT), 2001b, ***TNT Areas A and C Remedial Investigation, Volume 2 – Human Health Risk Assessment***, Final, Former Plum Brook Ordnance Works, Sandusky, Ohio, November.

IT Corporation (IT), 2001c, ***TNT Areas A and C Remedial Investigation, Volume 3 – Ecological Risk Assessment***, Final, Former Plum Brook Ordnance Works, Sandusky, Ohio, November.

Morrison-Knudsen Corporation (MK), 1994, ***Site Inspection Report***, Plum Brook Station, Sandusky, Ohio, January.

Shaw Environmental, Inc. (Shaw), 2009a, ***Addendum, TNT Area C, Focused Feasibility Study for Soil and Sediment, Draft, Former Plum Brook Ordnance Works, Sandusky, Ohio,*** January.

Shaw Environmental, Inc., (Shaw), 2005, ***2004 Groundwater Data Summary and Evaluation Report***, Former Plum Brook Ordnance Works, Sandusky, Ohio, April.

Shaw Environmental, Inc., (Shaw), 2003, ***TNT Areas A and C Remedial Investigation, Volume 4 – Focused Feasibility Study for Soil and Sediment***, Final, Former Plum Brook Ordnance Works, Sandusky, Ohio, October.

(These documents may be viewed on line at the USACE Huntington District website: http://www.lrh.usace.army.mil/projects/current/derp-fuds/pbow/documents.)

overhead flumes and pipes used to transport various liquids associated with the manufacturing process.

After plant operations ceased, the TNTC manufacturing process lines were decontaminated by the Army in late 1945. During decontamination, all structures, equipment, and manufacturing debris were either removed and salvaged or removed and burned. After the property was certified as decontaminated, 3,230 acres of the property were initially transferred to the Ordnance Department, then to the War Assets Administration in 1946. This transfer did not include the Plum Brook Depot area, which consists of 2,800 acres. The Department of the Army reacquired the 3,230 acres in 1954 and performed cleanup efforts from the mid-1950s until 1963. In 1955, the Army specifically completed further decontamination of TNTC. This effort included removal of contaminated surface and subsurface soil around the buildings and wooden and ceramic waste disposal lines containing TNT. Thousands of pounds of TNT were discovered in catch basins; this TNT was removed and burned at the burning grounds.

Two property use agreements were entered into by the Army and the National Advisory Committee of Aeronautics, the predecessor of NASA, in 1956 and 1958, respectively. On March 15, 1963, accountability and custody of the entire PBOW property (6,030 acres) was transferred to NASA by the Department of the Army. NASA performed further decontamination efforts during 1964. The NASA decontamination process included removing contaminated surface soil above the drain tiles, flumes, etc., destruction of all buildings by fire, then removal of all soil, debris, sumps, and above-grade portions of concrete foundations. Portions of the concrete foundations located below grade were left buried, and some that had been previously slightly above grade were likewise buried. All materials, including the soil in those areas, were flashed; the area was then rough-graded. The decontamination process was also to have included the burning of nitroaromatic-filled flumes that were excavated. The thoroughness of this decontamination effort at TNTC is not well documented (D&M, 1997).

NASA has operated and maintained the former PBOW property since 1963, and the facility is currently the NASA Glenn Research Center, Plum Brook Station. NASA operates the property as a space research facility in support of their John Glenn Research Center at Lewis Field, Cleveland, Ohio. Most of the aerospace testing facilities built in the 1960s at the site are currently on standby or inactive status. On April 18, 1978, NASA declared approximately 2,152 acres of PBOW as excess. The Perkins Township Board of Education acquired 46 acres of the excess acreage and uses this area as a bus transportation area. The General Services Administration retains ownership of the remaining excess acreage and currently has a use agreement with the Ohio National Guard for 604 acres of this land. NASA presently controls

approximately 6,400 acres. The details of land transactions are listed in the site management plan (ICI, 1995).

2.2.2 Statutory Authority

The PBOW property was acquired by DoD in 1941 for the U.S. Army Plum Brook Ordnance Works and operated under their direction until late 1945; therefore, the PBOW is administered as a FUDS site, and any contamination on the property that is a result of these activities is the responsibility of the Army under the DERP-FUDS program, as described in Section 2.1.

Under CERCLA, the president delegated authority to DoD (Secretary of Defense) for cleanup of active and formerly used defense sites. In addition, the Superfund Amendments and Reauthorization Act of 1986 (SARA) (Section 211) required the Secretary of Defense to carry out the DERP, which in turn delegated these authorities to the USACE, thereby granting the USACE the authority to conduct removal/remediation projects such as TNTC.

The legislative context of DERP includes the following: CERCLA; SARA; the Resource Conservation and Recovery Act (RCRA); the Federal Facility Compliance Act of 1992; the National Environmental Policy Act; and other environmental, safety, and occupational health laws and regulations (i.e., Clean Water Act, Clean Air Act, Toxic Substance Control Act, Safe Drinking Water Act, Occupational Safety and Health Act, Endangered Species Act, and National Historic Preservation Act of 1966).

The Defense and State Memorandum of Agreement (DSMOA) program was developed to involve states and territories in the cleanup of DoD installation through the DERP. Ohio EPA is currently working under this agreement to provide the necessary technical services required for remediation of the PBOW TNTC. Ohio EPA is funded via DSMOA for their review and participation at PBOW and have entered into a 2-year cooperative agreement which can be revised or extended as needed subject to changes in the DSMOA project.

2.3 Community Participation

Community relations activities are required under the NCP and SARA. The objective of this program is to provide a mechanism for the communication and exchange of information among Army agencies, government agencies, and residents of local communities and those adjacent to and downgradient from PBOW. In January 1997, a Restoration Advisory Board (RAB), composed of approximately 20 local citizens with varying backgrounds, was established to promote a two-way dialog to not only keep local citizens informed about site progress, but also

to facilitate the opportunity for them to provide input to site decisions. Since its inception, the RAB has been the basis for community involvement.

In compliance with CERCLA (Section 113), the USACE has developed the AR to provide documentation as to how and why decisions specific to the remediation of the site are made. To date, the investigations and assessments completed for TNTC are as follows: Report of Findings (IT, 2001a), HHRA (IT, 2001b), ERA (IT, 2001c), FFS (Shaw, 2003), and the FFS Addendum for TNTC (Shaw, 2009a). The AR contains these final documents as well as all others for the PBOW site. Currently, the final reports are located in the AR at the USACE Huntington District Office, 502 Eighth Street, Huntington, West Virginia, 25701. The AR can be viewed online at the USACE Huntington District website: http://www.lrh.usace.army.mil/projects/current/derp-fuds/pbow/documents.

A community relations plan (ICI, 1999) was prepared that outlines the procedures through which the community is involved with the restoration of PBOW. In addition to providing access to the AR, these procedures involve the following which are performed or initiated by the USACE Huntington District:

- AR maintenance
- Quarterly fact sheets and policy letters
- Bulletin boards for the RAB to post pertinent information within the community
- Project-specific exhibits for community functions
- Direct two-way communication with RAB members
- News releases
- Annual PBOW newsletter
- Exhibits at public activities.

The PBOW RAB received a Technical Assistance for Public Participation (TAPP) grant from DoD on March 29, 2005. TAPP grants have a maximum of $25,000 per year and a lifetime ceiling of $100,000. The purpose of the TAPP grant is to provide a mechanism for the RAB to obtain professional technical assistance to help its members understand the restoration program. Also, the RAB holds quarterly meeting which are co-chaired by a representative of the community and the USACE point of contact. Through this communication process, the community has had active involvement in the selection of the remedy for TNTC.

A recommendation for remediation of TNTC soil and sediment under a NTCRA was presented at the Bowling Green State University Firelands Library on May 10, 2004. Notice of the NTCRA and this meeting were published in the April 28, 2004 Sandusky Register. The public comment period extended from May 11 through June 11, 2004. The proposed alternatives,

including the recommendation for excavation, windrow composting, ex situ chemical stabilization, and on-site/off-site disposal, were presented at the public meeting. The USACE used this meeting also to solicit a wider cross section of community perspectives as to the reasonably anticipated future land use of TNTC. The public provided no substantive comments during the public meeting and no comments were received during the public comment period. However, it was subsequently decided for administrative reasons that this action would not be performed as a NTRCA. A revised preferred remedial alternative was presented in the Proposed Plan (Shaw, 2009b). This revision was based on the FFS Addendum (Shaw, 2009a). Notice of the Proposed Plan for TNTC soil and sediment was published in the February 26, 2009 Sandusky Register, and the Proposed Plan was presented to the RAB and other interested members of the community at a public meeting at Firelands Library on March 12, 2009. At this public meeting for the Proposed Plan, representatives of the USACE and Ohio EPA were present to answer questions, address concerns, and receive additional community input. The public comment period for the Proposed Plan extended from March 12, 2009 through April 13, 2009. The remedial decision is recorded in this Decision Document in consultation with Ohio EPA and the community. The TNTC soil/sediment FFS documents were made available to the public in the AR maintained at the Firelands Library, Bowling Green State University, Huron, Ohio and at the following web site address: http://www.lrh.usace.army.mil/projects/current/derp-fuds/pbow/documents. Community comments and concerns, as well as how the USACE addressed these comments, are included in the Responsiveness Summary (Chapter 3.0).

2.4 Scope and Role of TNTC

One of DoD's specific goals from the Defense Planning Guidance for the DERP is to reduce risk to human health and the environment through implementation of effective, legally compliant, and cost-effective response actions. To that end, the environmental investigation of PBOW has been divided into 16 areas of concern, also referred to as DERP-FUDS projects, to address the potential concerns presented by each area associated with former DoD activities. Separate closeout documents are required for each of the 16 DERP-FUDS projects. This current Proposed Plan specifically addresses contamination in TNTC soils and sediment only.

Once a DERP-FUDS project is closed out, the site is available, if NASA so decides, for excess to private or public interests and may be used as described in the specific closeout document. The 16 DERP-FUDS projects and their status are briefly identified below. Soil actions taken to date at the former PBOW are also summarized below.

TNTC. An FFS for soils and sediment was completed in 2003. A Proposed Plan was submitted in March 2009. Completion of the Decision Document is the next step in the process, which is expected to lead to a remedy for TNTC.

TNTA. An FFS for soils and sediment was completed in 2003. Completion of a Proposed Plan, scheduled for 2009, is the next step in the process. The Proposed Plan is expected to lead to the selection of a remedy for TNTA.

TNTB. A soils feasibility study (FS) has been completed. An Action Memorandum for a NTCRA regarding soils was presented to the public on March 28, 2002 and the Public Comment period was from March 28 to 30 April, 2002. The Action Memorandum was finalized in June 2003 and the Removal Action was completed in December 2006. The final report of the interim soil removal action was issued in 2007. A Proposed Plan and Decision Document are being prepared and are scheduled for completion in 2009.

Red Water Pond Areas. An FFS for the Red Water Ponds Areas soil was completed in December 2002. Investigations found no action relative to soils at the West Area Red Water Ponds Area necessary, so no remedial alternatives were developed in the FFS for this area. Remedial alternatives regarding the Pentolite Road Red Water Ponds (PRRWP) Area were developed and evaluated in the FFS. An Action Memorandum for a NTCRA regarding PRRWP soils was presented to the public in September 2002. The interim removal action began in January 2003, and the Action Memorandum was finalized in June 2003. During the NTCRA soil removal, the need for additional excavation was recognized based on the discovery of a dark seam of impacted soil. The USACE conducted field-scale and laboratory-scale treatability studies to determine the best approach to address this additional contamination at the PRRWP site. A composting action was selected and began in 2007 and was completed in September 2008. The final report of the interim soil removal action is scheduled for completion in March 2009. At the end of the Removal Action, this project will return to the normal CERCLA process remedial investigation/feasibility study (RI/FS phase), and a Decision Document is scheduled for completion in 2010.

Acid Areas 1, 2, and 3. The site investigations of the three acid areas were completed in December 1998. The Remedial Investigation (RI) of Acid Areas 2 and 3 has begun, with the Site Characterization Report being finalized in March 2007. The Risk Assessments are in progress, and an FS will follow. Fieldwork for the RI for Acid Area 1 began in April of 2007 and was completed in 2008. The RI will include a risk assessment, and an FS will follow.

Reservoir No. 2 Burning Grounds. The RI began in 2004, and the Site Characterization Report was issued in January 2006. An interim action was proposed through the Engineering Evaluation and Cost Analysis process, but the decision was made to return to the normal CERCLA process (RI phase) due to lack of evidence to demonstrate an imminent threat to justify the removal action. A risk assessment was begun as part of the RI in 2008.

Additional Burning Grounds. A Preliminary Assessment (PA) was performed in 1991. This project includes five burning ground areas. NASA has agreed to take full responsibility for three of these (Taylor Road, Snake Road, and Fox Road Burning Grounds). The other two (G-8 and "Additional" Burning Grounds) require further records research review. Based on this review, responsibility for these areas will be established.

Waste Water Treatment Plant Nos. 1 and 3. A Limited Site Investigation (SI) was completed in July 2000. A contract for an RI was awarded in June 2008, and fieldwork began in December 2008.

Waste Water Treatment Plant No. 2. A PA performed in 1991 found a potential for contamination of soil, surface water, sediment, and groundwater with acetone, pentaerythrinol, and tetraerythrinol tetranitrate. An SI was performed in 1997. An RI is recommended but has not yet been funded.

Power House Ash Pit No. 2. A PA was performed in 1991. A contract for an RI was awarded in September 2008, and fieldwork began in January 2009.

Power House Ash Pits Nos. 1 and 3. A limited SI performed in July 2000 resulted in the recommendation that a full SI be performed. A contract for an RI was awarded in June 2008, and fieldwork began in December 2008.

TNT Loading Areas. A limited SI was completed in July 2000. The site was recommended for no further action, and closeout was achieved with State concurrence in September 2006.

Pentolite Area Waste Lagoon. A limited SI was completed. The project was recommended for no further action and was closed out with State concurrence in September 2006.

Lower Toluene Tanks. A limited SI was completed in July 2000. The project was recommended for no further action and was closed out with State concurrence in September 2006.

Garage Maintenance Area. A limited SI was completed for the Locomotive Building Area in July 2000 that resulted in the recommendations to proceed with further investigation. The Locomotive Building Area is in the eastern portion of the Garage Maintenance Area. A contract for an RI was awarded for the Locomotive Building Area in October 2008, and fieldwork began in December 2008.

TNT Area and Red Water Pond Area Groundwater. A Baseline Human Health Risk Assessment of groundwater associated with the three former TNT areas and two former red water ponds was finalized in September 2006, and an FS for groundwater associated with these areas was completed in December 2008. The groundwater associated with these five areas is expected to be addressed in a single Decision Document. Note that groundwater associated with each of the other seven active DERP-FUDS projects is expected to be addressed in the separate Decision Document for that DERP-FUDS project.

Soil Actions. The soil actions undertaken at the PRRWP Area and TNTB and the proposed actions at Reservoir No. 2 Burning Grounds, TNTA, and TNTC are being implemented by the USACE under DERP-FUDS. To date, no other removal actions or response actions have been recommended, in part because several of the other DERP-FUDS projects await funding for continuation of the CERCLA evaluation process. The DERP-FUDS mandate is to address only those areas associated with DoD-generated materials. NASA is investigating contamination at former PBOW property that is associated with impacts resulting from NASA activities.

2.5 Site Characteristics

2.5.1 Site Overview

TNTC is located in the southwestern portion of PBOW (Figure 2-2). At present, this approximately 119-acre area is mostly overgrown with trees and brush. Several aboveground features that indicate former PBOW facilities were present are still evident at TNTC. These include roads, fire hydrants, water valves, a water valve control well, railroad track line foundations, and former building pad foundations (Building 667, Maintenance Shop; Building 689, Acid & Fume Recovery; and Building 657, Wastewater Settling Basin). Several below-ground features are also present: manholes, drains, and underground lines (as evidenced by aboveground water valves). Former buildings and other site features are shown on Figure 2-3. There are currently no NASA buildings on the site, and NASA does not currently use the area. One building present on the site was constructed and used by EPA to do testing in the 1980s and

is located near the former Wash House (Building 606) at Process Line 10. TNTC is transected by several small intermittent streams and ditches that are tributaries to Pipe Creek.

As described in Section 2.2.1, nitroaromatic explosives were manufactured at PBOW during 1942 through 1945 as part of the World War II effort. Soil and potentially other PBOW media were contaminated by nitroaromatic compounds and associated chemicals involved in the manufacturing processes at TNTC as the result of surface spills and subsurface pipeline leaks. Figure 2-4 depicts a simplified conceptual site model for contamination at TNTC. Note that more detailed exposure models for human and ecological receptors are presented in Sections 2.7.1 and 2.7.2.

2.5.2 Investigation Overview

Soil, surface water, and sediment samples were collected during the 2000 RI (IT, 2001a), and RI groundwater samples were collected beginning in 2001 (Shaw, 2005). Soil samples were also collected in 1993 (MK, 1994) and 1994 (D&M, 1997). Surface water and sediment samples were also collected in 1993 (MK, 1994). Activities and results related to soil sampling are summarized in Section 2.5.2.1, and those of the surface water and sediment are summarized in Section 2.5.2.2. Because TNTC groundwater will be addressed in a separate Decision Document for groundwater underlying the three TNT Areas and two red Water Pond Areas, the groundwater investigation is not described herein.

2.5.2.1 Soil

Three surface soil samples were collected in the vicinity of TNTC (MK, 1994) in 1993, and 30 soil samples were collected as part of the 1994 SI (D&M, 1997). Based on the results of these earlier samples and on site history, a total of 385 field screening samples were collected during the 2000 RI and analyzed for nitroaromatics using a modification of laboratory Method 8330 (IT, 2001a). Also, 30 confirmation samples were collected during the RI to support the screening results and to conduct risk assessments. These confirmation samples were analyzed for target compound list organics, target analyte list inorganics, and nitroaromatics.

During the RI, TNTC soil was investigated by process line or process type. The TNTC process areas and the 29 associated building areas investigated during the RI are listed below:

- Wastewater settling tanks
  - Building 657, wastewater disposal settling tank

- Process line 8
  - Building 681, mono house

- Building 682, bi-tri house
- Building 683, fortifier house
- Building 686, wash house
- Building 689, acid and fume recovery

- Process line 9
  - Building 691, mono house
  - Building 692, bi-tri house
  - Building 693, fortifier house
  - Building 696, wash house
  - Building 698, nailing house
  - Building 699, acid and fume recovery

- Process line 10
  - Building 601, mono house
  - Building 602, bi-tri house
  - Building 603, fortifier house
  - Building 606, wash house
  - Building 609, acid and fume recovery

- Process line 11
  - Building 611, mono house
  - Building 612, bi-tri house
  - Building 613, fortifier house
  - Building 616, wash house
  - Building 618, nailing house
  - Building 619, acid and fume recovery

- Process line 12
  - Building 621, mono house
  - Building 622, bi-tri house
  - Building 623, fortifier house
  - Building 626, wash house
  - Building 628, nailing house
  - Building 629, acid and fume recovery.

The placement of RI samples within these areas was skewed toward specific locations that were most likely to be contaminated, such as those of former storage tanks, drowning tanks, catch basins, and underground pipelines associated with production. All soil sampling locations are shown on Figure 2-5. The resulting COCs for TNTC soil are presented in Section 2.5.3.

2.5.2.2 Surface Water and Sediment Sampling

As part of the 1993 SI (MK, 1994), one collocated surface water and sediment sample pair was collected just downstream of the confluence of Pipe Creek and a small tributary running east to west in the northern portion of TNTC. As part of the RI, a total of 10 TNTC surface water and

15 TNTC sediment samples were collected in 2000 (IT, 2001a); all were from on-site wet weather conveyances that flow to Pipe Creek (Figure 2-6). A total of 15 surface water samples had been planned, but 5 of the locations were dry.

The results of the surface water samples indicate low levels of nitroaromatics were present, but not at concentrations that would adversely affect TNTC surface water; thus, no surface water COCs were identified. Contamination in sediment was found at concentrations that may potentially adversely affect human or ecological receptors at one location (TNTC-SD009), approximately 260 feet northwest of Building 618; no surface water was present at this location. The resulting COCs for TNTC sediment are presented in Section 2.5.4.

2.5.3 Contamination Characterization of Soil

TNTC soil COCs include the following 13 constituents:

- Nitroaromatics: 2-Amino-4,6-dinitrotoluene (2-ADNT), 4-amino-2,6-dinitrotoluene (4-ADNT), 2,4-DNT, 2,6-DNT, and TNT
- Polynuclear aromatic hydrocarbons (PAH): benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenze(a,h)anthracene, and indeno(1,2,3-c,d)pyrene
- PCBs: Aroclor 1254 and Aroclor 1260
- Lead.

Table 2-1 provides a data summary of the COCs in total soil, including frequency of detection, concentration ranges, and the exposure point concentrations (EPC) used in the HHRA (Section 2.7.1).

Spatial Distribution and Potential Sources. Of the 29 TNTC building areas and process areas investigated (Section 2.5.2.1), those with one or more detections of COCs at concentrations exceeding the respective soil RGs are identified as requiring soil cleanup. Thus, the 14 building areas listed below require remediation.

Building Area 602	Building Area 629	Building Area 689
Building Area 603	Building Area 657	Building Area 692
Building Area 606	Building Area 682	Building Area 693
Building Area 616	Building Area 683	Building Area 696
Building Area 626	Building Area 686	

For purposes of soil volume estimation (see below), contamination at each sampling location having a nitroaromatic, PAH, or PCB RG exceedance was assumed to extend out approximately

10 feet in each direction, or to the nearest sample that does not exceed any of the RGs (if that distance is less than 10 feet). In cases where an RG was exceeded by a factor of 10 or more, contamination was assumed to extend out 30 feet in each direction, rather than 10 feet. Vertical extent of contamination was assumed to extend to the top of the deepest sample in which no RG exceedance was observed. If the deepest sample interval collected within a boring had an RG exceedance, then contamination was assumed to extend to 10 feet below ground surface (bgs), to the top of bedrock, or to the top of the water table, whichever of these was shallower. For building areas with a lead RG exceedance, the extent of contamination was assumed to be a 10-foot-wide strip around the perimeter of the foundation. This strip was assumed to extend 2 to 3 feet below the surface, except in areas where nitroaromatic, PAH, or PCB contamination was specifically encountered (to which the above protocol was applied). Specific areas to be remediated are shown on Figure 2-7.

The highest concentrations of nitroaromatics were generally found in areas of former storage tanks, drowning tanks, catch basins, or underground lines. Of these areas, the highest nitroaromatic concentrations were typically found in surface or shallow subsurface soil (1 to 3 feet bgs), except for those associated with locations where underground storage lines had existed. Concentrations of PCBs exceeding RGs (refer to Section 2.8.1) were found only in three TNTC building areas. The highest concentration of PCBs (5.07 milligrams per kilogram [mg/kg] of Aroclor 1260) in TNTC soil was found in a surface soil sample at Building Area 629; a shallow subsurface soil sample from this boring also had an Aroclor 1260 concentration (2.1 mg/kg) exceeding the RG. The two other exceedances of the PCBs RG were in surface soil at Building Areas 686 and 689. The source(s) of these PCB concentrations is not apparent, but may be leaking transformers and/or PCB-containing fluid spills or leaks, as PCBs were formerly used in transformers and fluids such as hydraulic oils.

Four areas had at least one sample with a concentration of summed COC PAH concentrations that exceeded the RG. Of the four areas with PAH COC exceedances, two of these were in surface soil (26 mg/kg at Building Area 686 and 1.3 mg/kg at Building Area 616), and the highest concentration was in a shallow subsurface sample (35 mg/kg at Building Area 696 [2.0 to 2.5 feet bgs]). The remaining total PAH COC exceedance was in a sample collected from 3 to 5 feet bgs (1.5 mg/kg at Building Area 657).

Four areas had at least one sample with a lead concentration that exceeded the RG. These were in surface soil immediately adjacent to Buildings 696 (934 mg/kg), 682 (721 mg/kg), and 686 (621 mg/kg). Lead was also found in a shallow subsurface soil sample (2.5 to 3.5 feet bgs) immediately adjacent to Building 629 (761 mg/kg). It is assumed that the lead contamination

originated from building materials. PAHs are fairly ubiquitous in the environment and may result from incomplete combustion (either natural or associated with human activities, including automobile exhaust), asphalt, and/or petroleum products. PAHs would also have been generated by burning the former TNTC buildings during demolition. One or a combination of these sources may represent the major source(s) of PAHs in TNTC soils.

Toxicity and Mobility of the COCs. The toxic characteristics of the 13 COCs are presented in Section 2.7.1.3. In summary, 2,4-DNT, 2,6-DNT, TNT, Aroclor 1254, Aroclor 1260, and the five PAH COCs are regarded as carcinogens. Each of the five nitroaromatic COCs, Aroclor 1254, and lead have known adverse noncancer effects, as presented in Section 2.7.1.3.

Because the concentrations of nitroaromatics generally dissipate notably with depth, it does not appear that these chemicals have been very mobile in soil. The relatively low concentrations found in bedrock groundwater (Shaw, 2005) also provide evidence that nitroaromatics in soil are not very mobile. PCBs, PAHs, and lead generally have low mobility. Although PCBs and PAHs occur in both the surface and subsurface, these compounds are not found in groundwater (Shaw, 2005); this indicates that PCBs are bound to soil particles. Neither lead nor PCB RG exceedances were found in soil at a depth greater than 3 feet below grade, indicating limited mobility in soil.

Quantity of Waste. The total volume of contaminated soil requiring remediation is estimated at 9,205 cy. Of this, the FFS estimated that 2,310 cy will be classified as RCRA characteristic hazardous waste. Most of this volume of hazardous waste is based solely on anticipated 2,4-DNT toxicity characteristic leaching procedure (TCLP) testing results. It was estimated that 400 cy will be characterized as hazardous due to lead concentrations. The Army has no knowledge of any Resource Conservation and Recovery Act (RCRA) listed hazardous waste in TNTC soils or sediments.

Potential Human and Ecological Receptors at Risk. Human health and ecological risks are summarized in Sections 2.7.1 and 2.7.2, respectively. No current human receptors appear to be at risk. Estimated noncancer hazards index and cancer risks in the HHRA for the hunter (5 and 3×10^{-5}, respectively), who would serve as an appropriately conservative surrogate for any current individuals who may visit TNTC, exceeded the hazard index (HI) criterion of 1 and the Ohio EPA incremental lifetime cancer risk (ILCR) criterion of 1×10^{-5}. However, these HI and ILCR values were based chiefly on a maximum detected concentration (MDC) of TNT in surface soil of 41,261 mg/kg. This MDC was taken from a stone-lined ditch. The second highest concentration of TNT was nearly an order of magnitude less (5,067 mg/kg). The HI and ILCR

values for the hunter associated with the second highest surface soil sample concentration would be 0.6 and 7×10^{-6}, both of which are less than the respective Ohio EPA HI and ILCR criteria for acceptable risk. Risks associated with future land use exceeded the acceptable criteria; these exceedances could not be attributed solely to a questionable sample collected from a ditch.

Terrestrial ecological receptors were found to be potentially at risk in the ERA (IT, 2001c). However, the FFS estimated that risks to ecological receptors would be substantially reduced by remediating soil to the human health RG levels. Therefore, the FFS recommended no additional action specifically for the protection of ecological receptors.

2.5.4 Contamination Characterization of Sediment

The following three constituents were identified as COCs in the sediment: 2-ADNT, 4-ADNT, and TNT. Table 2-1 provides a data summary of the COCs in sediment, including frequency of detection, concentration ranges, and the EPCs used in the HHRA (Section 2.7.1). The ERA indicated that aquatic receptors such as the mallard and raccoon may potentially be adversely affected by contamination in sediment. However, large uncertainties exist in the hazard estimations, which tend to be biased high, and the aquatic habitat quantity and quality is very limited. For these reasons, it was determined that remediation is unwarranted for sediment specifically with respect to ecological receptors (Section 2.7.2). Also, remediation of the sediment based on human health concerns will likewise decrease any potential for adverse effects to ecological receptors.

Spatial Distribution and Potential Sources. Sources of contamination include surface runoff of contaminated soil from the TNTC former process building area. The only area recommended for remediation of sediment is associated with TNTC-SD009. This sample is located in a wet weather conveyance that flows east to west but had been dry during the time of sampling in September 2000. The nearest former buildings to TNTC-SD009 are Building 618, located approximately 220 feet southeast, and Building 616, located approximately 450 feet south. Both of these are located in areas that, based on the topography, may have contributed runoff to this ditch. The former had only very low nitroaromatics detections (less than 0.3 mg/kg), but Building Area 616 had maximum detections of TNT exceeding 2,000 mg/kg and is, thus, a potential source area for sediment contamination.

Toxicity and Mobility of the COCs. The toxic characteristics of the three sediment COCs are presented in Section 2.7.1.3. In summary, TNT is regarded as a carcinogen. Each of the three sediment COCs have known adverse noncancer effects, as presented in Section 2.7.1.3. Because the concentration of nitroaromatics in surface water is very low (less than 1 microgram

per liter), it does not appear that these chemicals have been very mobile in the aqueous environment.

Quantity of Waste. The FFS estimates the total volume of contaminated sediment requiring remediation at 600 cy. None of this is anticipated to be characterized as hazardous.

Potential Human and Ecological Receptors at Risk. Human health and ecological risks are summarized in Sections 2.7.1 and 2.7.2, respectively. No current human receptors appear to be at risk. Estimated noncancer hazards in the HHRA for the future resident and construction worker, which would serve as appropriately conservative surrogates for future land use, exceeded the threshold criterion. The recommendation for remediation is based on potential future risks, assuming unrestricted land use.

The ERA indicated that aquatic receptors such as the mallard and raccoon may potentially be adversely affected by sediment. However, large uncertainties exist in the hazard estimations, which tend to be biased high (including the use of MDCs as representative concentrations throughout the site), and the aquatic habitat quantity and quality is very limited. Also, the FFS estimated that risks to ecological receptors would be substantially reduced by the recommended response action based on human health concerns. For these reasons, it was determined that no additional action was necessary specifically for the protection of ecological receptors.

2.6 Current and Potential Future Land Uses

TNTC consists mostly of old field and shrubby thicket vegetation, with less than 10 percent wooded. This area currently has no regular use, though it is opened for hunting during specified times. At some point in the future, it is possible that NASA may desire to either use or excess the property. If a decision were made to excess, the GSA would be contacted to facilitate transfer of the property through their process. TNTC could potentially be developed in the future, either for commercial/industrial or residential purposes. Other potential future uses for the site include training for National Guard, or the property may be used for wildlife management. These uses are consistent with those of the adjacent property, which is mostly rural residential. It is noted that a portion of the adjacent property previously excessed by NASA (see Section 2.2.1) is used by the National Guard for training. The small streams and ditches that transect TNTC (Section 2.1.2) are not large enough to support gamefish and have no identified human uses; however, the streams provide aquatic habitat and a source of water for wildlife.

2.7 Summary of Site Risks

Potential risks to human health and the environment were evaluated for TNTC. The purposes of this section are:

- Provide a brief summary of the relevant portions of the HHRA (Section 2.7. 1)
- Provide a brief summary of the ecological risk assessment (Section 2.7.2)
- Provide a discussion of the human health and ecological risk results (Section 2.7.3)
- State the basis for taking action at the site (Section 2.7.4).

2.7.1 Summary of Human Health Risks

The HHRA for TNTC soil, sediment, and surface water was completed in 2001 (IT, 2001b). The identification of COCs, exposure assessment, toxicity assessment, and risk characterization are described below. Only validated analytical data were used in the HHRA.

2.7.1.1 Identification of COCs

COCs were identified for TNTC soil and sediment as those chemicals that contributed most to an additional cancer risk of 1×10^{-5} or an additional noncancer HI of 1. The following chemicals were identified as COCs for total soil and sediment, are discussed in Sections 2.5.3 and 2.5.4, respectively.

- ***Soil (combined surface and subsurface soil):*** 2,4,6-TNT, 2,4-DNT, 2,6-DNT, 2-ADNT, 4-ADNT, Aroclor 1254, Aroclor 1260, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-c,d)pyrene, and lead.
- ***Sediment:*** TNT, 2-ADNT, and 4-ADNT.

2.7.1.2 Exposure Assessment

Exposure assessment presents the exposure pathways evaluated, the populations potentially exposed to the chemicals of potential concern (COPC), the data and assumptions used to characterize EPCs, and assumptions about exposure frequency and duration included in the exposure assessment. The mathematical output of the exposure assessment is the chronic daily intake (CDI), which represents the level of exposure to a chemical that an individual would receive under a given set of exposure assumptions. Exposure associated with the COPCs was evaluated using the following human receptors as surrogates to represent all plausibly exposed groups of people at TNTC under current land use, future land use, or both. The exposure

pathways for all environmental media and human receptors evaluated are depicted on Figure 2-8. Each of the receptors is briefly described below.

Groundskeeper. The current groundskeeper represents a long-term, on-site outdoor worker exposed to surface soil. Potential soil exposure pathways evaluated were incidental ingestion and dermal contact with surface soil and inhalation of dust.

Indoor Worker. The indoor worker represents a long-term, on-site worker exposed to lower levels of surface soil than an outdoor worker. Pathways quantified for this receptor are the incidental ingestion of surface soil. The inhalation route was evaluated but not quantified because no volatile organic compounds were identified as COPCs in subsurface soil.

Construction Worker. The construction worker represents a shorter-term worker potentially exposed to total soil, as well as surface water and sediment. The following pathways were evaluated for the construction worker: incidental ingestion and dermal contact with soil, inhalation of dust, dermal contact with surface water, and incidental ingestion and dermal contact with sediment.

Hunter/Venison Consumer. A current hunter was assumed to be exposed to surface soil (via incidental ingestion and dermally) and ingestion of venison from deer that fed on plants growing on TNTC surface soil. Also, a young child (ages 1 through 6) venison consumer was assumed to be exposed via the ingestion of venison taken from TNTC. Cancer risk and noncancer hazard estimates were performed separately for the adult and child.

Future On-Site Resident. A future on-site resident was assumed to be exposed to total soil, surface water, and sediment. The following pathways were evaluated for the on-site resident: incidental ingestion and dermal contact with soil, inhalation of dust, dermal contact with surface water, and incidental ingestion and dermal contact with sediment. The on-site residential scenario was evaluated using both an adult and a young child (ages 1 through 6 years). Cancer risk was estimated as the sum of the risks calculated for the adult and the child. The child was used for the noncancer evaluation to capture the greater conservativeness of the larger incidental soil and sediment ingestion rates for the child, when normalized for body weight.

Exposure Point Concentrations. The EPCs are based on reasonable maximum exposure assumptions (EPA, 1989); either the 95 percent upper confidence limit of the mean or the MDC, whichever is less, was used (IT, 2001b). The EPC values for the COCs are included in Table 2-1.

2.7.1.3 Toxicity Assessment

The toxicity assessment provides information regarding the type and severity of adverse health effects that could result from exposure to COPCs and a measure of the dose-response relationship for each chemical. The dose-response relationships for oral, inhalation, and dermal toxicity are expressed quantitatively as noncancer chronic reference doses (RfD) and cancer slope factors (SF). The exception is lead, known to have neurological effects, especially with respect to developing children. Lead exposure and risk is evaluated based on modeled blood-lead concentrations. A residential soil concentration of 400 mg/kg was developed based on the model and used in the HHRA to identify areas which had unacceptably high soil lead concentrations.

RfDs are chemical-specific values that have been developed by EPA for indicating the potential for adverse noncancer health effects resulting from exposure. RfDs, which are expressed in units of milligrams per kilogram of body weight per day (mg/kg-day), are estimates of lifetime daily exposure levels for humans, including sensitive individuals. SFs are developed by EPA and were used to estimate excess lifetime cancer risks associated with exposure to potentially carcinogenic chemicals. SFs, expressed in cancer incidence per mg/kg-day ($[\text{mg/kg-day}]^{-1}$), were used in the HHRA to provide an upper-bound estimate of excess lifetime cancer risk associated with exposure to contaminants in TNTC media. A weight-of-evidence classification is placed on each SF by the EPA's Carcinogenic Assessment Group and shown in Table 2-2.

These chemical-specific RfD and SF values were obtained from the EPA Integrated Risk Information System (IRIS) database (EPA, 2000) or from other EPA sources if no values were available from IRIS. Target organ information for noncancer effects and additional toxicity information were likewise obtained from IRIS or other sources if not available on IRIS. Toxicity values and associated information used in the HHRAs for the COCs are shown in Table 2-2.

2.7.1.4 Risk Characterization

Risk characterization is the process of applying numerical methods and professional judgment to determine the potential for adverse human health effects to result from exposure to site-specific contaminants. ILCR and noncancer HI values were calculated separately for each receptor and exposure scenario.

For carcinogens, risks are generally expressed as the incremental probability of an individual developing cancer over a lifetime as the result of exposure to the carcinogen. The ILCR represents the "excess" risk posed by exposure to the specific carcinogen source in question.

The baseline cancer risk for the U.S. population has been estimated at approximately 30 percent. EPA's generally acceptable risk range (EPA, 1999a; 1991a; 1990) is between and 1×10^{-4} (1 in 10,000) and 1×10^{-6} (1 in 1,000,000). The Ohio EPA uses a criterion of 1×10^{-5}. For the sake of illustration, if it were assumed that an individual had exactly a 30 percent chance (300,000 in 1,000,000) of developing cancer without a specific exposure, an additional exposure at an ILCR of 1×10^{-5} (1 in 100,000) would result in an overall cancer risk of 300,010 in 1,000,000.

The ILCR is calculated from the following equation:

$$ILCR = CDI \times SF$$

where:

ILCR = incremental lifetime cancer risk of an individual developing cancer over a lifetime (unitless)
CDI = chronic daily intake averaged over a 70-year lifetime (mg/kg-day)
SF = slope factor ($[mg/kg\text{-}day]^{-1}$).

The potential for noncancer effects is evaluated by comparing an exposure level over a specified time period (e.g., 30 years) with an RfD appropriate for that time period (i.e., chronic). An RfD is the threshold level at which one could be exposed and not suffer any deleterious effect. The ratio of exposure to the RfD is the hazard quotient (HQ). The HQ values were calculated for PBOW as follows:

$$HQ = CDI/RfD$$

where:

HQ = noncancer hazard quotient
CDI = chronic daily intake (mg/kg-day)
RfD = chronic reference dose.

Thus, a CDI less than the RfD would result in an HQ of less than 1. The HI is calculated by adding the HQ values of the COCs that affect the same target organ in a given environmental medium (e.g., soil) or across all media to which an individual is assumed to be exposed. An HI of less than or equal to 1 indicates that adverse noncancer effects are unlikely to occur; an HI exceeding 1 indicates that adverse effects may potentially occur.

The following paragraphs summarize the risks associated with the COCs for the various receptors to surface soil and total soil, which were the predominant contributors to the ILCR and HI for the respective receptors. Risk characterization results for the COCs are presented in

Tables 2-3 through 2-10. Overall HHRA results for each receptor, including all COPCs, are summarized in Table 2-11.

Surface Soil. The total ILCR from all groundskeeper (5×10^{-4}), indoor worker (2×10^{-4}), and hunter (3×10^{-5}) to surface soil exceeded the Ohio EPA criterion of 1×10^{-5}; the child venison consumer (2×10^{-7}) pathway did not. TNT (via ingestion and dermal exposure) contributed well over 90 percent of the ILCR for each of these receptors, and each of the ILCR values would have been less than the 1×10^{-5} criterion if not for the exposure associated with TNT. The total HI for the groundskeeper (95), indoor worker (41), and hunter (5) exceeded the HI criterion of 1. TNT (via ingestion and dermal exposure) contributed about 99 percent of the ILCR for each of these receptors (Tables 2-3 through 2-6, respectively). The HI associated with the child venison consumer (*de minimis*; no COPCs identified) was less than the acceptable value of 1 (Table 2-6).

Total Soil. The site-related total ILCR (5×10^{-5}) from all construction worker exposure pathways to total soil exceeds the 1×10^{-5} Ohio EPA criterion, and the total HI (359) exceeds the acceptable value of 1 (Table 2-7). The COCs that contribute most to the ILCR values (via potential ingestion and dermal exposure) are TNT (4×10^{-5}) and 2,4-DNT (5×10^{-6}). The COCs that contribute most to the HI values (via potential ingestion and dermal exposure) are TNT (355) and 2-ADNT (3).

The site-related total ILCR (3×10^{-3}) and the site-related total HI (1241) for potential exposures of a future on-site resident to total soil pathways exceed the Ohio EPA cancer risk criterion of 1×10^{-5} and HI criterion of 1 (Table 2-8). Both the ILCR and HI are associated with the potential oral and dermal exposures to surface and subsurface soil. The COCs that contribute most to the cancer risk are TNT (3×10^{-3}), 2,4-DNT (4×10^{-4}), and benzo(a)pyrene (1×10^{-4}). The HI is primarily associated with TNT (1227), 2-ADNT (9), and 4-ADNT (3).

Sediment. The site-related total HI from all construction worker exposure pathways to sediment (14) exceeds the acceptable criterion of 1, but the ILCR (1×10^{-6}) sediment is less than the Ohio EPA acceptable criterion of 1×10^{-5} (Table 2-9). The COC that contributes most to the HI exceedance (via potential ingestion and dermal exposure) is TNT (12), with lesser contributions from the other two COCs, 2-ADNT (0.8) and 4-ADNT (0.9).

The site-related total HI from all future on-site resident exposure pathways to sediment (6) exceeds the acceptable criterion of 1. The sediment ILCR (1×10^{-5}) does not exceed the Ohio EPA acceptable criterion of 1×10^{-5} (Table 2-10). The COC that contributes most to the HI

exceedance (via potential ingestion and dermal exposure) is TNT (5), with lesser contributions from the other two COCs, 2-ADNT (0.3) and 4-ADNT (0.4).

Surface Water. No COCs were identified for TNTC surface water, which was found to present *de minimis* risk levels.

Uncertainty Analysis. Numerous uncertainties, many of which are difficult to quantify, exist throughout the risk assessment process and may affect the ILCR and HI estimates. An uncertainty of high relevance for TNTC risk estimates is the degree to which the EPC values used in the HHRA represent actual site conditions. EPA guidance states that the EPC should be based on a conservative estimate of the arithmetic mean concentration (EPA, 1989). However, in accordance with the agreed statistical approach used for TNTC and based on the nature of the data sets, the MDC values were used as the EPCs for most of the COCs. In particular, the maximum TNT concentration in surface soil (41,261 mg/kg) was used as the EPC (due to the undefined data distribution) for both surface soil and total soil, while the arithmetic mean concentration was 1,405 mg/kg. This estimate of central tendency is 29 times lower than the maximum concentration and suggests that using the maximum concentration is overly conservative. Further, the soil MDC was collected from a drainage ditch at a concentration over 8 times higher than the second highest concentration of TNT in soil (5,067 mg/kg). The representativeness of a drainage ditch sample as soil to which a receptor would typically be exposed at TNTC is questionable. If the MDC of 41,261 mg/kg were eliminated from the surface soil and total soil data sets, the resultant mean TNT concentrations would be 596 and 383 mg/kg, respectively.

Another related issue of uncertainty is the number of soil samples collected as qualified confirmation data versus those collected as screening data. A total of 385 screening samples were collected; however, these were not of definitive quality such as can be used for risk assessment. Therefore, the HHRA was based only on the results of 30 confirmation samples. The relatively small number of samples may pose some doubt as to the thoroughness of their representation of site conditions. It is noted that the number of samples used in the HHRA does not affect the derivation of RGs (Section 2.8.1), and the screening concentrations were conservatively used in determining the extent of contamination and estimation of remediation volumes (Section 2.5.3).

2.7.2 Ecological Risk Summary

An ERA, composed of a screening-level ecological risk assessment (SLERA) and baseline ecological risk assessment (BERA), was performed for TNTC (IT, 2001c). A SLERA is

composed of two main parts: the ecological site description and the selection of chemicals of potential ecological concern (COPEC). The TNTC SLERA was performed to determine whether contamination associated with a site may possibly adversely affect ecological receptors, based on screening assumptions, and necessitate a BERA. Results of the TNTC SLERA indicated that a BERA was necessary; therefore, a BERA was subsequently conducted. The BERA takes the COPECs forward through the following ERA steps: exposure assessment, ecological effects assessment, and ecological risk characterization. The results of the ERA are summarized below following the EPA (1999a) Record of Decision guidance format.

2.7.2.1 Identification of COPECs

COPECs were selected based on frequency of detection and a comparison to risk-based screening ecological toxicity values for soil, surface water, and sediment. COPECs, as identified for the various media, are presented in Tables 2-12 through 2-15. COCs were not formally identified based on ecological risks, but human health COCs were also found to be among the major risk drivers for ecological risks (see Section 2.8.1).

2.7.2.2 Ecological Exposure Assessment

The exposure assessment provides an estimate of the nature, extent, and magnitude of potential exposure of assessment receptors to COPECs that are present at or migrating from the site, considering both current and reasonably plausible future use of the site. The assessment receptors are based on the types of habitat and wildlife present at the site, as well as other site conditions that together are used to determine potential exposure pathways.

Ecological Exposure Setting. TNTC consists mostly of early and late old field combined with shrubby thicket vegetation, with less than 10 percent wooded. Some wetland vegetation was found along wet weather conveyances and the small streams present on TNTC. An area of a drainage ditch approximately 60 feet long is proposed for remediation. This ditch will be restored and revegetated to its previous elevation and condition; if it is currently vegetated with wetland vegetation, then it will be revegetated with wetland species. No other actions are expected to impact any streams or drainage ditches.

Closed gentian (*Gentiana clausa*), listed as an Ohio potentially threatened plant species at the time of the SLERA, was found in the western portion of TNTC. This species has since been removed from the Ohio list as potentially threatened. No current rare, threatened, or endangered animals or plants were identified as present at TNTC during the SLERA or during a September 2009 site reconnaissance. No areas of vegetative stress were found on TNTC. Areas east of TNTC are primarily old field and shrub; areas to the south, southeast, northeast, north and west

are primarily forested; and to the southwest are old field and early shrub thicket. Several wet weather conveyances are present on TNTC. During rain events, these flow into any of three small streams that eventually flow to Pipe Creek, located northwest of TNTC. Note that even these three streams were not flowing throughout their length during RI sample collection. Given the nature of the surface waters at the site, they are not likely to support significant populations of forage fish due to their shallow depth and intermittent nature. However, they do provide a source of water for terrestrial animals.

Exposure Pathways. Exposure pathways consist of four primary components: source and mechanism of contaminant release, transport medium, potential receptors, and exposure route. A chemical may also be transferred between several intermediate media before reaching the potential receptor. If any of these components are not complete, then the exposure pathway is incomplete, and the contaminants in those media do not constitute an environmental risk at that specific site. TNTC soil, surface water, and sediment exposure pathways are all regarded as complete.

Ecological Receptors. Site biota are organized into major functional groups. For terrestrial communities, the major groups are plants and wildlife, including terrestrial invertebrates, mammals, and birds. For aquatic and/or wetland communities, the major groups are flora and fauna, including vertebrates (water fowl and fish), aquatic invertebrates, and wetland/terrestrial mammals. Species presence at the sites was determined during a literature review and site reconnaissance, prior to identification of target receptor species.

The following seven receptor species were selected to evaluate the potential terrestrial effects for TNTC soil COPECs.

- Deer mouse (*Peromyscus maniculatus*) (small, omnivorous mammal)
- Short-tailed shrew (*Blarina brevicauda*) (small, insectivorous mammal)
- Eastern cottontail rabbit (*Sylvilagus floridanus*) (medium-sized herbivorous mammal)
- Marsh wren (*Cistothorus palustris*) (small insectivorous bird)
- White-tailed deer (*Odocoileus virginianus*) (large herbivorous mammal)
- Raccoon (*Procyon lotor*) (medium-sized omnivorous mammal)
- Red-tailed hawk (*Buteo jamaicensis*) (large, carnivorous bird).

Potential impacts to terrestrial plants are considered qualitatively in the risk characterization.

The following two receptor species were selected to evaluate the potential aquatic effects for TNTC surface water and sediment COPECs.

- Raccoon (*Procyon lotor*) (medium-sized omnivorous mammal)
- Mallard duck (*Anas platyrhynchos*) (medium-sized aquatic omnivorous bird).

Potential effects to macroinvertebrates and phytoplankton (algae) were assessed qualitatively in the risk characterization, using available surface water and sediment quality criteria for the protection of aquatic life. Terrestrial and aquatic food web diagrams for the above receptors are provided as Figures 2-9 and 2-10, respectively.

Exposure Routes. Ecological routes of exposure for biota may be direct or indirect via the consumption of contaminated organisms. Direct exposure routes include dermal contact, absorption, inhalation, and ingestion. Examples of direct exposure include animals incidentally ingesting contaminated soil or sediment (e.g., during burrowing or dust-bathing activities), animals ingesting surface water, plants absorbing contaminants by uptake from contaminated sediment or soil, and the dermal contact of aquatic organisms with contaminated surface water or sediment. Media-to-tissue transfer factors and food-chain multiplier values were used to model indirect exposure via ingestion of contaminated biota.

For terrestrial faunal receptors, calculation of exposure rates relies upon determination of an organism's exposure to COPECs found in surface water and soil and on transfer factors used for food-chain exposure. Exposure rates for terrestrial wildlife receptors are based solely upon ingestion of contaminants from these media and from consumption of other organisms. A soil of depth of 0 to 1 foot bgs was used for direct exposure to nonburrowing animals, and a soil depth from 0 to 6 feet bgs was used for direct exposure to burrowing animals, exposure to plants, and indirect exposure.

For aquatic faunal receptors, the calculation of exposure rates depends on the determination of the contaminant concentration in surface water and sediment and on food-chain multipliers, bioconcentration factors, and bioaccumulation factors. Estimated surface water and sediment ingestion rates were used to determine exposure levels for the raccoon and mallard. For benthic species exposed to organic contaminants found in sediment, calculations have been performed to quantify pore water contaminant concentrations given a known sediment concentration.

2.7.2.3 Ecological Effects Assessment

The ecological effects assessment includes the identification of assessment and measurement endpoints. The assessment endpoints for TNTC are stated as "the protection of long-term survival and reproductive capabilities for terrestrial invertebrates, herbivorous mammals, omnivorous mammals, insectivorous mammals and birds, carnivorous birds, benthic invertebrates, omnivorous aquatic mammals, and omnivorous aquatic birds."

Measurement endpoints are frequently numerical expressions of observations (e.g., toxicity test results or community diversity indices) that can be compared statistically to detect adverse responses to a site contaminant (EPA, 1997a). In the TNTC ERA, appropriate benchmark values were selected and reference toxicity values (RTV) were developed as measurement endpoints.

The RTVs derived for TNTC focus on the growth, survival, and reproduction of species and/or populations and provide a reference point for the comparison of toxicological effects upon exposure to a contaminant. TNTC RTVs were based on either a no-observed-adverse-effects level (NOAEL) or a value estimated to approximate a NOAEL. The NOAEL is a dose of each COPEC that produces no known adverse effects in the test species. In addition, the lowest-observed-adverse-effects level (LOAEL) may be used as a point of comparison for risk management decision making, or may be used to derive an estimated NOAEL, when an appropriate NOAEL has not been otherwise identified. In the ERA, both NOAEL-based and LOAEL-based RTVs were derived. Other values such as the LD_{50}, described as the dose at which 50 percent of test organisms died, were used when NOAEL or LOAEL values were not available. The hierarchy for toxicity values used in deriving NOAEL-based RTVs in the BERA were as follows:

- Appropriate NOAEL
- Estimated NOAEL derived from an appropriate LOAEL (LOAEL divided by 10)
- Estimated NOAEL derived from an appropriate LD_{50} (LD_{50} divided by 100).

To calculate a LOAEL-based RTV, the NOAEL (or estimated NOAEL) was scaled to body weight (mammalian receptors only), and adjusted for the degree of relatedness between the test species and receptor species and duration of the study. In cases where data are unavailable for a site-related COPEC, toxicological information for surrogate chemicals was used. Similarly, LOAEL-based RTVs were developed as points of comparison. LOAEL toxicity values used for LOAEL-based RTVs were as follows:

- Appropriate LOAEL

- Estimated LOAEL derived from an appropriate NOAEL (NOAEL multiplied by 10)

- Estimated LOAEL derived from an appropriate LD_{50} (LD_{50} divided by 10).

2.7.2.4 Ecological Risk Characterization

The risk characterization integrates information on exposure and effects of the COPECs on the receptor populations. Potential adverse affects to terrestrial plants were qualitatively assessed by comparing COPEC concentrations to plant toxicity benchmarks. Potential adverse impacts to aquatic biota were qualitatively assessed by comparing surface water and sediment COPEC concentrations to respective surface water and sediment quality criteria for the protection of aquatic life. Ecological hazard quotients (EHQ) for terrestrial and aquatic wildlife were calculated in the predictive assessment by dividing the receptor exposure rate by the RTV for each contaminant.

Terrestrial Plant Impact Assessment. Screening benchmarks were exceeded by four COPECS: TNT, lead, manganese, and zinc (Table 2-16). Each of these constituents exceeded the respective screening criteria at several building area locations. However, no vegetative stress was found associated with any of the locations associated with exceedances, and TNTC soil manganese concentrations were consistent with those of background soil.

Aquatic Biota Surface Water Assessment. Although several of the COPECs had maximum concentrations that exceeded some of the surface water benchmark values, the limited and temporal nature of the aquatic habitat reduces the concern for potential impact to aquatic biota. Surface water COPEC concentrations for aluminum, barium, cadmium, calcium, copper, iron, manganese, and carbon disulfide exceeded some or all of the available benchmarks for the protection of aquatic life (Table 2-17). As up to four different benchmarks are used for the surface water assessment, a weight-of-evidence approach was taken; the observation that only cadmium, iron, and manganese exceeded more than one of the benchmarks further reduces concern for potential ecological impacts. The limited number of surface water samples collected at TNTC resulted in the MDC for each of the inorganics being used as the source-term concentration in these comparisons, resulting in likely overestimates of ecological hazard.

Aquatic Biota Sediment Assessment. With respect to sediment, only the COPEC concentrations for lead exceeded three or more of the six ecological screening values (Table 2-18). However, the TNT concentration at TNTC-SD009 (1,496 mg/kg) exceeded the benchmark value by a factor of 160. Again, it is noted that aquatic conditions at TNTC are

temporal and do not constitute a major habitat type, lessening the concern for ecological impacts associated with both surface water and sediment.

Predictive Risk Estimation for Terrestrial and Aquatic Wildlife. Quantitative risk estimations for terrestrial and aquatic wildlife were performed through a series of quantitative EHQ calculations. EHQs less than or equal to 1 present no probable risk. Generally, HQs between 1 and 10 present a low potential for environmental effects; EHQs from 10 to 100 present a significant potential that effects could result from exposure; and EHQs of 100 or greater present the highest potential for expected effects (Wentsel, et al., 1996).

The simple EHQ ratios were summed to provide conservative ecological hazard index (EHI) estimates for all chemicals and exposure pathways for a given receptor. Note that for a given receptor, it is scientifically defensible to sum only EHQs for those chemicals that have a similar mode of toxicological action. The summation of EHQs into an EHI was performed, in part, to determine whether or not individual COPEC EHQs should be segregated by mode of toxicological action.

Conservative NOAEL-based/LOAEL-based EHIs for terrestrial receptors at TNTC were as follows (Table 2-19):

- 31,559/6,190 for the deer mouse
- 36,410/7,274 for the cottontail rabbit
- 5,621/977 for the shrew
- 25,077/1,150 for the marsh wren
- 26,141/5,110 for the raccoon
- 3,100/614 for the white-tailed deer
- 73/4 for the red-tailed hawk.

For each of the seven terrestrial receptors, a majority of the potential ecological risk was associated with soil COPECs. TNT was the major soil risk driver for each of these ecological receptors, and Aroclor 1260 also contributed substantially to TNTC soil risks. Ingestion of surface water added little potential risk to terrestrial receptors, though aluminum added an LOAEL-based EHI of 2 to the deer.

NOAEL-based EHI values for aquatic receptors exposed to TNTC surface water and sediment are 2,350 for the mallard and 1,130 for the raccoon; respective LOAEL-based HI values are 97 and 265 for these receptors (Table 2-20). Virtually all of the estimated risks for the mallard and raccoon are associated with exposure to sediment. Note that both terrestrial and aquatic (i.e.,

sediment) hazards have been estimated for the raccoon, as this receptor exhibits a combined terrestrial and aquatic lifestyle; EHI and EHQ values for the terrestrial and aquatic pathways may be summed for this receptor. Sediment risk drivers, listed in generally decreasing order of concern, are TNT, selenium, aluminum, Aroclor 1260, 2-ADNT, and 4-ADNT. The ingestion of benthic invertebrates is the exposure pathway resulting in greatest potential ecological hazard to the raccoon and mallard.

Uncertainty Analysis. The results of the ERA are influenced to some degree by variability and uncertainty. The uncertainty within the risk analysis can be reduced by using species-specific and site-specific data, but detailed media, prey, and receptor field studies needed to obtain such information are not cost effective. Because assessment criteria were developed based on conservative assumptions, the results of the screening and predictive assessments err on the side of conservativeness.

Species physiology, feeding patterns, and nesting behavior are poorly predictable; therefore, all toxicity information derived from toxicity testing, field studies, or observation have uncertainties associated with them. Laboratory studies conducted to obtain site-specific, measured information may have limited relevance to the actual exposure and uptake conditions on site; that is, bioavailability, exposure, and assimilation, are generally greater under laboratory conditions as compared to field conditions.

Some of the other issues thought to contribute most heavily to uncertainty are the following:

- Assuming that COPECs are 100 percent bioavailable
- Using laboratory-derived or empirically estimated partitioning and transfer factors to predict COPEC concentrations in plants, invertebrates, and sediment pore water
- Using octanol-water partition values without adjustment to estimate macroinvertebrate bioconcentration factors for organic COPECs.

Other specific uncertainties likely to contribute to an overestimate of risks include assumptions regarding the maximum COPEC concentrations used in the ERA and specific RTVs. Of particular interest at TNTC, the TNT MDC in total soil (41,261 mg/kg) was used as the source-term concentration (due to the undefined data distribution), while the arithmetic mean concentration of the total soil sample set used in the ERA was 1,405 mg/kg. This estimate of central tendency is 29 times lower than the mean concentration and suggests that use of the MDC is overly conservative for the estimation of central tendency that likely introduces a

corresponding high bias to estimates of risk. Also, this MDC was taken from a ditch whose sides were lined with stones; the degree to which soil from this ditch represents soil throughout the site is highly questionable. The second highest concentration of TNT in total soil was nearly an order of magnitude less (5,067 mg/kg). The use of the TNT MDC total soil value in the ERA introduces a high bias to the predictive risk estimates. Use of MDC values for other analytical parameters also likely introduces a high bias in general, although for specific data sets this is not necessarily the case.

2.7.3 Discussion of Human Health and Ecological Risk Results

Site-related HI values exceeding the criterion of 1 are associated with TNTC surface soil exposure for the groundskeeper, indoor worker, and hunter, and associated with TNTC total soil exposure for the construction worker and future on-site resident. Likewise, an ILCR value exceeding the Ohio EPA risk criterion of 1×10^{-5} was associated with surface soil exposure to the groundskeeper and indoor worker and total soil exposure to the construction worker and future on-site resident. Also, HI values exceeding a value of 1 are associated with sediment exposure by the construction worker and future on-site resident. Therefore, human health COCs were identified and human health-based RGs were developed for COCs in total soil (Section 2.8.1) and sediment (Section 2.8.2). No human health COCs were identified for surface water.

A weight-of-evidence approach was used to interpret the findings of the ERA. Soil COPEC impacts to terrestrial plants were determined to be generally insignificant. Terrestrial receptors were predicted to incur elevated EHIs, especially due to exposure to TNT and Aroclor-1260 in soil and aluminum in surface water. However, considerable uncertainty is associated with the ecological hazard estimations for terrestrial receptors.

Aquatic macroreceptors (raccoon and ducks) are predicted to have elevated hazards, primarily from exposure to TNT, selenium, aluminum, Aroclor 1260, 2-ADNT, and 4-ADNT in sediment. However, COPEC concentrations were based on the MDCs, instead of a more appropriate statistical value, because of limited sample size. Also, limited aquatic habitat quantity and quality at the site reduces the concern for impact to aquatic biota, and there is considerable uncertainty associated with toxicity and estimates of concentrations in aquatic insects.

As presented in Section 2.8.1, remedial action objectives (RAO) have been developed for soil and sediment in the FFS based on human health risks. Meeting the RAOs will consist of attaining human health-based RG concentrations throughout TNTC. Because of uncertainties associated with ecological toxicity, the fact that no areas of stressed vegetation have been observed, and the assessment that human health-based RGs adequately address ecological

concerns, RAOs based specifically on ecological risk were not recommended in the ERA or FFS for soil or sediment. The major risk drivers for terrestrial ecological risks also are predominant with respect to human health risks; therefore, the attainment of RG concentrations for human health COCs will substantially reduce the estimation of terrestrial ecological hazard. Similarly, the major risk drivers for ecological risks associated with sediment are also predominant for human health concerns, meaning that the attainment of sediment RG concentrations for human health COCs will result in substantial reduction in aquatic ecological hazard. These reductions are further discussed in Sections 2.8.1 and 2.8.2.

In conclusion, by implementing the soil and sediment response action to meet human health-based RGs, it is expected that residual COCs at TNTC will be at soil and sediment concentrations that are protective of the environment. Based on human health and ecological considerations, no remediation is required for surface water.

2.7.4 Basis for Action

The response action selected in this Decision Document is necessary to protect the public health and the environment from actual or threatened releases of 1) hazardous substances into the environment, and 2) pollutants or contaminants from the site which may present an imminent and substantial endangerment to public health or welfare.

2.8 Remedial Action Objectives

The RAOs identified in the TNTC FFS are stated below.

- Prevention of human exposure via any exposure route (ingestion, inhalation, or dermal contact) to site soil containing any of the 13 COCs at concentrations that exceed RGs.

- Prevention of human exposure via any exposure route (ingestion, inhalation, or dermal contact) to site sediment containing any of the three COCs at concentrations that exceed RGs.

The soil RGs and sediment RGs were derived assuming future unrestricted land use. This assumption is appropriate because the area surrounding the former PBOW facility is rural and residential. This is consistent with the remedial objectives of other PBOW sites that have been remediated by the USACE. Also, it is consistent with the cleanup goals used for PBOW sites remediated by NASA. The derivations of the RGs for soil and sediment are described in Section 2.8.1 and 2.8.2, respectively.

2.8.1 Soil Remedial Goals

RGs for nitroaromatics are the residential risk-based remediation concentration (RBRC) values presented in the FFS, which are the lowest (most health protective) RBRCs developed. These RBRCs were back-calculated using the residential scenario and chemical-specific values from the HHRA. The RG for total carcinogenic PAH COCs, 1 mg/kg, was derived based on discussions between the USACE and the Ohio EPA. A value of 1 mg/kg, as presented in Section 40 of CFR 761.61, is recognized as a chemical-specific applicable or relevant and appropriate requirement (ARAR) for Aroclor 1254 and Aroclor 1260. This ARAR was used as the RG for total PCBs in TNTC soil. The EPA (1998) 400 mg/kg residential screening level for lead was selected as an RG for TNTC soil. RG values for soil are presented in Table 2-21 for the COCs.

As discussed in Section 2.7.3, no COCs were identified and no RAOs were developed specifically for ecological receptors. The major risk drivers for human health risks include those that drive the potential for adverse ecological effects; therefore, it is anticipated that remediation to human health-based RGs will also substantially reduce the estimation of ecological hazard. Following remediation which attains human health-based RG concentrations, estimated potential ecological hazards will be greatly reduced; most dramatically, for the shrew, ecological hazard estimates associated with TNT are expected to be reduced over 29,000-fold (Table 2-22).

2.8.2 Sediment Remedial Goals

Because unrestricted use for TNTC is anticipated, the sediment RGs for the three nitroaromatic COCs are the lowest RBRC values presented in the FFS (Table 2-23). These RBRCs were back-calculated using the construction worker and chemical-specific values from the HHRA, which yielded lower values than the resident-based RBRCs for sediment.

As discussed in Section 2.7.3, no COCs were identified and no RAOs were developed specifically for ecological receptors. The human health COCs include chemicals that drive the potential for adverse ecological effects; therefore, it is anticipated that remediation to human health-based sediment RGs will also substantially reduce the estimation of EHIs. Of greatest note, the overall residual EHQ value for TNT is expected to be reduced more than 500-fold (Table 2-24).

2.8.3 Use of the Remedial Goals

The TNTC RGs are used for three purposes: 1) Identify and estimate the extent of areas to be remediated prior to the commencement of remediation efforts, 2) Determine the limits of excavation during confirmation sampling, and 3) Determine whether a given batch of treated material may be placed on site.

The RGs were used as not-to-exceed criteria for the purpose of identifying areas at TNTC requiring soil remediation. They will also be used statistically during excavation and confirmation sampling as part of a risk-based approach to aid in determining whether additional soil removal is required. This will involve the averaging of samples from each excavation and comparing the analytical results to the respective RGs. The exceedance of an individual RG will be acceptable for an area of an excavation as long as the overall Ohio EPA risk goals are not exceeded for the area represented by those samples (ILCR$\leq$1E-5 and HI$\leq$1). Also, for selected Remedial Alternative 5 (Section 2.9), which is the only alternative that may include on-site placement of treated materials, the RGs will serve as cleanup criteria. Even if an individual RG is exceeded for a batch of treated material, the material may be placed on site as long as the overall Ohio EPA risk goals are not exceeded for this batch (i.e., ILCR<1E-5 and HI$\leq$1).

2.9 Description of Alternatives

A total of 14 building areas were identified that require remediation, as they each had at least one COC present at a concentration that exceeds its RG level. These areas are shown on Figure 2-7, which also identifies the areas to be remediated. Only one area (near the vicinity of sample TNTC-SD009) within any of the streams or drainage ditches was identified as exceeding sediment RGs.

Five alternatives were initially evaluated in the FFS to mitigate risks associated with TNTC soil and sediment in these areas. Subsequent to the final submittal of the TNTC FS, remediation efforts were begun and completed at TNTB and the PRRWP Area. During the course of that remedial effort, specific implementation and cost information was obtained that was not available at the time of the TNTC FFS submittal. Therefore, the USACE determined that an addendum to the FFS should be submitted to accomplish the following:

- Screen new remedial technologies that have been developed since the October 2003 FFS
- Revise the technology screening and development of remedial alternatives to include new information about technologies that have been implemented in recent remedial actions at other areas of PBOW
- Revise the costs
- Revise the comparative analysis of remedial alternatives.

This Addendum was completed in January 2009 (Shaw, 2009a). The following five remediation alternatives were evaluated in the FFS Addendum for TNTC:

- Alternative 1 – No Action
- Alternative 2 – Excavation, Windrow Composting, and Off-Site Disposal
- Alternative 3 – Excavation and Off-Site Treatment/Disposal
- Alternative 4 – Excavation, Windrow Composting, Ex Situ Chemical Stabilization, and Off-Site Disposal
- Alternative 5 – Excavation, Alkaline Hydrolysis, Windrow Composting, Ex Situ Chemical Stabilization, and Off-Site Disposal/On-Site Placement.

Each of the four action-based alternatives, Alternatives 2 through 5, would require the excavation of an estimated 9,205 cy of contaminated soil from the locations shown on Figure 2-7. Of this, an estimated 6,805 cy will be disposed of at an appropriate nonhazardous solid waste landfill without treatment. All CERCLA wastes sent off site for disposal in Alternatives 2 through 5 will be coordinated with EPA in accordance with 40 CFR 300.440. The remaining 2,310 cy are anticipated to be a characteristic hazardous waste based on toxicity as determined by TCLP testing. This hazardous soil will require treatment prior to disposal at a nonhazardous waste landfill (Alternatives 2 through 5) or on-site placement (Alternative 5). Approximately 2,103 cy of this contaminated soil are estimated to be hazardous prior to treatment based on elevated 2,4-DNT concentrations, and 400 cy are estimated to be hazardous based on elevated soil lead concentrations. Thus, nearly half of the high-lead soil is also expected to contain concentrations of 2,4-DNT sufficiently high to require treatment. The estimated volumes were calculated using the "20 times rule." The 20 times rule calculation is made based on the mass of TCLP solution used in an analysis being equal to 20 times the mass of the soil sample. Thus, the theoretical maximum TCLP concentration (in mg/L) is assumed to equal $1/20^{th}$ the concentration (in mg/kg) that was present in the original soil sample. The application of the 20 times rule to estimate volumes of hazardous soil is a conservative approach, and the actual volumes of hazardous soil could be less.

The technologies associated with Alternatives 2 through 5 are not designed to treat PCBs. Generally, areas with elevated concentrations of PCBs in TNTC soil are collocated with elevated nitroaromatics concentrations. Where this is the case, the nitroaromatic-contaminated soil will be treated and disposed of off site at an approved RCRA hazardous waste treatment, storage and disposal facility (TSDF) under each of the treatment alternatives. If areas with elevated PCB soil

concentrations at TNTC are encountered that do not have elevated nitroaromatics, then this soil will be excavated and disposed of at a nonhazardous waste landfill without treatment. Disposal at a Toxic Substances Control Act-approved landfill is not expected to be required because none of the RI soil or sediment samples had PCB concentrations that approach the concentration of 50 mg/kg that would result in a classification as a PCB remediation waste.

No ARARs were identified for Alternative 1, since no remedial action is proposed in this alternative. The only key ARARs common to the four action alternatives (Alternatives 2 through 5) are specific to PCBs. The PCB cleanup standard is a numeric cleanup concentration for PCBs which must be met before the site is released for unrestricted use. The PCB waste disposal requirements specify acceptable disposal facilities for wastes contaminated with PCBs. Additional key ARARs for Alternatives 2, 4, and 5 are hazardous waste land disposal restriction standards (LDR) and staging pile regulations. The LDR standards provide chemical-specific numeric concentrations which must be met prior to soil being disposed on the land (i.e., returned to the AOC or disposed off site). The staging pile regulations provide design and operating requirements for the temporary storage of solid, non-flowing hazardous remediation waste (e.g., excavated soil) in staging piles. The additional key ARARs for Alternative 3 consist of hazardous waste characterization requirements for generators of remediation waste. The additional key ARARs for the preferred alternative (Alternative 5) include hazardous waste LDR standards and staging pile regulations.

The extent of soil excavation needed to attain RAOs would be confirmed in the field by sampling and analysis of the excavation sidewalls. Additional soil excavation may be required laterally if indicated by a comparison of the confirmation samples to the RGs and the Ohio EPA's cancer risk goal ($\leq 1 \times 10^{-5}$) and noncancer HI goal (≤ 1); description of the use of RGs during excavation is presented in Section 2.8.3. Additional removal of soil vertically is not anticipated, as the estimated depths of virtually all of the excavations, are expected to extend to either bedrock or the water table, whichever is encountered first. If exceedances of the RGs and the Ohio EPA's cancer risk and noncancer HI goals are encountered in samples collected from the floor of an excavation at a depth that is less than the top of bedrock (competent shale) or the top of the water table, additional soil will be removed until one of the following four is encountered: 1) the water table, 2) the top of bedrock, 3) a depth of 10 feet below ground surface, or 4) average soil concentrations from the excavation floor that meet the Ohio EPA cancer risk and noncancer risk criteria. Characterization of the excavated soil as hazardous or nonhazardous waste will be confirmed by analysis using TCLP prior to disposal.

Alternative 1 – No Action. A no-action alternative is carried forward as a baseline for comparison. Under this alternative, no remedial action or monitoring would be conducted for contaminated soil or sediment at the site. This alternative fails to meet the RAOs for soil and sediment at the site.

The following estimated costs and durations are associated with Alternative 1:

Capital Cost: $0 K
Annual Operation and Maintenance Costs: $0 K
Present Worth Cost: $0 K
Time to Implement: 0 Months
Time to Achieve Remedial Action Objectives: (would not be met in the foreseeable future).

Alternative 2 – Excavation, Windrow Composting, and Off-Site Disposal. This alternative includes the excavation of the contaminated soil and sediment from the areas depicted on Figure 2-7, TCLP testing, segregation of the hazardous lead-contaminated soil, windrow composting of the soil and sediment that is hazardous due to elevated levels of 2,4-DNT, off-site disposal of the composted materials and untreated nonhazardous soil and sediment at a nonhazardous solid waste landfill, and off-site disposal of the hazardous lead-contaminated soil at a RCRA hazardous waste TSDF.

The excavated soil and sediment will be hauled to an outdoor staging area and characterized as hazardous or nonhazardous using the TCLP test. Materials that passed the TCLP criteria will be hauled to the Erie County Landfill or other nonhazardous solid waste landfill without treatment. Although these materials are characterized as nonhazardous with regard to landfill disposal, they do not meet remedial goals for on-site placement, as these materials may present a potential environmental risk or hazard if left on site.

Soil and sediment that failed the TCLP testing for 2,4-DNT will be composted at the outdoor composting area established for TNTC, until TCLP criteria for 2,4-DNT and alternative LDR treatment standards for underlying hazardous constituents in contaminated soil are met. This contaminated soil and sediment will be blended with amendments, such as straw and manure, turned occasionally with a windrow compost turner, and kept moist. The nitroaromatic compounds are biodegraded and transformed into less toxic and less mobile compounds through a series of sequential aerobic and anaerobic treatments, which are facilitated by mixing the soil and sediment with the amendments and periodic turning of the compost.

Contaminated soils which failed the TCLP test for lead will be hauled off site to a RCRA hazardous waste TSDF.

The following estimated costs and durations are associated with Alternative 2:

Capital Cost: $3.27M
Annual Operation and Maintenance Costs: $0
Present Worth Costs: $3.27M
Time to Implement: 16-22 Months
Time to Achieve Remedial Action Objectives: 16-22 Months

Alternative 3 – Excavation and Off-Site Treatment/Disposal. This alternative includes the excavation of the contaminated soil and sediment from the areas depicted on Figure 2-7, TCLP testing, segregation of soil and sediment hazardous due to elevated levels of 2,4-DNT and lead, the off-site disposal of nonhazardous soil and sediment at a nonhazardous solid waste landfill, and the off-site treatment/disposal of hazardous soil and sediment at a RCRA hazardous waste TSDF.

The following estimated costs and durations are associated with Alternative 3:

Capital Cost: $2.86M
Annual Operation and Maintenance Costs: $0
Present Worth Costs: $2.86M
Time to Implement: 10-16 Months
Time to Achieve Remedial Action Objectives: 10-16 Months

Alternative 4 – Excavation, Windrow Composting, Ex-Situ Chemical Stabilization, and Off-Site Disposal. This alternative includes the excavation of the contaminated soil and sediment from the areas depicted on Figure 2-7, TCLP testing, windrow composting of hazardous 2,4-DNT contaminated soil and sediment, chemical stabilization of soil that is a hazardous waste due to elevated concentrations of lead, and the off-site disposal of the treated and untreated nonhazardous soil and sediment at a nonhazardous solid waste landfill.

The excavated soil and sediment will be hauled to an outdoor staging area and characterized as hazardous or nonhazardous using the TCLP test. Soil and sediment that passed the TCLP test will be hauled to the Erie County Landfill or other nonhazardous solid waste landfill that can accept the wastes.

Soil contaminated with hazardous levels of both 2,4-DNT and lead will be composted first and then chemically stabilized. Composting should not interfere with the lead stabilization process as long as chemical stabilization is performed after composting.

Soil and sediment that failed the TCLP test for 2,4-DNT will be composted until TCLP criteria for 2,4-DNT and alternative LDR treatment standards for underlying hazardous constituents in contaminated soil are met. During composting, the contaminated soil and sediment will be blended with amendments, such as straw and manure, turned occasionally with a windrow compost turner, and kept moist. The nitroaromatic compounds are biodegraded and transformed into less toxic and less mobile compounds through a series of sequential aerobic and anaerobic treatments, which are facilitated by mixing the soil and sediment with the amendments and periodic turning of the compost.

Lead-contaminated soil under this alternative will be chemically stabilized using a reagent such as MAECTITE® developed by Sevenson Environmental Services, Inc. MAECTITE is a cost-effective technology because the chemical can be mixed into the soil using an excavator. This technology has been used successfully in the past at PBOW to stabilize lead-contaminated soil. After treatment, TCLP testing will be used to confirm that the stabilized material is nonhazardous for lead.

All treated and nonhazardous untreated soil and sediment will be disposed of at a nonhazardous solid waste landfill after alternative LDR treatment standards for underlying hazardous constituents in contaminated soil are met.

The following estimated costs and durations are associated with Alternative 4:

Capital Cost: $3.23M
Annual Operation and Maintenance Costs: $0
Present Worth Costs: $3.23M
Time to Implement: 16-22 Months
Time to Achieve Remedial Action Objectives: 16-22 Months

Alternative 5 – Excavation, Alkaline Hydrolysis, Windrow Composting, Ex Situ Chemical Stabilization, and Off-Site Disposal/On-Site Placement. This alternative includes the excavation of the contaminated soil and sediment from the areas depicted on Figure 2-7, TCLP testing, segregation of the hazardous lead-contaminated soil, segregation of the hazardous 2,4-DNT contaminated soil and sediment, alkaline hydrolysis or window composting or a combination of both (if necessary), neutralization of the treated soil (if necessary), chemical

stabilization of the lead-contaminated soil (if necessary), and the off-site disposal of the nonhazardous untreated soil at a nonhazardous solid waste landfill and off-site disposal or on-site placement of the treated material. Treated soil that meets RGs, either without composting or after composting, and that complies with the alternative LDR treatment standards for underlying hazardous constituents in contaminated soil (provided the soil was hazardous when generated) will be placed on site rather than disposed of at a landfill.

The excavated soil and sediment will be hauled to the outdoor staging area and characterized as hazardous or nonhazardous using the TCLP test. Materials that pass the TCLP test will be hauled to the Erie County Landfill or other nonhazardous solid waste landfill.

Soil and sediment that fail the TCLP testing for 2,4-DNT would be treated with an alkaline chemical mixture (e.g., caustic soda and ferric chloride) at a treatment area, which would be established for TNTC, until TCLP criteria for 2,4-DNT and alternative LDR treatment standards for underlying hazardous constituents in contaminated soil are met. Chemicals would be mixed into the soil and sediment using an excavator or wheel loader. The nitroaromatics are chemically reacted to less toxic compounds. Alkaline hydrolysis is effective at treating TNT, but is less effective in the treatment of DNTs. Therefore, if necessary for on-site placement of alkaline-treated soil or to meet TCLP or LDR criteria, this treated soil will be polished using windrow composting until TCLP/LDR are met. Composting is expected to be effective in meeting RGs for PAHs. If RGs are met, the composted material will be placed on site; if RGs are not met, then the composted material will be disposed of off site.

Alternatively, composting alone or alkaline hydrolysis alone may be employed rather than a combination of alkaline hydrolysis and composting. Regardless, RGs will have to be met for on-site placement.

Soil that fail TCLP for lead would be treated with a stabilization reagent (e.g., MAECTITE) to immobilize the lead within the soil matrix. After treatment, TCLP testing would be used to confirm that the stabilized soil is nonhazardous for lead. Treated and nonhazardous untreated soil and sediment would be disposed of at a nonhazardous solid waste landfill. Treatment with the alkaline agent (caustic soda) may irreversibly bind the lead to soil, even after neutralization. If this is the case, stabilization will not be required, and the costs associated with this alternative would be decreased.

The following estimated costs and durations are associated with Alternative 5:

Capital Cost: $2.44M
Annual Operation and Maintenance Costs: $0
Present Worth Costs: $2.44M
Time to Implement: 16-22 Months
Time to Achieve Remedial Action Objectives: 16-22 Months

Alkaline hydrolysis-treated soil may not require the addition of chemicals to neutralize the pH of treated soil for placement back on site. Alkaline hydrolysis-treated soil at another site was not chemically neutralized, and the soil pH at this site dropped to near neutral over a period of 3 months while staged on site. If chemical addition is not required for pH neutralization, a further cost savings may be realized.

2.10 Comparative Analysis of Alternatives

Each of the five soil/sediment alternatives was evaluated with respect to the following nine criteria, as required by the NCP at 40 CFR 300.430 (e)(9)(iii). Criteria 1 and 2 are the threshold criteria, which *must* be met, criteria 3 through 7 are the primary balancing criteria, and criteria 8 and 9 are the modifying criteria.

Threshold Criteria
1. Overall Protectiveness of Human Health and the Environment
2. Compliance with Applicable or Relevant and Appropriate Requirements

Primary Balancing Criteria
3. Long-Term Effectiveness and Permanence
4. Reduction of Toxicity, Mobility, or Volume of Contaminants through Treatment
5. Short-Term Effectiveness
6. Implementability
7. Cost

Modifying Criteria
8. State Support/Agency Acceptance
9. Community Acceptance.

An analysis of each alternative against these criteria is presented in Table 2-25. A comparison among the remedial alternatives with respect to these criteria is provided in this section.

Threshold Criteria. Each of the four action-based alternatives (i.e., Alternatives 2 through 5) meet the threshold criteria for protection of human health and the environment and compliance with ARARs. Alternative 1, no action, does not meet the threshold criterion for protection of human health and the environment. Thus, Alternative 1 is not regarded as viable for TNTC and is not further discussed in this evaluation of alternatives.

Primary Balancing Criteria. Alternatives 2 through 5 would be equally effective in the long term because the contaminated soil and sediment would be treated and/or taken off site; under Alternative 5, the treated material that meets the RGs will be placed on site. Alternatives 2, 4, and 5 would meet the preference for treatment technologies that result in a reduction in toxicity, mobility, or volume. Alternative 3 relies only on off-site disposal, although the materials that are the most highly contaminated may be treated at the RCRA TSDF prior to disposal.

Each of the five action-based alternatives could be performed in less than 24 months upon commencement of field remediation activities. Alternative 3 is estimated to take the shortest time (10 to 16 months). Alternatives 2, 4, and 5 could all be performed within a similar time frame (16 to 22 months). Alternatives 2 through 5 can all be carried out safely without appreciable risk to remediation workers, NASA employees, or nearby residents. However, it should be noted that Alternative 5 requires the handling of hazardous chemicals (e.g., caustic soda, ferric chloride). The increased chemical hazards associated with Alternative 5 can be mitigated by implementing the proper chemical storage and material handling procedures and providing site workers with the appropriate personal protective equipment, safety training and supervision. Proper adherence to the safety and health plan would allow for safe implementation of each alternative.

Each of the alternatives represents a proven technological approach and is regarded as implementable. Windrow composting, the primary technology for Alternatives 2 and 4 and a potential polishing step in Alternative 5, has been used successfully at PBOW sites TNTB and the PRRWP Area. Alternative 3 is implementable, as it is simply off-site disposal/treatment. One of the primary technologies for Alternative 5, alkaline hydrolysis, is proven to work on even high concentrations of nitroaromatics, especially TNT.

Costs of the four action-based alternatives are as follows, from least to most expensive:

- Alternative 5 – $2.44M
- Alternative 3 – $2.86M
- Alternative 4 – $3.23M
- Alternative 2 – $3.27M.

Alkaline hydrolysis treated soil (Alternative 5) may not require the addition of chemicals to neutralize the noncomposted soil for on-site placement. Alkaline hydrolysis-treated soil at another site was not chemically neutralized and the soil dropped to a near neutral pH over a period of approximately 3 months while staged on site. If chemical addition is not required for

pH neutralization, a further cost savings may be realized. Lead in nitroaromatic contaminated soil that is treated via alkaline hydrolysis might be stabilized without further treatment because the lead precipitates as lead hydroxide under conditions of elevated pH. If chemical addition is not required for pH neutralization and/or if alkaline hydrolysis would effectively immobilize lead, further cost savings under this alternative should be realized.

Modifying Criteria. The two modifying criteria, state acceptance and public acceptance, are not fully evaluated until the Responsiveness Summary of the Decision Document is complete. The evaluation in the Responsiveness Summary is based on state comment on the Proposed Plan, state comments during the public meeting and comment period, and public comment during the public meeting and public comment period.

It is noted that each of the technologies represented by the four action-based alternatives have been presented to the state and public in the past. Neither the state nor the public has expressed concern over any of these technologies in the past. Both composting (used in Alternatives 2, 4, and 5) and alkaline hydrolysis (though with lime; Alternative 5 uses caustic soda) have been presented to the state and public and in the past. Both of these technologies have been employed at different PBOW sites.

2.11 Principal Threat Waste

The NCP establishes a preference for methods that employ treatment that reduces toxicity, mobility, or volume (300.430[e][9][ii][D]). This especially includes the expectation that treatment will be used to address principal threats posed by a site when practicable (300.430[a][1][iii][A]). The term “principal threat wastes” refers to source materials, but does not include contaminants dissolved or suspended in groundwater (EPA, 1991b). At TNTC, the principal threat wastes are the highest soil and sediment concentrations of nitroaromatics that may serve as a source for groundwater contamination, or to which an individual may be directly exposed under a future land-use scenario (EPA, 1997b). The toxicity and mobility of these principal threat wastes will be reduced through treatment, using alkaline hydrolysis (Alternative 5) and and/or windrow composting (Alternatives 2, 4, and 5), except possibly under Alternative 3. Although Alternative 3 utilizes off-site disposal, it is possible that the hazardous waste materials taken to the RCRA Subtitle C TSDF will be treated prior to disposal.

2.12 Selected Remedy

2.12.1 Rationale for Selection

The rationale for selecting Alternative 5, Excavation, Alkaline Hydrolysis, Windrow Composting, Ex Situ Chemical Stabilization, and On-Site/Off-Site Disposal, for the soil/sediment response action is provided in the FFS Addendum. Essentially, this alternative meets both of the threshold evaluation criteria and provides the best overall set of tradeoffs in meeting the primary balancing criteria. Notably, Alternative 5 meets the NCP statutory preference for treatment technologies that permanently reduce the toxicity and mobility through treatment, and Alternative 5 is estimated to be the least expensive alternative for TNTC. Also, the community has expressed a preference for windrow composting and other treatment technologies over those remedial approaches that rely primarily on landfill disposal, and NASA has expressed the desire to use composted materials on site if these materials meet the RGs.

2.12.2 Description of Selected Remedy

The selected alternative involves the excavation of contaminated soil within proposed remediation areas (Figure 2-7), TCLP testing, segregation of the hazardous lead-contaminated soil and PCB-contaminated soil that exceeds the RGs, segregation of the hazardous 2,4-DNT contaminated soil and sediment, alkaline hydrolysis or window composting or a combination of both (if necessary), neutralization of the treated soil (if necessary), ex situ chemical stabilization of the hazardous lead-contaminated soil, on-site disposal of treated materials that meet RGs and alternative LDR treatment standards for underlying hazardous constituents in contaminated soil, and off-site disposal of all untreated soil, PCB-contaminated soil, and lead-stabilized soil as a nonhazardous waste in a Subtitle D landfill. Approximately 9,205 cy of consolidated soil will be excavated, with 2,310 cy of consolidated soil treated using alkaline hydrolysis/windrow composting and 400 cy of consolidated soil chemically stabilized.

For cost estimating purposes in the FS, it was assumed that all 2,310 cy of soil identified as hazardous with respect to 2,4-DNT will be treated using alkaline hydrolysis. Of the 2,310 cy of soil that are treated with alkaline hydrolysis, it is assumed that 80 percent will meet the TCLP criteria for 2,4-DNT, alternative LDR treatment standards for underlying hazardous constituents in contaminated soil, and RGs for on-site placement. The remaining 20 percent (i.e., 462 cy) will be treated with windrow composting as a polishing step until these criteria are met. These conceptual design assumptions are not intended to limit the extent to which either alkaline hydrolysis or composting are used during the remedial action (i.e., either alkaline hydrolysis or composting may be used to a greater or lesser extent, or not at all, based on the contaminant concentrations in the excavated soil). The goal of alkaline hydrolysis/windrow composting

treatment is to meet RGs so that treated soil is allowed to be placed back on site. Soil that cannot be treated to meet RGs for all COCs will be managed as a nonhazardous waste for off-site disposal provided it passes TCLP and complies with LDR requirements.

Alkaline hydrolysis and windrow composting were selected to be used in tandem for a variety of reasons. First, although windrow composting is effective at treating the DNTs and TNT, ADNTs are generated during the composting of TNT-contaminated materials. Past experience at PBOW has shown that it is difficult to cost-effectively reduce ADNTs to RGs using composting. Alkaline hydrolysis is very effective at treating TNT and has the added benefit that ADNTs are not generated during treatment. Alkaline hydrolysis is also effective at treating 2,4-DNT unless the initial concentrations in soil are very high, but is somewhat less effective at treating 2,6-DNT. Thus, if the TCLP, LDR, and/or RG criteria for the DNTs are not met after alkaline hydrolysis, then windrow composting would likely be an effective polishing step for the alkaline hydrolysis-treated soil.

The treatment area previously prepared at PBOW for windrow composting will be used for alkaline hydrolysis and composting operations. The composting treatment area is 800 feet long by 260 feet wide and surrounded by an earthen berm to contain storm water runoff. Treatment operations will be conducted in the open. The treatment area is graded and compacted to a 2 percent slope to control storm water. The treatment area is not covered with an artificial surface such as asphalt or concrete. The windrows will be constructed within the treatment area, and stockpiles of amendments, untreated soil, and treated compost will be staged in the area.

Storm water will be pumped from sumps on the lower end of the treatment area to a 260-foot-long by 30-foot-wide by 3-foot-deep contact water retention basin. The basin is lined with 60-mil plastic. Water in the basin will be applied to the windrows as needed to maintain the moisture content of the compost. Excess water will be trucked off site to an industrial wastewater treatment facility. No on-site treatment of contact water will be required.

Soil within the remediation areas will be excavated and screened to remove oversize material and reduce particle size to increase the efficiency of the alkaline hydrolysis and composting processes. The excavated soil will be trucked to the treatment area for screening. The screened soil will be stockpiled at the treatment facility for treatment or disposal. Soil adhering to the oversize material will be removed so that the oversize material can be returned to the excavation. Any oversize material not appropriate for use as backfill will be disposed off site at an approved disposal facility. Additionally, soil that is not a PCB remediation waste (i.e., less than 50 mg/kg PCBs), but that exceeds the RG for total PCBs (1 mg/kg) were detected (up to 5 mg/kg) in a few

locations. PCB-containing soil from these locations will be segregated, as neither alkaline hydrolysis nor windrow composting is expected to effectively treat this soil to meet RGs for on-site placement. This soil will be treated if necessary for the other COCs to meet nonhazardous criteria for off-site disposal

The conceptual design of the alkaline hydrolysis technology was based on both previous experience at Volunteer Army Ammunition Plant (Tetra Tech, Inc., 2008) and an alkaline hydrolysis treatability study completed for PBOW. Alkaline hydrolysis will be implemented by adding caustic soda and ferric chloride to the excavated soil. The soil will be neutralized before placement back on site. Nitroaromatic-contaminated soil will be treated in 300 cy batches, approximately 52 feet square by 3 feet deep per treatment cell. It is estimated that the remediation field crew could have four or five treatment cells in process at the same time within the treatment area. Nine or 10 batches will be required to complete treatment at TNTC. Approximately 61 pounds of caustic soda will be required per cy of soil. Caustic soda pellets will be spread across the soil in the treatment cell and mixed into the soil using an excavator and/or wheel loader. Water is applied to the soil to promote dissolution of the caustic soda. A 30 percent solution of ferric chloride is sprayed on the soil at the ratio of 1 gallon of $FeCl_3$ solution per cy of soil. The batch of soil is turned every other day and moisture is applied as necessary to keep the soil near saturation. The hydrolysis reaction should be complete in about 7 days based on the alkaline hydrolysis treatability study and previous field tests at VAAP. At this point, ferrous sulfate may be added to the soil to neutralize the caustic soda. It is assumed that another 3 days would be required with some additional mixing to lower the pH of the soil. Approximately 108 pounds of ferrous sulfate would be required to neutralize all the caustic soda applied to the soil based on the treatability study results. Alternatively, the soil may be stored on site for a period of time to allow the soil pH to drop naturally to a near neutral level.

Composting amendments will be brought to the facility as needed so that large amounts of amendments are not required to be stored on site. This minimizes the cost of amendment storage as well as odor problems associated with manure, as the odor increases with storage duration. Equipment, labor and amendments needed to run the composting operation are available locally.

It is assumed that the compost will consist of 25 percent by volume (74.7 percent by weight) contaminated soil, 72 percent by volume (19.6 percent by weight) straw, and 3 percent by volume (5.7 percent by weight) chicken manure. The compost will be constructed into windrows 16 feet wide by 6 feet high. A typical treatment cycle for a batch of nitroaromatic-contaminated soil that has not been subjected to alkaline hydrolysis may require 6 weeks, 5 weeks for treatment and 1 week for curing and analytical testing. The typical composting cycle is expected

to be reduced for soil pretreated using alkaline hydrolysis. The treatment cycles for windrows will be staggered so that the windrows do not complete the treatment cycle at the same time.

The compost will be turned periodically with the windrow turner to mechanically aerate the material. After the compost is turned, microorganisms within the pile aerobically degrade organic compounds until the available oxygen within the pile is utilized. Beyond this point, further contaminant degradation is achieved through an anaerobic process. The periodic turning of the compost pile permits the composting process to alternate between aerobic and anaerobic treatment phases. This is the most effective approach to the biological degradation of nitroaromatic explosives.

Lead-contaminated soil under this alternative will be chemically stabilized ex situ using a reagent such as MAECTITE developed by Sevenson Environmental Services, Inc. MAECTITE is a cost-effective technology because the chemical can be mixed into the soil using equipment already on site, such as an excavator. This technology has been used successfully in the past at PBOW to stabilize lead-contaminated soil. Chemical stabilization of lead-contaminated soil will take place after either alkaline hydrolysis or composting, if these treatments are needed to reduce the concentration of nitroaromatic compounds or PAHs. Alkaline hydrolysis and composting should not interfere with the lead stabilization process as long as chemical stabilization is performed after these other treatment operations. Alkaline hydrolysis may promote stabilization of lead in the soil because the solubility of lead typically decreases with increasing pH. The lead-contaminated material will be disposed of off site once it is treated sufficiently to pass the TCLP and comply with alternative LDR treatment standards for underlying hazardous constituents in contaminated soil. The treated lead-contaminated soil will not be disposed of on site because stabilization will not reduce the total lead content, and the soil will still exceed the lead RG.

Precompliance (in-process) testing of the alkaline hydrolysis treated soil involves taking samples for field pH measurements to determine if treatment is uniform throughout the batch. Compliance testing for the alkaline hydrolysis technology will be performed in two phases. The first phase takes place at the end of treatment with caustic soda and ferric chloride (~ day 7). A composite sample will be collected from each 300 cy batch and analyzed for total nitroaromatics, nitrate/nitrite, and TCLP 2,4-DNT. The second phase of compliance testing will be performed at the end of soil neutralization (~ day 10). A composite sample will be collected from each 300 cy batch and analyzed for pH (field test) and nitrate/nitrite (off-site laboratory).

Precompliance testing of the compost will consist of sampling the compost immediately after formation and once a week during treatment. One composite sample will be collected from each windrow each week and analyzed as follows: TNT colorimetric field test, PAH qualitative colorimetric field test, total nitroaromatics (off-site laboratory), total PAHs (off-site laboratory), and total PCBs.

If the precompliance results indicate that RG levels have been achieved, compliance samples will then be collected to confirm the results of the definitive analyses used for precompliance testing. Compliance testing for the chemical stabilization technology involves collecting two composite samples from the entire volume of stabilized soil and analysis for TCLP lead. This sampling and analytical strategy is proposed as the basis for estimating remedial costs. The actual sampling and analytical strategy will be developed by the USACE, in consultation with the state, during the remedial design. It is noted, consistent with 40 CFR 300.515(e)(2)(ii), that state concurrence with this strategy is not a prerequisite for its implementation.

2.12.3 Estimated Costs of Selected Remedy

The overall estimated capital cost and present worth cost for the implementation of Alternative 5, as presented in Section 2.9, is $2.44M. A detailed breakdown of the estimated costs for implementing the Selected Remedy is provided in Table 2-26. The cost information in Table 2-26 is based on the best available information regarding the scope of the remedial alternative. Changes in the cost elements are likely to occur as the result of new information and data collected during the engineering design of the remedial alternative. Major changes that may affect the overall costs may be documented in the form of a memorandum in the AR file, an Explanation of Significant Difference, or an Amendment to the Decision Document Amendment.

2.12.4 Expected Outcome of Selected Remedy

The expected outcome of the Selected Remedy is that the TNTC property will have unrestricted use with respect to soils, surface water, and sediment. Also, the Selected Remedy will result in soil and sediment concentrations that are protective of environmental receptors. It is noted that this Decision Document does not directly address contamination in underlying groundwater. Groundwater underlying TNTC will be addressed in a subsequent Decision Document.

2.13 Statutory Determinations

Exposure to soil and sediment associated with TNTC may result in adverse human health effects and/or may adversely affect environmental receptors as indicated by the HHRA and the ERA. Therefore, remedial actions are necessary at TNTC.

Remedial Alternative 5 will be implemented for the remediation of TNTC soil and sediment as described in the TNTC FFS Addendum, which is summarized as follows:

- Excavation of soil and sediment that exceed the RGs
- Removal and disposal of soil and sediment exceeding the RG for lead at a RCRA Subtitle C TSDF
- Alkaline hydrolysis and windrow composting of all other excavated soil and sediment
- On-site placement of composted materials that meet RGs.

If an RG is not met for a given batch of composted material, additional composting may be performed until the RG is met. Alternatively, composted materials that do not meet RGs could be disposed of off site at a nonhazardous waste landfill (e.g., Erie County Landfill), provided that an alternative LDR treatment standards for underlying hazardous constituents in contaminated soil are met.

This remedial alternative satisfies the following CERCLA Section 121 statutory requirements found at NCP 300.430(f)(5)(ii). Documentation of the selected alternative meeting these requirements is found in the paragraphs that follow:

- Protection of human health and the environment
- Compliance with ARARs and/or justification of an ARAR waiver
- Cost effectiveness
- Utilization of permanent solutions and treatment or resource recovery technologies to the maximum extent practicable
- Preference for treatment as a principal element that reduces toxicity, mobility, or volume.

Protection of Human Health and the Environment. The preferred alternative is protective of human health via the excavation of soil and sediment that had not met the RGs. The excavations will be backfilled with treated and/or other clean materials. Treated materials that may be placed on site meet stringent criteria for unrestricted land use. The selected remedy does not pose unacceptable short-term risks and also reduces potential ecological risks.

Compliance with ARARs. The selected alternative complies with all action-specific and chemical-specific ARARs (Table 2-27). No location-specific ARARs were identified for TNTC.

Cost Effectiveness. The selected remedy was regarded as cost effective, as it meets the RAOs and the nine NCP criteria at a feasible cost in comparison with the other remedial alternatives. Additional overall PBOW remedial cost savings may be realized if similar technologies are used at multiple PBOW sites.

Utilization of Permanent Solutions and Treatment. The selected remedy meets the permanence and treatment criteria. The toxicities of the previously hazardous nitroaromatic-impacted materials will be permanently reduced through alkaline hydrolysis and windrow composting. Lead-contaminated materials will be permanently removed from TNTC and taken to a RCRA Subtitle C TSDF. PAHs will be treated with windrow composting and/or permanently removed off site at a nonhazardous waste landfill.

Treatment as a Principal Element. The selected remedy satisfies the requirement for treatment by using alkaline hydrolysis and windrow composting of materials identified as characteristic hazardous wastes.

Five-Year Reviews. No 5-year reviews will be required for the remediation of soil and sediment.

2.14 Documentation of Significant Changes

The Proposed Plan for TNTC soil and sediment was released in March 12, 2009. The Proposed Plan (Shaw, 2009b) identified Alternative 5 (excavation, alkaline hydrolysis, windrow composting, ex-situ chemical stabilization, and on-site/off-site disposal) as the Preferred Alternative for soil and sediment remediation. Based on the USACE review of all written and verbal comments received during the public comment period, it was determined that no significant changes to the Preferred Alternative identified in the Proposed Plan were necessary or appropriate.

3.0 Responsiveness Summary

A presentation of the Proposed Plan was provided by the USACE to the community during a March 12, 2009 public meeting jointly chaired by representatives of the RAB and the USACE. As discussed in Section 2.3, this meeting was announced in the Sandusky Register on February 26, 2009. The State of Ohio was represented at the public meeting, as was NASA. The only concerns expressed during the public were by Mr. Mark Bohne, the public Co-Chairman of the RAB. He was encouraged by the USACE to formally submit these in writing. The comments were received April 2, 2009, and are presented below with responses. None of these comments resulted in a revision to the Selected Remedy. No other concerns were expressed during the public meeting or during the public comment period which extended from March 12, 2009 through April 13, 2009.

Comment No. 1. Windrow composting of contaminated soils will render soils contaminated with ADNT after completion of the process. This will require disposal of non-lead contaminated soils in the Erie County Landfill.

A. What specific environmental / human hazards are associated with ADNT that preclude on-site use of the soils and require disposal at the Erie County Landfill?

B. Would it be more cost effective to treat non-lead contaminated soils after windrow composting with the proposed Alkaline Hydrolysis process to eliminate the ADNT and therefore eliminating the need for offsite disposal?

Response No. 1. The selected remedial alternative for TNTC includes composting, alkaline hydrolysis, or a combination of these two technologies. A goal of the remedial action for TNTC will be to minimize the residual post-treatment concentrations so that the materials can be placed back on site for unrestricted use. It is possible that composting may not be used, and it is possible that composting will be used but that the criteria for on-site placement for unrestricted use will be met for ADNT (as well as the other chemicals of concern). Responses to Comments 1A and 1B are provided below.

Response No. 1A. At the estimated exposure levels associated with unrestricted on-site use, which as described in the feasibility study is based on residential use, there is a potential hazard for adverse human health effects. The health effects associated with exposure to the ADNT isomers are based on liver effects in dogs and erythrocyte effects (methemoglobinemia and hemolytic anemia) in rats, mice, and dogs at low doses. The potential for adverse human health effects exposed to ADNT in humans is extrapolated from the animal studies using U.S.

Environmental Protection Agency human health risk assessment methodologies, which include an uncertainty factor (i.e., "safety" factor) of 3,000 in the case of ADNTs (EPA, 2003).

Response No. 1B. The limited available information does not suggest that alkaline hydrolysis is highly effective at directly treating soil that is already contaminated with ADNT. However, unlike composting, ADNTs are not generated from the treatment of TNT-contaminated soil under alkaline hydrolysis. Our reasoning for suggesting alkaline hydrolysis as a first step is that this process greatly reduces the TNT concentration without generating ADNTs. During site remediation multiple approaches with respect to composting and alkaline hydrolysis will be evaluated to arrive at the most cost-effective approach to meet the remedial objectives.

Comment No 2. Erie County Landfill has been issued a permit from the Ohio EPA to use ADNT-contaminated soils as temporary cover at the landfill. I understand that the Army Corps of Engineers is not responsible for the proper disposal of soils contaminated with ADNT at the Erie County Landfill. As there may be environmental issues related to Erie County's disposal of contaminated soils, please address the following:

A. What are the potential hazards when airborne particles migrating off of the disposal site from the temporary cover is carried to neighboring properties?

B. In February 2008, a Title V Air Permit Public Hearing was held for the Erie County Landfill. Evidence was provided showing that soils were being carried by vehicle traffic offsite. The soils were carried north and south from the landfill site on Hoover Road. What are the potential hazards related to ADNT-contaminated soils being carried off site and spread down the public right-of-way?

C. Soils being carried by vehicle traffic from the Erie County Landfill are also left at the entrance area to the landfill. Mud Brook, a tributary to the Huron River and consequently to Lake Erie, passes along the south of the entrance area. What are the potential hazards related to ADNT soils being washed into Mud Brook from the landfill entrance area?

Response No. 2. While it is true that the USACE is not responsible for the handling of materials that have been disposed of at the Erie County Landfill, it should be clarified that the USACE is responsible for the proper disposal of soils and materials from PBOW.

Response No. 2A. Ms. Lisa Humphreys of the USACE, Huntington District, spoke with Mr. Bob Sennish, a representative of the Erie County Landfill on June 12, 2009, to discuss landfill operations including dust control. The information provided is that the daily cover is sufficiently moist that it does not create a "dusty" environment. However, if dust is generated from other

areas, then the landfill's method of dust control is water suppression, just like on any construction site. Mr. Sennish stated that the landfill has all measures in place to spray when necessary. Water suppression is only a spray/mist to keep the dust contained. Therefore, water suppression efforts do not generate enough water to be considered "run-off" that would otherwise be contained in the leachate collection system.

Based on Mr. Sennish's description, the level of dust originating from the stockpiled compost that is used as daily landfill cover would be minimal and the resulting exposure by off-site individuals to ADNT in this material would likely be negligible. However, the USACE has provided human health-based responses to Comments 2A and 2B under the highly unlikely assumption that a significant amount of the compost is becoming entrained in the air as dust and is being carried to the breathing space of adjacent residents and also being deposited in their yards as surface soil. Further detail on this response is provided in the attachment, "Further Detail and Calculations in Support of the Response to Comment No. 2A of the Responsiveness Summary."

The phenomenon of airborne particles being carried off site raises two major issues with respect to risk: 1. "What is the potential hazard of inhaling contaminated particulate matter?", and 2. "What is the hazard of being exposed to the particulate matter that has been deposited on the soil?" These questions are addressed separately below.

1. "What is the potential hazard of inhaling contaminated matter?" The inhalation toxicity of ADNTs has not been determined due to a lack of any studies that have been performed on ADNTs (or TNT which has been used as a surrogate chemical for the ADNTs) via this exposure pathway. Only a provisional chronic oral toxicity intake rate value for ADNTs has been derived (EPA, 2003). This value is 2E-4 milligrams of ADNT per kilogram of body weight per day. Also referred to as a chronic reference dose (RfD), this value represents a intake rate at or below which adverse noncancer health effects are unlikely in any individual.

   For the particulate inhalation pathway described, there are four basic components: a) Dust (i.e., soil) concentration in the air; b) Contaminant concentration in the dust; c) Resulting dose under inhalation exposure; and; d) Potential hazard associated with the dose.

   a) As an extremely conservative surrogate, the dust concentration associated with a site groundskeeper was assumed for an off-site resident. The groundskeeper is assumed to be regularly involved in dust-raising activities which result in an airborne concentration of soil in the work area that is more than 100 times greater than that typically modeled based on wind erosion alone.

b) The maximum combined ADNT concentration (b) in any of the stockpiled soil/compost associated with TNTB was 11.8 mg/kg, and the average concentration was 2.4 mg/kg. This maximum concentration is nearly the same as the soil concentration used as the 4-ADNT soil concentration of 11.3 mg/kg in the TNTC risk assessment (IT, 2001b).

c) This TNTC soil concentration of 11.3 mg/kg resulted in a 4-ADNT intake rate of 2.2E-7 mg/kg-day (see Table B.2-1 of the TNTC risk assessment). If the dust concentration in an adjacent residential property were to be the same as that associated with a groundskeeper's breathing zone working on site (a highly doubtful occurrence), then a young child resident would be expected to receive a higher level of exposure than a groundskeeper due to the higher inhalation rate on a per-body weight basis and a more frequent rate of exposure. This difference, based on exposure modeling assumptions, is a factor of 3.3 (see the attachment). Thus, if a young child were to be exposed to the dust concentration that the groundskeeper would encounter at an ADNT concentration of 11.3 mg/kg, the resulting dose would be 7.3E-7 mg/kg-day, which is 3.3 times the dose received by the groundskeeper in the TNTC risk assessment.

d) The resulting ADNT dose to the resident child of 7.3E-7 mg/kg-day is (far) less than the RfD of 2E-4 mg/kg-day, inhalation exposure to nearby residents is unlikely to result in adverse health effects. In human health risk assessment terms, this results in a hazard index of 0.004; the USACE and Ohio EPA consider hazard index values of 1 or less as unlikely to result in adverse noncancer health effects.

2. "What is the hazard of being exposed to the particulate matter that has been deposited on the soil?" As stated above, the average combined ADNT concentration in the stockpiled material samples from TNTB used as landfill cover is 2.4 mg/kg and the maximum combined concentration of this material among these samples is 11.8 mg/kg. The maximum concentration is slightly less than the EPA Region 9 PRG table residential soil value for ADNT of 12 mg/kg. This value is considered safe for residential use, even if all soil associated with the residence contained ADNT at this concentration. Note that the average combined 2ADNT/4ADNT concentration in the stockpiled material for TNTB was 2.4 mg/kg. This is less than the TNTC combined ADNT cleanup goal of 3.0 mg/kg, which is a safe level for residential use and considers that other contaminants may also be present at concentrations up to their respective cleanup levels.

   In summary, the average ADNT concentration in the stockpiled material itself meets residential soil criteria. It is possible that some of this material could be carried by wind currents and deposited on the surface of adjacent residences at some distance from the site, although as stated above, dust controls in place at the landfill would likely minimize the amount of stockpiled material that becomes entrained in the air as dust. The surface soil at such residences would also include the native soil, as well as materials deposited from other sources, especially those

outside of the landfill. Given the variety of sources and the likelihood that the vast majority of the soil from adjacent residential areas would be from origins not related to PBOW or the landfill, the concentrations of ADNT in the soil from adjacent residences would likely be much lower than the residential PRG or the TNTC cleanup levels.

Response 2B. According to the Mr. Sennish, the trucks which bring the daily cover material to the landfill never drive directly on the daily cover or waste material; therefore, the material does not collect in the tires to be tracked out onto the haul road. The trucks drive in, one by one, turn around, then back in to where the cover material is collected in stockpiles, dump the cover material and move out. This creates a succession of stockpiles from which the dozer can take the cover material and distribute it over the trash. The dozer remains in the cell area until its completion so it does not track the daily cover out either.

Based on the information provided by Mr. Sennish, the material tracked onto Hoover Road represents mud tracked from the several hundred yards of unpaved road from the unloading area (excluding the stockpiled material itself), down the haul road, to Hoover Road.

Response 2C. As stated in the response to Comment 2B, virtually none of the material tracked by trucks is expected to be stockpiled cover material. Mr. Sennish stated that all run-off is collected in the landfill's leachate collection system, which is then collected in tank trucks and disposed of off-site. Therefore, no run-off from the stockpiles would go into Mud Brook.

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TABLES

Table 2-1

Summary of Chemicals of Concern and Exposure Point Concentrations
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

Chemical of Concern	Units	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	95% Upper Confidence Limit of the Mean	EPC	Statistical Measure of EPC
Medium: Total Soil							
2-Amino-4,6-dinitrotoluene	mg/kg	29/40	0.0712	38.0	455	38	Max-SS
4-Amino-2,6-dinitrotoluene	mg/kg	28/40	0.0876	14.6	11.3	11.3	UCL-SS
2,4-Dinitrotoluene	mg/kg	27/40	0.0493	275	275	275	Max-Sub
2,6-Dinitrotoluene	mg/kg	16/40	0.0616	65.5	19.4	19.4	UCL-Sub
Benzo(a)anthracene	mg/kg	13/40	0.0384	11.1	6.94	6.94	UCL-SS
Benzo(a)pyrene	mg/kg	13/40	0.0361	8.2	6.33	6.33	UCL-SS
Benzo(b)fluoranthene	mg/kg	10/40	0.0826	10.2	8.43	8.43	UCL-SS
Dibenz(a,h)anthracene	mg/kg	5/40	0.0817	1.4	1.86	1.4	Max-Sub
Indeno(1,2,3-cd)pyrene	mg/kg	5/40	0.21	3.64	1.95	1.95	UCL-Sub
2,4,6-Trinitotoluene	mg/kg	38/40	0.0622	41,261	41,261	41,261	Max-SS
Aroclor 1260	mg/kg	34/40	0.00951	4.88	4.88	4.88	Max-SS
Lead	mg/kg	38/38	4.05	934	1860	934	Max-Sub
Medium: Sediment							
2-Amino-4,6-dinitrotoluene	mg/kg	4/15	0.214	12.8	12.8	12.8	Maximum
4-Amino-2,6-dinitrotoluene	mg/kg	4/15	0.126	11.2	11.2	11.2	Maximum
2,4,6-Trinitotoluene	mg/kg	8/15	0.0715	1,496	1,496	1,496	Maximum

EPC = exposure point concentration; Max-SS = maximum detected concentration in surface soil; Max-Sub = maximum detected concentration in subsurface soil; UCL-SS = upper 95th percent confidence limit of the mean in surface soil; UCL-Sub = upper 95th percent confidence limit of the mean in subsurface soil; mg/kg = milligrams per kilogram; µg/L = micrograms per liter.

The table shows the chemicals of concern (COC), which are the chemicals that contribute the majority of site risks. The EPCs are those used in the human health risk assessment (HHRA) to estimate exposure and risks. Total soil is either surface soil or subsurface soil, whichever data set would result in the higher EPC.

Table 2-2

COC-Specific Toxicity Values Used in the Human Health Risk Assessment
TNT Area C
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	GAF	Oral RfD (mg/kg-day)	Target Organs (Oral)	Dermal RfD (mg/kg-day)	Inhalation RfD (mg/kg-day)	Target Organs (Inhalation)	Cancer Weight-of-Evidence Group	Oral SF (/mg/kg-day)	Dermal SF (/mg/kg-day)	Inhalation SF (/mg/kg-day)
Metals										
Lead	0.1	ND	NA	NA	ND	NA	B2	ND	ND	ND
Nitroaromatics										
2-Amino-4,6-dinitrotoluene	0.6	6.00E-05	L, E	3.60E-05	ND	NA	D	ND	ND	ND
4-Amino-2,6-dinitrotoluene	0.6	6.00E-05	L, E	3.60E-05	ND	NA	D	ND	ND	ND
2,4,6-Trinitrotoluene	0.6	5.00E-04	L, E	3.00E-04	ND	NA	C	3.00E-02	5.00E-02	ND
PCBs										
Aroclor 1254	0.9	2.00E-05	IS, S	1.80E-05	ND	NA	B2	2.00E+00	2.00E+00	2.00E+00
Aroclor 1260	0.9	ND	NA	NA	ND	NA	B2	2.00E+00	2.00E+00	2.00E+00
Semivolatile Organic Compounds										
2,4-Dinitrotoluene	1	2.00E-03	CNS, L, E	2.00E-03	ND	NA	B2	6.80E-01	6.80E-01	ND
2,6-Dinitrotoluene	1	1.00E-03	CNS, L, E, K	1.00E-03	ND	NA	B2	6.80E-01	6.80E-01	ND
Benzo(a)anthracene	0.5	ND	NA	NA	ND	NA	B2	7.30E-01	1.46E+00	3.10E-01
Benzo(a)pyrene	0.5	ND	NA	NA	ND	NA	B2	7.30E+00	1.46E+01	3.10E+00
Benzo(b)fluoranthene	0.5	ND	NA	NA	ND	NA	B2	7.30E-01	1.46E+00	3.10E-01
Dibenz(a,h)anthracene	0.8	ND	NA	NA	ND	NA	B2	7.30E+00	9.13E+00	3.10E+00
Indeno(1,2,3-cd)pyrene	0.5	ND	NA	NA	ND	NA	B2	7.30E-01	1.46E+00	3.10E-01

COC = Chemical of concern.
GAF = Gastrointestinal absorption factors.
RfD = Reference dose.
SF = Slope factor.
ND = No data; NA = Not applicable.

Target Organs:
CNS = central nervous system, L = liver, E = erythrocyte, K = kidney; IS = immune system; S = skin.

Weight of Evidence Group:
A - Human carcinogen; B1 - Probable human carcinogen (human data); B2 - Probable human carcinogen (animal data);
C - Possible human carcinogen; D - Not classifiable as to carcinogenicity to humans.

This table provides carcinogen and noncarcinogenic human health risk toxicity information which is relevant to the contaminants of concern in TNTC soil. This information was used in the human health risk assessment. Dermal toxicity values are not available. Following U.S. Environmental Protection Agency guidance, dermal RfD and dermal SF values were derived in the risk assessment by either multiplying (RfD) or dividing (SF) the corresponding oral toxicity values by the GAF. This adjustment accounts for the fact that oral toxicity values are based on ingested doses which may not be absorbed at 100 percent, whereas dermal exposure is based on an estimate of the actual dose absorbed across the dermis.

Table 2-3

COC Cancer Risk and Noncancer Hazard Index: Groundskeeper Exposure to Surface Soil
TNT Area C
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Source-Term Concentration (mg/kg)	Oral HQ	Oral ILCR	Dermal HQ	Dermal ILCR	Inhalation HQ	Inhalation ILCR	**Total HI All Pathways**	**Total ILCR All Pathways**
Metals									
Lead	9.34E+02	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Nitroaromatics									
2-Amino-4,6-dinitrotoluene	3.80E+01	6.20E-01	NA	1.05E-01	NA	NA	NA	**7.25E-01**	**NA**
4-Amino-2,6-dinitrotoluene	1.13E+01	1.84E-01	NA	3.12E-02	NA	NA	NA	**2.15E-01**	**NA**
2,4,6-Trinitrotoluene	4.13E+04	8.07E+01	4.33E-04	1.37E+01	7.33E-05	NA	NA	**9.44E+01**	**5.06E-04**
PCBs									
Aroclor 1260	4.88E+00	NA	3.41E-06	NA	2.08E-07	NA	6.81E-08	**NA**	**3.68E-06**
Semivolatile Organic Compounds									
2,4-Dinitrotoluene	9.85E+00	4.82E-03	2.34E-06	4.90E-04	2.38E-07	NA	NA	**5.31E-03**	**2.58E-06**
2,6-Dinitrotoluene	9.52E+00	9.31E-03	2.26E-06	9.47E-04	2.30E-07	NA	NA	**1.03E-02**	**2.49E-06**
Benzo(a)anthracene	6.94E+00	NA	1.77E-06	NA	3.60E-07	NA	1.50E-08	**NA**	**2.15E-06**
Benzo(a)pyrene	6.33E+00	NA	1.61E-05	NA	3.28E-06	NA	1.37E-07	**NA**	**1.96E-05**
Benzo(b)fluoranthene	8.43E+00	NA	2.15E-06	NA	4.38E-07	NA	1.83E-08	**NA**	**2.61E-06**
Dibenz(a,h)anthracene	1.03E+00	NA	2.63E-06	NA	3.34E-07	NA	2.23E-08	**NA**	**2.98E-06**
Indeno(1,2,3-cd)pyrene	2.05E+00	NA	5.22E-07	NA	1.06E-07	NA	4.43E-09	**NA**	**6.32E-07**
Total HI		**81.6**		**13.8**		**NA**		**95**	
Total ILCR			**4.64E-04**		**7.85E-05**		**2.65E-07**		**5E-04**

COC = Chemical of concern.
HQ = Hazard quotient.
HI = Hazard index; sum of the HQ values.
ILCR = Incremental lifetime cancer risk.
mg/kg = Milligrams per kilogram.
NA = Not applicable.
PCB = Polychlorinated biphenyl.
1) HI values equal to or less than 1 are unlikely to result in adverse noncancer human health effects for any member of the exposed population and are regarded as acceptable.
2) ILCR values equal to or less than 1E-5 (1 in 100,000) are generally regarded by the Ohio Environmental Protection Agency as acceptable. Risks less than 1E-6 are regarded as very minimal, and risks greater than 1E-5 further study if appropriate. It is noted that the average lifetime cancer risk of the general American population is estimated as about 300,000 in 1,000,000.

Table 2-4

COC Cancer Risk and Noncancer Hazard Index: Indoor Worker Exposure to Surface Soil
TNT Area C
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure-Point Concentration (mg/kg)	Oral HQ	Oral ILCR
Metals			
Lead	9.34E+02	NA	NA
Nitroaromatics			
2-Amino-4,6-dinitrotoluene	3.80E+01	3.10E-01	NA
4-Amino-2,6-dinitrotoluene	1.13E+01	9.19E-02	NA
2,4,6-Trinitrotoluene	4.13E+04	4.04E+01	2.16E-04
PCBs			
Aroclor 1260	4.88E+00	NA	1.70E-06
Semivolatile Organic Compounds			
2,4-Dinitrotoluene	9.85E+00	2.41E-03	1.17E-06
2,6-Dinitrotoluene	9.52E+00	4.66E-03	1.13E-06
Benzo(a)anthracene	6.94E+00	NA	8.85E-07
Benzo(a)pyrene	6.33E+00	NA	8.07E-06
Benzo(b)fluoranthene	8.43E+00	NA	1.08E-06
Dibenz(a,h)anthracene	1.03E+00	NA	1.31E-06
Indeno(1,2,3-cd)pyrene	2.05E+00	NA	2.61E-07
Total HI		**41**	
Total ILCR			**2E-04**

COC = Chemical of concern.
HQ = Hazard quotient.
HI = Hazard index; sum of the HQ values.
ILCR = Incremental lifetime cancer risk.
mg/kg = Milligrams per kilogram.
NA = Not applicable.
PCB = Polychlorinated biphenyl.
1) HI values equal to or less than 1 are unlikely to result in adverse noncancer human health effects for any member of the exposed population and are regarded as acceptable.
2) ILCR values equal to or less than 1E-5 (1 in 100,000) are generally regarded by the Ohio Environmental Protection Agency as acceptable. Risks less than 1E-6 are regarded as very minimal, and risks greater than 1E-5 further study if appropriate.
It is noted that the average lifetime cancer risk of the general American population is estimated as about 300,000 in 1,000,000.

Table 2-5

COC Cancer Risk and Noncancer Hazard Index: Adult Hunter Exposure
TNT Area C
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure-Point Concentration (mg/kg)	Oral HQ	Oral ILCR	Dermal HQ	Dermal ILCR	Venison Consumption HQ	Venison Consumption ILCR	**Total HI All Pathways**	**Total ILCR All Pathways**
Metals									
Lead	9.34E+02	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Nitroaromatics									
2-Amino-4,6-dinitrotoluene	3.80E+01	3.47E-02	NA	2.37E-03	NA	NA	NA	**3.71E-02**	**NA**
4-Amino-2,6-dinitrotoluene	1.13E+01	1.03E-02	NA	7.02E-04	NA	NA	NA	**1.10E-02**	**NA**
2,4,6-Trinitrotoluene	4.13E+04	4.52E+00	2.91E-05	3.09E-01	1.98E-06	NA	NA	**4.83E+00**	**3.11E-05**
PCBs									
Aroclor 1260	4.88E+00	NA	2.29E-07	NA	5.63E-09	NA	1.16E-07	**NA**	**3.51E-07**
Semivolatile Organic Compounds									
2,4-Dinitrotoluene	9.85E+00	2.70E-04	1.57E-07	1.10E-05	6.44E-09	NA	NA	**2.81E-04**	**1.64E-07**
2,6-Dinitrotoluene	9.52E+00	5.21E-04	1.52E-07	2.14E-05	6.22E-09	NA	NA	**5.43E-04**	**1.58E-07**
Benzo(a)anthracene	6.94E+00	NA	1.19E-07	NA	9.74E-09	NA	2.00E-08	**NA**	**1.49E-07**
Benzo(a)pyrene	6.33E+00	NA	1.09E-06	NA	8.89E-08	NA	2.98E-07	**NA**	**1.47E-06**
Benzo(b)fluoranthene	8.43E+00	NA	1.45E-07	NA	1.18E-08	NA	3.79E-08	**NA**	**1.94E-07**
Dibenz(a,h)anthracene	1.03E+00	NA	1.77E-07	NA	9.04E-09	NA	9.36E-08	**NA**	**2.79E-07**
Indeno(1,2,3-cd)pyrene	2.05E+00	NA	3.51E-08	NA	2.87E-09	NA	1.44E-08	**NA**	**5.24E-08**
Total HI		**4.57**		**0.312**		**NA**		**5**	
Total ILCR			**3.12E-05**		**2.12E-06**		**5.80E-07**		**3E-05**

Note: Exposure based on direct contact with soil and ingestion of venison from deer that grazed on vegetation grown in TNT Area C surface soil.
COC = Chemical of concern.
HQ = Hazard quotient.
HI = Hazard index; sum of the HQ values.
ILCR = Incremental lifetime cancer risk.
mg/kg = Milligrams per kilogram.
NA = Not applicable.
PCB = Polychlorinated biphenyl.
1) HI values equal to or less than 1 are unlikely to result in adverse noncancer human health effects for any member of the exposed population and are regarded as acceptable.
2) ILCR values equal to or less than 1E-5 (1 in 100,000) are generally regarded by the Ohio Environmental Protection Agency as acceptable. Risks less than 1E-6 are regarded as very minimal, and risks greater than 1E-5 further study if appropriate. It is noted that the average lifetime cancer risk of the general American population is estimated as about 300,000 in 1,000,000.

Table 2-6

COC Cancer Risk and Noncancer Hazard Index: Child Venison Consumer
TNT Area C
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure-Point Concentration (mg/kg)	Venison Consumption HQ	Venison Consumption ILCR
Metals			
Lead	9.34E+02	NA	NA
Nitroaromatics			
2-Amino-4,6-dinitrotoluene	3.80E+01	NA	NA
4-Amino-2,6-dinitrotoluene	1.13E+01	NA	NA
2,4,6-Trinitrotoluene	4.13E+04	NA	NA
PCBs			
Aroclor 1260	4.88E+00	NA	4.18E-08
Semivolatile Organic Compounds			
2,4-Dinitrotoluene	9.85E+00	NA	NA
2,6-Dinitrotoluene	9.52E+00	NA	NA
Benzo(a)anthracene	6.94E+00	NA	7.19E-09
Benzo(a)pyrene	6.33E+00	NA	1.07E-07
Benzo(b)fluoranthene	8.43E+00	NA	1.36E-08
Dibenz(a,h)anthracene	1.03E+00	NA	3.36E-08
Indeno(1,2,3-cd)pyrene	2.05E+00	NA	5.18E-09
Total HI		**NA**	
Total ILCR			**2E-07**

Note: Exposure based on ingestion of venison from deer that grazed on vegetation grown in TNT C surface soil.
COC = Chemical of concern.
HQ = Hazard quotient.
HI = Hazard index; sum of the HQ values.
ILCR = Incremental lifetime cancer risk.
mg/kg = Milligrams per kilogram.
NA = Not applicable.
PCB = Polychlorinated biphenyl.
1) HI values equal to or less than 1 are unlikely to result in adverse noncancer human health effects for any member of the exposed population and are regarded as acceptable.
2) ILCR values equal to or less than 1E-5 (1 in 100,000) are generally regarded by the Ohio Environmental Protection Agency as acceptable. Risks less than 1E-6 are regarded as very minimal, and risks greater than 1E-5 further study if appropriate.
It is noted that the average lifetime cancer risk of the general American population is estimated as about 300,000 in 1,000,000.

Table 2-7

COC Cancer Risk and Noncancer Hazard Index: Construction Worker Exposure to Total Soil
TNT Area C
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure-Point Concentration (mg/kg)	Oral HQ	Oral ILCR	Dermal HQ	Inhalation ILCR	Total HI All Pathways	Total ILCR All Pathways
Metals							
Lead	9.34E+02	NA	NA	NA	NA	NA	NA
Nitroaromatics							
2-Amino-4,6-dinitrotoluene	3.80E+01	1.79E+00	NA	9.31E-01	NA	2.72E+00	NA
4-Amino-2,6-dinitrotoluene	1.13E+01	5.32E-01	NA	2.76E-01	NA	8.08E-01	NA
2,4,6-Trinitrotoluene	4.13E+04	2.34E+02	2.51E-05	1.21E+02	NA	3.55E+02	3.81E-05
PCBs							
Aroclor 1254	7.45E-01	1.05E-01	3.02E-08	2.19E-02	7.29E-10	1.27E-01	3.66E-08
Aroclor 1260	4.88E+00	NA	1.98E-07	NA	4.77E-09	NA	2.39E-07
Semivolatile Organic Compounds							
2,4-Dinitrotoluene	2.75E+02	3.89E-01	3.79E-06	1.21E-01	NA	5.10E-01	4.97E-06
2,6-Dinitrotoluene	1.94E+01	5.48E-02	2.67E-07	1.71E-02	NA	7.19E-02	3.50E-07
Benzo(a)anthracene	6.94E+00	NA	1.03E-07	NA	1.05E-09	NA	1.68E-07
Benzo(a)pyrene	6.33E+00	NA	9.37E-07	NA	9.60E-09	NA	1.53E-06
Benzo(b)fluoranthene	8.43E+00	NA	1.25E-07	NA	1.28E-09	NA	2.04E-07
Dibenz(a,h)anthracene	1.40E+00	NA	2.07E-07	NA	2.12E-09	NA	2.90E-07
Indeno(1,2,3-cd)pyrene	2.05E+00	NA	3.03E-08	NA	3.10E-10	NA	4.94E-08
Total HI		**236**		**123**		**359**	
Total ILCR			**3.08E-05**		**1.99E-08**		**5E-05**

COC = Chemical of concern.
HQ = Hazard quotient.
HI = Hazard index; sum of the HQ values.
ILCR = Incremental lifetime cancer risk
NA = not applicable
PCB = Polychlorinated biphenyl.
1) HI values equal to or less than 1 are unlikely to result in adverse noncancer human health effects for any member of the exposed population and are regarded as acceptable.
2) ILCR values equal to or less than 1E-5 (1 in 100,000) are generally regarded by the Ohio Environmental Protection Agency as acceptable. Risks less than 1E-6 are regarded as very minimal, and risks greater than 1E-5 further study if appropriate.
It is noted that the average lifetime cancer risk of the general American population is estimated as about 300,000 in 1,000,000.

Table 2-8

COC Cancer Risk and Noncancer Hazard Index: On-Site Resident Exposure to Total Soil
TNT Area C
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure-Point Concentration (mg/kg)	Oral HQ	Oral ILCR	Dermal HQ	Dermal ILCR	Inhalation HQ	Inhalation ILCR	**Total HI All Pathways**	**Total ILCR All Pathways**
Metals									
Lead	9.34E+02	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Nitroaromatics									
2-Amino-4,6-dinitrotoluene	3.80E+01	7.29E+00	NA	2.13E+00	NA	NA	NA	**9.41E+00**	**NA**
4-Amino-2,6-dinitrotoluene	1.13E+01	2.16E+00	NA	6.30E-01	NA	NA	NA	**2.79E+00**	**NA**
2,4,6-Trinitrotoluene	4.13E+04	9.50E+02	1.74E-03	2.77E+02	1.15E-03	NA	NA	**1.23E+03**	**2.89E-03**
PCBs									
Aroclor 1254	7.45E-01	4.29E-01	2.10E-06	5.00E-02	4.98E-07	NA	1.42E-10	**4.79E-01**	**2.60E-06**
Aroclor 1260	4.88E+00	NA	1.37E-05	NA	3.26E-06	NA	9.29E-10	**NA**	**1.70E-05**
Semivolatile Organic Compounds									
2,4-Dinitrotoluene	2.75E+02	1.58E+00	2.63E-04	2.77E-01	1.04E-04	NA	NA	**1.86E+00**	**3.68E-04**
2,6-Dinitrotoluene	1.94E+01	2.23E-01	1.86E-05	3.90E-02	7.34E-06	NA	NA	**2.62E-01**	**2.59E-05**
Benzo(a)anthracene	6.94E+00	NA	7.14E-06	NA	5.65E-06	NA	2.05E-10	**NA**	**1.28E-05**
Benzo(a)pyrene	6.33E+00	NA	6.51E-05	NA	5.15E-05	NA	1.87E-09	**NA**	**1.17E-04**
Benzo(b)fluoranthene	8.43E+00	NA	8.67E-06	NA	6.86E-06	NA	2.49E-10	**NA**	**1.55E-05**
Dibenz(a,h)anthracene	1.40E+00	NA	1.44E-05	NA	7.12E-06	NA	4.13E-10	**NA**	**2.15E-05**
Indeno(1,2,3-cd)pyrene	2.05E+00	NA	2.10E-06	NA	1.66E-06	NA	6.04E-11	**NA**	**3.77E-06**
Total ILCR		**961**	**2.14E-03**	**280**	**1.34E-03**	**NA**	**3.87E-09**	**1241**	**3E-03**

COC = Chemical of concern.
HQ = Hazard quotient.
HI = Hazard index; sum of the HQ values.
ILCR = Incremental lifetime cancer risk
NA = not applicable
PCB = Polychlorinated biphenyl.
1) HI values equal to or less than 1 are unlikely to result in adverse noncancer human health effects for any member of the exposed population and are regarded as acceptable.
2) ILCR values equal to or less than 1E-5 (1 in 100,000) are generally regarded by the Ohio Environmental Protection Agency as acceptable. Risks less than 1E-6 are regarded as very minimal, and risks greater than 1E-5 further study if appropriate. It is noted that the average lifetime cancer risk of the general American population is estimated as about 300,000 in 1,000,000.

Table 2-9

COC Cancer Risk and Noncancer Hazard Index: Construction Worker Exposure to Sediment
TNT Area C
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure-Point Concentration (mg/kg)	Oral HQ	Oral ILCR	Dermal HQ	Dermal ILCR	**Total HI All Pathways**	**Total ILCR All Pathways**
Nitroaromatics							
2-Amino-4,6-dinitrotoluene	1.12E+01	5.28E-01	NA	2.26E-01	NA	**7.54E-01**	**NA**
4-Amino-2,6-dinitrotoluene	1.28E+01	6.04E-01	NA	2.58E-01	NA	**8.62E-01**	**NA**
2,4,6-Trinitrotoluene	1.50E+03	8.47E+00	9.10E-07	3.62E+00	3.89E-07	**1.21E+01**	**1.30E-06**
Total HI		**9.60**		**4.10**		**14**	
Total ILCR			**9.10E-07**		**3.89E-07**		**1E-06**

COC = Chemical of concern.
HQ = Hazard quotient.
ILCR = Incremental lifetime cancer risk
mg/kg = Milligrams per kilogram.
NA = Not applicable
1) HI values equal to or less than 1 are unlikely to result in adverse noncancer human health effects for any member of the exposed population and are regarded as acceptable.
2) ILCR values equal to or less than 1E-5 (1 in 100,000) are generally regarded by the Ohio Environmental Protection Agency as acceptable. Risks less than 1E-6 are regarded as very minimal, and risks greater than 1E-5 further study if appropriate. It is noted that the average lifetime cancer risk of the general American population is estimated as about 300,000 in 1,000,000.

Table 2-10

COC Cancer Risk and Noncancer Hazard Index: On-Site Resident Exposure to Sediment
TNT Area C
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure-Point Concentration (mg/kg)	On-Site Resident Oral HQ	On-Site Resident Oral ILCR	On-Site Resident Dermal HQ	On-Site Resident Dermal ILCR	**On-Site Resident Total All Pathways HI**	**On-Site Resident Total All Pathways ILCR**
Nitroaromatics							
2-Amino-4,6-dinitrotoluene	1.12E+01	2.39E-01	NA	6.96E-02	ND	**3.08E-01**	**NA**
4-Amino-2,6-dinitrotoluene	1.28E+01	2.73E-01	NA	7.96E-02	ND	**3.52E-01**	**NA**
2,4,6-Trinitrotoluene	1.50E+03	3.83E+00	7.03E-06	1.12E+00	4.63E-06	**4.94E+00**	**1.17E-05**
Total ILCR		**4.34**	**7.03E-06**	**1.26**	**4.63E-06**	**6**	**1E-05**

COC = Chemical of concern.
HI = Hazard index; sume of HQ values.
HQ = Hazard quotient.
ILCR = Incremental lifetime cancer risk
mg/kg = Milligrams per kilogram.
NA = Not applicable
ND = Not determined.
1) HI values equal to or less than 1 are unlikely to result in adverse noncancer human health effects for any member of the exposed population and are regarded as acceptable.
2) ILCR values equal to or less than 1E-5 (1 in 100,000) are generally regarded by the Ohio Environmental Protection Agency as acceptable. Risks less than 1E-6 are regarded as very minimal, and risks greater than 1E-5 further study if appropriate. It is noted that the average lifetime cancer risk of the general American population is estimated as about 300,000 in 1,000,000.

Table 2-11

Summary of Total Hazard Index and Total Cancer Risk from Site-Related Chemicals of Potential Concern
TNT Area C
Plum Brook Ordnance Works, Sandusky, Ohio

	Groundskeeper		Indoor Worker		Adult Hunter		Construction Worker		On-Site Resident	
Contaminant Source	Total HI[a]	Total ILCR[b]	Total HI	Total ILCR	Total HI	Total ILCR	Total HI	Total ILCR	Total HI	Total ILCR
Surface Soil	95.4	5.43E-04	40.8	2.32E-04	4.88	3.39E-05	NA	NA	NA	NA
Total Soil[c]	NA[d]	NA	NA	NA	NA	NA	360	5.01E-05	1241	3.48E-03
Surface Water[e]	NA	NA	NA	NA	NA	NA	0.2	1.77E-08	0.08	3.38E-07
Sediment[e]	NA	NA	NA	NA	NA	NA	14	1.36E-06	6	1.22E-05
Total across all media	**95**	**5E-04**	**41**	**2E-04**	**5**	**3E-05**	**374**	**5E-05**	**1247**	**3E-03**

[a]The hazard index (HI) is a measure of noncancer hazard for an exposed individual.
[b]The incremental lifetime cancer risk (ILCR) is the estimated extra cancer risk which an individual encounters based on exposure to a site.
[c]Total soil is combined surface and subsurface soil.
[d]NA = Not applicable.
[e]The surface water and sediment were screened out, indicating minimal risk.
Notes:
1) HI values equal to or less than 1 are unlikely to result in adverse noncancer human health effects for any member of the exposed population and are regarded as acceptable.
2) ILCR values equal to or less than 1E-5 (1 in 100,000) are generally regarded by the Ohio Environmental Protection Agency as acceptable. The U.S. Environmental Protection Agency (1990) National Oil and Hazardous Substances Pollution Contingency Plan under CERCLA (NCP) (40CFR300.430) states that cancer risks between 1E-6 and 1E-4 are generally regarded as acceptable. Risks less than 1E-6 are regarded as very minimal, and risks greater than 1E-5 further study if appropriate. It is noted that the average lifetime cancer risk of the general American population is estimated as about 300,000 in 1,000,000.
3) Shading indicates an unacceptable HI or ILCR value.
4) A child venison consumer was also evaluated for TNT Area C. Cancer risks (less than 1E-6) and potential noncancer hazards (less than 0.1) for this receptor were found to be very minimal.

Table 2-12

Statistical Summary of COPECs in Surface Soil
TNT Area C
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical Name (mg/kg)	Frequency of Detection	Range of Detections	Range of Detection Limits	Statistical Distribution	Arithmetic Mean	95% UCL[b]	Background Screening Criterion[c]	Ecological Screening Criterion[d]	COPEC?[e,f]	Source Term Concentration[g]
Inorganics										
Calcium	17 - 17	2590 - 55100	NA	L	2.33E+04	4.28E+04	5.23E+04	NA	Y(b)	4.28E+04
Copper	17 - 17	3.73 - 99.8	NA	L	2.40E+01	4.34E+01	5.62E+01	6.00E+01	Y(a)(b)	4.34E+01
Lead	17 - 17	8.07 - 934	NA	L	2.42E+02	1.35E+03	4.86E+01	4.05E+01	Y(a)(b)	9.34E+02
Magnesium	17 - 17	1040 - 13200	NA	L	4.38E+03	7.10E+03	1.04E+04	NA	Y(a)(b)	7.10E+03
Manganese	17 - 17	63.7 - 3800	NA	L	6.24E+02	1.37E+03	3.51E+03	1.00E+02	Y(a)(b)	1.37E+03
Mercury (Inorganic)	15 - 17	0.021 - 0.39	0.037 - 0.037	L	1.00E-01	1.98E-01	8.50E-02	5.10E-04	Y(a)(b)	1.98E-01
Nitroaromatics										
1,3,5-Trinitrobenzene	11 - 17	0.153 - 7.93	0.08 - 0.1	L	1.77E+00	2.74E+01		3.76E-01	Y(a)	7.93E+00
1,3-Dinitrobenzene	6 - 17	0.078 - 0.751	0.08 - 0.1	U	1.29E-01	7.51E-01		6.56E-01	Y(a)	7.51E-01
2,4,6-Trinitrotoluene	17 - 17	0.198 - 41261	NA	L	3.12E+03	5.15E+07		NA	Y(a)	4.13E+04
2,4-Dinitrotoluene	12 - 17	0.06 - 10.6	0.377 - 3.91	L	2.23E+00	1.23E+01		1.28E+00	Y(a)	1.06E+01
2,6-Dinitrotoluene	7 - 17	0.062 - 10.7	0.372 - 4.37	L	1.82E+00	6.95E+00		3.30E-02	Y(a)	6.95E+00
2-Amino-4,6-Dinitrotoluene	15 - 17	0.071 - 38	0.0917 - 0.0952	L	7.19E+00	1.92E+02		NA	Y(a)	3.80E+01
3-Nitrotoluene	4 - 17	0.271 - 1.71	0.16 - 0.2	U	2.84E-01	1.71E+00		NA	Y(a)	1.71E+00
4-Amino-2,6-Dinitrotoluene	14 - 17	0.088 - 14.6	0.0917 - 0.1	N	4.42E+00	6.34E+00		NA	Y(a)	6.34E+00
Dinitrotoluene[h]	10 - 17	0.288 - 16.7	0.0909 - 0.1	L	2.43E+00	4.91E+01		6.50E-01	Y(a)	1.67E+01
Tetryl	1 - 17	0.626 - 0.626	0.16 - 0.2	U	1.27E-01	6.26E-01		NA	Y(a)	6.26E-01
PCBs										
Aroclor 1260	16 - 17	0.024 - 4.875	0.0807 - 0.0807	L	8.33E-01	4.71E+00		3.71E-01	Y(a)	4.71E+00
Semivolatile Organics										
Benzo(a)anthracene	7 - 17	0.05 - 6.94	0.368 - 4.105	L	1.32E+00	6.64E+00		5.21E+00	Y(a)	6.64E+00
Benzo(a)pyrene	7 - 17	0.045 - 6.33	0.368 - 4.105	L	1.28E+00	6.52E+00		1.52E+00	Y(a)	6.33E+00
Chrysene	6 - 17	0.066 - 6.28	0.368 - 4.105	L	1.26E+00	4.60E+00		4.73E+00	Y(a)	4.60E+00

COPEC - Chemical of Potential Ecological Concern; UCL - Upper Confidence Limit.
mg/kg - milligram per kilogram.
Surface soil is defined by samples taken from 0-2 feet below ground surface. These include two samples from 1.5 - 2.5 and one sample from 1.3 to 2.3 feet below ground surface.

[a] L - Data are found to have lognormal distribution; N - Data are found to have normal distribution; U - Data are found to be nonparametric distribution.
[b] Calculated based on statistical distribution indicated in Section 2.2.2 of the Ecological Risk Assessment (ERA).
[c] Background data for constituents in soil as presented in Table 2-9 of the ERA.
[d] Ecological screening criteria for constituents in soil as presented in Appendix C of the ERA.
[e] N = Chemical is not chosen as a COPEC:
(a) = Maximum detection is less than the Ecological Screening Criterion.
(b) = Maximum detection is less than the Background Screening Criterion.
[f] Y = Chemical is chosen as a COPEC:
(a) = Maximum detection is greater than the Ecological Screening Criterion or no screening criteria is available.
(b) = Maximum detection is greater than the Background Screening Criterion.
[g] Source term concentration represents the minimum of the MDC or the 95% UCL.
[h] Data for 2,4-Dinitrotoluene and 2,6-Dinitrotoluene utilized for assessment since the total of the source term concentrations is greater than the source term concentration of total dinitrotoluene.

Table 2-13

Statistical Summary of COPECs in Total Soil
TNT Area C
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical Name (mg/kg)	Frequency of Detection	Range of Detections	Range of Detection Limits	Statistical Distribution[a]	Arithmetic Mean	95% UCL[b]	Background Screening Criterion[c]	Ecological Screening Criterion[d]	COPEC?[e,f]	Source Term Concentration[g]
Inorganics										
Calcium	31 - 31	1410 - 252000	NA	L	3.05E+04	5.79E+04	5.23E+04	NA	Y(b)	5.79E+04
Chromium	31 - 31	3.71 - 202	NA	U	1.58E+01	1.00E+01	2.90E+01	4.00E-01	Y(a)(b)	1.00E+01
Copper	31 - 31	1.36 - 99.8	NA	L	1.91E+01	3.00E+01	5.62E+01	6.00E+01	Y(a)(b)	3.00E+01
Lead	31 - 31	6.03 - 934	NA	L	1.84E+02	5.78E+02	4.86E+01	4.05E+01	Y(a)(b)	5.78E+02
Magnesium	31 - 31	422 - 18700	NA	L	4.53E+03	7.07E+03	1.04E+04	NA	Y(b)	7.07E+03
Manganese	31 - 31	33.7 - 3800	NA	L	5.27E+02	8.51E+02	3.51E+03	1.00E+02	Y(a)(b)	8.51E+02
Mercury (Inorganic)	27 - 31	0.019 - 0.39	0.036 - 0.038	L	7.69E-02	1.08E-01	8.50E-02	5.10E-04	Y(a)(b)	1.08E-01
Nickel	31 - 31	3.72 - 90.8	NA	L	1.49E+01	1.88E+01	5.51E+01	3.00E+01	Y(a)(b)	1.88E+01
Sodium	31 - 31	78.2 - 403	NA	L	1.93E+02	2.16E+02	NA	NA	Y(a)(b)	2.16E+02
Zinc	31 - 31	5.8 - 708	NA	L	1.22E+02	1.99E+02	3.22E+02	8.50E+00	Y(a)(b)	1.99E+02
Nitroaromatics										
1,3,5-Trinitrobenzene	16 - 31	0.0616 - 7.93	0.08 - 0.1	U	1.04E+00	4.08E-01		3.76E-01	Y(a)	4.08E-01
1,3-Dinitrobenzene	6 - 31	0.0778 - 0.751	0.08 - 0.1	U	9.28E-02	1.00E-01		6.56E-01	Y(a)	1.00E-01
2,4,6-Trinitrotoluene	31 - 31	0.0622 - 41261	NA	L	1.81E+03	1.58E+06		NA	Y(a)	4.13E+04
2,4-Dinitrotoluene	21 - 31	0.0493 - 275	0.374 - 3.91	L	1.16E+01	2.02E+01		1.28E+00	Y(a)	2.02E+01
2,6-Dinitrotoluene	11 - 31	0.0616 - 23.8	0.372 - 4.37	U	2.12E+00	4.45E-01		3.30E-02	Y(a)	4.45E-01
2-Amino-4,6-dinitrotoluene	25 - 31	0.0712 - 38	0.087 - 0.1	L	4.51E+00	4.71E+01		NA	Y(a)	3.80E+01
2-Nitrotoluene	4 - 31	0.921 - 3.27	0.16 - 0.2	U	3.48E-01	2.00E-01		NA	Y(a)	2.00E-01
3-Nitrotoluene	8 - 31	0.263 - 4.82	0.16 - 0.2	U	3.76E-01	2.00E-01		NA	Y(a)	2.00E-01
4-Amino-2,6-dinitrotoluene	24 - 31	0.0876 - 14.6	0.092 - 0.1	L	2.77E+00	1.94E+01		NA	Y(a)	1.46E+01
4-Nitrotoluene	3 - 31	1.18 - 2.86	0.16 - 0.2	U	2.82E-01	2.00E-01		NA	Y(a)	2.00E-01
Dinitrotoluene, total[h]	20 - 31	0.0855 - 236	0.087 - 0.1	U	1.45E+01	7.77E-01		6.50E-01	Y(a)	7.77E-01
Tetryl	1 - 31	0.626 - 0.626	0.16 - 0.2	U	1.14E-01	2.00E-01		NA	Y(a)	2.00E-01
PCBs										
Aroclor 1260	28 - 31	0.0095 - 4.875	0.075 - 0.081	L	5.65E-01	1.71E+00		3.71E-01	Y(a)	1.71E+00
Semivolatile Organics										
Benzo(a)anthracene	12 - 31	0.0384 - 11.1	0.368 - 7.66	L	1.33E+00	3.35E+00		5.21E+00	Y(a)	3.35E+00
Benzo(a)pyrene	12 - 31	0.0361 - 8.2	0.368 - 7.66	L	1.21E+00	3.32E+00		1.52E+00	Y(a)	3.32E+00
Chrysene	10 - 31	0.0535 - 8.74	0.368 - 7.66	U	1.23E+00	6.32E-01		4.73E+00	Y(a)	6.32E-01

Table 2-13

Statistical Summary of COPECs in Total Soil
TNT Area C
Plum Brook Ordnance Works, Sandusky, Ohio

COPEC - Chemical of Potential Ecological Concern; UCL - Upper Confidence Limit.
mg/kg - milligram per kilogram.
Total soil is defined by samples taken from 0-6 feet below ground surface.

[a] L - Data are found to have lognormal distribution; N - Data are found to have normal distribution; U - Data are found to be nonparametric distribution.
[b] Calculated based on statistical distribution indicated in Section 2.2.2 of the Ecological Risk Assessment (ERA).
[c] Background data for constituents in soil as presented in Table 2-9 of the ERA.
[d] Ecological screening criteria for constituents in soil as presented in Appendix C of the ERA.
[e] N = Chemical is not chosen as a COPEC:
(a) = Maximum detection is less than the Ecological Screening Criterion.
(b) = Maximum detection is less than the Background Screening Criterion.
(c) = Frequency of detection is less than 5%.
[f] Y = Chemical is chosen as a COPEC:
(a) = Maximum detection is greater than the Ecological Screening Criterion or no screening criteria is available.
(b) = Maximum detection is greater than the Background Screening Criterion.
[g] Source term concentration represents the minimum of the MDC or the 95% UCL
[h] Data for 2,4-Dinitrotoluene and 2,6-Dinitrotoluene utilized for assessment since the total of the source term concentrations is greater than the source term concentration of total dinitrotoluene.

Table 2-14

Statistical Summary of COPECs in Surface Water
TNT Area C
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical Name (mg/L)	Frequency of Detection	Range of Detections	Range of Detection Limits	Statistical Distribution	Arithmetic Mean	95% UCL[a]	Ecological Screening Criterion[b]	COPEC?[c,d]	Source Term Concentration[e]
Inorganics									
Aluminum	10 - 10	0.152 - 3.83	NA	L	9.59E-01	3.22E+00	8.70E-02	Y	3.22E+00
Barium	10 - 10	0.028 - 0.125	NA	L	5.66E-02	8.27E-02	4.00E-03	Y	8.27E-02
Cadmium	2 - 10	0.00212 - 0.00519	0.003 - 0.003	U	1.93E-03	5.19E-03	6.60E-04	Y	5.19E-03
Calcium	10 - 10	99.7 - 235	NA	N	1.68E+02	1.93E+02	NA	Y	1.93E+02
Copper	7 - 10	0.00129 - 0.00581	0.005 - 0.005	L	2.67E-03	3.68E-03	5.00E-03	Y	3.68E-03
Iron	10 - 10	0.2315 - 15.3	NA	L	3.40E+00	2.40E+01	1.00E+00	Y	1.53E+01
Lead	5 - 10	0.00162 - 0.00689	0.003 - 0.003	U	2.66E-03	6.89E-03	1.30E-03	Y	6.89E-03
Magnesium	10 - 10	25.6 - 51.7	NA	N	3.61E+01	4.12E+01	NA	Y	4.12E+01
Manganese	10 - 10	0.06095 - 3.01	NA	L	7.80E-01	4.73E+00	1.20E-01	Y	3.01E+00
Potassium	10 - 10	0.967 - 3.1	NA	L	1.99E+00	2.55E+00	NA	Y	2.55E+00
Selenium	3 - 10	0.00278 - 0.00311	0.005 - 0.005	U	2.65E-03	3.11E-03	3.90E-04	Y	3.11E-03
Sodium	10 - 10	1.35 - 5.48	NA	N	3.94E+00	4.86E+00	NA	Y	4.86E+00
Nitroaromatics									
2,4,6-Trinitrotoluene	1 - 10	0.00034 - 0.00034	0.00026 - 0.00026	U	1.51E-04	3.44E-04	NA	Y	3.44E-04
2-Amino-4,6-Dinitrotoluene	1 - 10	0.00098 - 0.00098	0.00026 - 0.00026	U	2.15E-04	9.84E-04	NA	Y	9.84E-04
2-Nitrotoluene	1 - 10	0.0104 - 0.0104	0.00052 - 0.00052	U	1.27E-03	1.04E-02	NA	Y	1.04E-02
3-Nitrotoluene	1 - 10	0.00147 - 0.00147	0.00052 - 0.00052	U	3.81E-04	1.47E-03	NA	Y	1.47E-03
4-Nitrotoluene	1 - 10	0.0043 - 0.0043	0.00052 - 0.00052	U	6.64E-04	4.30E-03	NA	Y	4.30E-03
4-Amino-2,6-Dinitrotoluene	2 - 10	0.00033 - 0.00055	0.00026 - 0.00026	U	1.92E-04	5.49E-04	NA	Y	5.49E-04
Dinitrotoluene	2 - 10	0.00097 - 0.00792	0.00026 - 0.00026	U	9.93E-04	7.92E-03	NA	Y	7.92E-03
Semivolatile Organics									
Di-n-butyl phthalate	1 - 10	0.00525 - 0.00525	0.01025 - 0.012	L	5.45E-03	5.64E-03	1.00E-03	Y	5.25E-03
Volatile Organics									
Carbon disulfide	10 - 10	0.0011 - 0.0231	NA	L	8.11E-03	2.51E-02	9.20E-04	Y	2.31E-02

COPEC - Chemical of Potential Ecological Concern; UCL - Upper Confidence Limit.
L - Data are found to have lognormal distribution; N - Data are found to have normal distribution; U - Data are found to be nonparametric distribution.
mg/kg - milligram per kilogram.

[a] Calculated based on statistical distribution indicated in Section 2.2.2 of the Ecological Risk Assessment (ERA).
[b] Ecological screening criteria for surface water as presented in Appendix C of the ERA.
[c] N = Chemical is not chosen as a COPEC: Maximum detected concentration does not exceed screening criterion.
[d] Y = Chemical is chosen as a COPEC: Maximum detected concentration exceeds screening criterion or no screening criteria is available.
[e] Source term concentration represents the minimum of the MDC or the 95% UCL.

Table 2-15

Statistical Summary of COPECs in Sediment
TNT Area C
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical Name (mg/kg)	Frequency of Detection	Range of Detections	Range of Detection Limits	Statistical Distribution	Arithmetic Mean	95% UCL[a]	Background Screening Criterion[b]	Ecological Screening Criterion[c]	COPEC?[d,e]	Source Term Concentration[f]
Inorganics										
Aluminum	15 - 15	1200 - 15600	NA	L	6.52E+03	1.10E+04	1.55E+04	NA	Y(a)(b)	1.10E+04
Cadmium	15 - 15	0.144 - 1.24	NA	N	5.88E-01	7.25E-01	NA	5.96E-01	Y(a)	7.25E-01
Calcium	15 - 15	1320 - 182000	NA	L	2.75E+04	1.06E+05	5.23E+04	NA	Y(a)(b)	1.06E+05
Lead	15 - 15	2.83 - 86.3	NA	L	2.62E+01	4.88E+01	4.86E+01	3.10E+01	Y(a)(b)	4.88E+01
Selenium	11 - 15	0.904 - 2.47	1.19 - 1.31	L	1.32E+00	1.77E+00	2.00E+00	NA	Y(a)(b)	1.77E+00
Sodium	15 - 15	164 - 272	NA	L	2.07E+02	2.23E+02	NA	NA	Y(a)	2.23E+02
Nitroaromatics										
1,3,5-Trinitrobenzene	1 - 15	0.832 - 0.832	0.0833 - 0.1	U	1.00E-01	8.32E-01		1.21E-04	Y(a)	8.32E-01
2,4,6-Trinitrotoluene	8 - 15	0.0715 - 1496	0.0833 - 0.1	U	1.00E+02	1.50E+03		NA	Y(a)	1.50E+03
2,4-Dinitrotoluene	3 - 15	0.0884 - 0.276	0.42 - 0.568	N	2.19E-01	2.42E-01		7.51E-02	Y(a)	2.42E-01
2,6-Dinitrotoluene	1 - 15	0.183 - 0.183	0.385 - 0.568	L	2.25E-01	2.38E-01		2.06E-02	Y(a)	1.83E-01
2-Amino-4,6-Dinitrotoluene	4 - 15	0.214 - 12.8	0.0833 - 0.1	U	1.14E+00	1.28E+01		NA	Y(a)	1.28E+01
4-Amino-2,6-Dinitrotoluene	4 - 15	0.126 - 11.2	0.0833 - 0.1	U	9.97E-01	1.12E+01		NA	Y(a)	1.12E+01
RDX (Cyclonite)	1 - 15	0.521 - 0.521	0.167 - 0.2	U	1.25E-01	5.21E-01		NA	Y(a)	5.21E-01
Dinitrotoluene[g]	7 - 15	0.102 - 0.414	0.0833 - 0.1	U	1.23E-01	4.14E-01		NA	Y(a)	4.14E-01
PCBs										
Aroclor 1260	8 - 15	0.0292 - 0.769	0.084 - 0.115	U	1.88E-01	7.69E-01		3.41E-02	Y(a)	7.69E-01
Semivolatile Organics										
Benzo(a)anthracene	2 - 15	0.0693 - 0.0947	0.385 - 0.548	U	2.05E-01	9.47E-02		3.17E-02	Y(a)	9.47E-02
Benzo(a)pyrene	3 - 15	0.0324 - 0.0699	0.42 - 0.548	U	1.92E-01	6.99E-02		3.19E-02	Y(a)	6.99E-02
Chrysene	1 - 15	0.0737 - 0.0737	0.385 - 0.568	U	2.18E-01	7.37E-02		5.71E-02	Y(a)	7.37E-02
Di-n-butyl phthalate	1 - 15	0.0702 - 0.0702	0.385 - 0.568	U	2.16E-01	7.02E-02		1.00E-03	Y(a)	7.02E-02
Fluoranthene	1 - 15	0.147 - 0.147	0.385 - 0.548	N	2.18E-01	2.30E-01		1.11E-01	Y(a)	1.47E-01
Pyrene	1 - 15	0.11 - 0.11	0.385 - 0.568	N	2.20E-01	2.38E-01		5.30E-02	Y(a)	1.10E-01

COPEC - Chemical of Potential Ecological Concern; UCL - Upper Confidence Limit.

L - Data are found to have lognormal distribution; N - Data are found to have normal distribution; U - Data are found to be nonparametric distribution.

mg/kg - milligram per kilogram.

[a] Calculated based on statistical distribution indicated ub Section 2.2.2 of the Ecological Risk Assessment (ERA).

[b] Background data for constituents in soil as presented in Table 2-9 of the ERA.

[c] Ecological screening criteria for sediment as presented in Appendix C of the ERA.

[d] N = Chemical is not chosen as a COPEC: Maximum detected concentration does not exceed screening criterion.

(a) = Maximum detection is less than the Ecological Screening Criterion.

(b) = Maximum detection is less than the Background Screening Criterion.

[e] Y = Chemical is chosen as a COPEC: Maximum detected concentration exceeds screening criterion or no screening criteria is available.

(a) = Maximum detection is greater than the Ecological Screening Criterion or no screening criteria is available.

(b) = Maximum detection is greater than the Background Screening Criterion.

[f] Source term concentration represents the minimum of the MDC or the 95% UCL.

[g] Data for 2,4-Dinitrotoluene and 2,6-Dinitrotoluene utilized for assessment since the total of the source term concentrations is greater than the source term concentration of total dinitrotoluene.

Table 2-16

Terrestrial Plant Soil Benchmark Exceedances
TNT Area C
Plum Brook Ordnance Works, Sandusky, Ohio

Constituent	Source-Term Surface Soil Concentration[a] (mg/kg)	Benchmark Concentration for Plants (mg/kg)	Benchmark Exceeded?
Organics			
2,4,6-Trinitrotoluene	41,261	30[b]	Yes
Inorganics			
Lead	934	50[c]	Yes
Manganese	1,370	500[c]	Yes
Zinc	321	50[c]	Yes

[a] 95 percent upper confidence limit concentrations presented for COPECs in Table 2-10 of the Ecological Risk Assessment (ERA).

[b] Source: Talmage, S. S. et. al., 1999, "Nitroaromatic Munition Compounds: Environmental effects and Screening Values," ***Toxicology,*** Volume 161, pp. 1-156.

[c] Source: Efroymson, R. A., G. W. Suter II, Wooten, A. C., and W. E. Will, 1997c, ***Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants, 1997 Revision***, Oak Ridge National Laboratory. Report No. ES/ER/TM-85/R3.

Table 2-17

Aquatic Biota Surface Water Benchmark Exceedances
TNT Area C
Plum Brook Ordnance Works, Sandusky, Ohio

Constituent	Source-Term Concentration (µg/L) [a]	NAWQ [b] (µg/L)	Tier II [c] (µg/L)	State of Ohio [d] (µg/L)	Other [e] (µg/L)	Benchmark Exceeded?
Organics						
Carbon disulfide	23.1	NA	8.89	NA	244 *	Yes (1/2)
Inorganics						
Aluminum	3,220	87	NA	NA	1,900 *	Yes (2/2)
Barium	82.7	NA	3.8	NA	5,800 *	Yes (1/2)
Cadmium (hardness dependent)	5.19	3.4	NA	7.3	0.15 *	Yes (2/3)
Calcium	193,000	NA	NA	NA	116,000 *	Yes (1/1
Copper (hardness dependent)	3.68	38	NA	30	0.23 *	Yes (1/3)
Iron	15,300	1,000	NA	NA	158 *	Yes (2/2)
Manganese	3,010	1,500 #	80.3	NA	< 1,100 *	Yes (3/3)

[a] COPECs and UCL concentrations from Table 2-12 of the Ecological Risk Assessment..
[b] National Ambient Water Quality (NAWQ) criteria for chronic exposure (federal) from 40 CFR 131.36, Quality Criteria for Water (Red Book) (EPA, 1976), and EPA Health and Ecological Criteria Division recommendations (1997). Hardness of 400 mg/L assumed. Lowest effect concentration (LEC) values (that are not criteria) are indicated with "#."
[c] Values calculated using Great Lakes Water Quality Initiative Tier II methodology, as summarized in Eco Update (EPA, 1996b) and Suter and Mabrey (1994).
[d] Ohio Water Quality Criteria for the protection of aquatic life (Lake Erie Basin; Title 3745-1-33, assuming a hardness of 400 mg/L $CaCO_3$).
[e] Other references include the following:
- * indicates that the value is chronic LEC, or estimated lowest chronic value for daphnids and fish from Suter and Mabrey (1994).
- ** indicates that the value is a LOEC from Talmage, et. al. (1999).

[f] Number of benchmarks exceeded/number of benchmarks available shown in parentheses.

Notes:
1) Water hardness measurements ranged from 372 to 592 mg/L at West Area Red Water Ponds and from 284 to 488 mg/L at Pentolite Road Red Water Ponds (IT, 2000). These values were assumed to be representative of TNT Area C.
2) NA = Not Available.
3) Hardness dependent criteria calculated for total water body concentration, not dissolved fraction, using average hardness of approximately 400 mg/L $CaCO_3$.

Table 2-17

Aquatic Biota Surface Water Benchmark Exceedances
TNT Area C
Plum Brook Ordnance Works, Sandusky, Ohio

Sources: Suter, G.W., II and J.B. Mabrey, 1994, ***Toxicological Benchmarks for Screening of Potential Contaminants of Concern for Effects on Aquatic Biota***, 1994 revision, DE-AC05-840R21400, Office of Environmental Restoration and Waste Management, U.S. Department of Energy, Washington, D.C.

U.S. Environmental Protection Agency, 1997, ***National Recommended Water Quality Criteria***, Office of Water, Washington, D.C.

U.S. Environmental Protection Agency, 1996, ***ECO Update: Ecotox Thresholds***, Office of Emergency and Remedial Response, EPA/540/F-95/038, OSWER-9345.0-12FSI, January.

Table 2-18

Aquatic Biota Sediment Benchmark Exceedances
TNT Area C
Plum Brook Ordnance Works, Sandusky, Ohio

COPEC	Source-Term Concentration[a] (mg/kg)	NOAA ER-L[b] (mg/kg)	NOAA ER-M[c] (mg/kg)	FDEP TEL[d] (mg/kg)	FDEP PEL[e] (mg/kg)	OMOE Low[f] (mg/kg)	OMOE Severe[g] (mg/kg)	Talmage et. al. SQC[h] (mg/kg)	Benchmark Exceeded?
Organics									
1,3,5-Trinitrobenzene	0.832	NA[i]	NA	NA	NA	NA	NA	0.24	Yes (1/1)[j]
2,4,6-Trinitrotoluene	1,496	NA	NA	NA	NA	NA	NA	9.2	Yes (1/1)
Aroclor 1260	0.769	NA	NA	NA	NA	0.005	0.24	NA	Yes (2/2)
Benzo(a)anthracene	0.095	0.261	1.6	0.075	0.693	0.32	1,480	NA	Yes (1/6)
Fluoranthene	0.147	0.6	5.1	0.113	1.49	0.75	1,020	NA	Yes (1/6)
Inorganics									
Cadmium	0.725	1.2	9.6	0.68	4.21	0.6	10	NA	Yes (2/6)
Lead	48.8	46.7	218	30.2	112	31	250	NA	Yes (3/6)

[a] COPECs and 95% UCL concentrations are from Table 2-13 of the Ecological Risk Assessment.
[b] Effects Range - Low, developed by NOAA published by Long and Morgan (1990), updated by Long (1995, and summarized in Jones, et al. (1996). Should be used only if no freshwater benchmarks available (e.g., OMOE, 1993).
[c] Effects Range - Medium, developed by NOAA published by Long and Morgan (1990), updated by Long (1995), and summarized in Jones, et al. (1996). Should be used only if no freshwater benchmarks available (e.g., OMOE, 1993).
[d] Florida Department of Environmental Protection, threshold effects level, summarized in Jones, et al. (1996).
[e] Florida Department of Environmental Protection, probable effects level, summarized in Jones, et al. (1996).
[f] Ontario Ministry of the Environment (OMOE, 1993), Low = lowest effect level and is the 5th percentile of the screening level concentration.
[g] Ontario Ministry of the Environment (OMOE, 1993), Severe = severe effect level and is the 95th percentile of the screening level concentration.
[h] Talmage, et al. (1999), Sediment Quality Criteria/Screening Benchmarks.
[i] NA = Not available.
[j] Number of benchmarks exceeded/number of benchmarks available.

Table 2-18

Aquatic Biota Sediment Benchmark Exceedances
TNT Area C
Plum Brook Ordnance Works, Sandusky, Ohio

Sources:

Jones, D.S., R.N. Hull, and G. W. Suter, II, 1996, ***Toxicological Benchmarks for Screening Potential Contaminants of Concerns for Effects on Sediment-Associated Biota***, ES/ER/TM-95/R2.

Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder, 1995, "Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments, ***Environmental Management****,* Vol. 19, No. 1, pp. 81-97.

Long, E.R., and L.G. Morgan, 1990, ***The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program****,* NOAA Tech. Memo NOS OMA 52, National Oceanic and Atmospheric Administration, Seattle, Washington.

Table 2-19

Terrestrial Receptors Ecological Hazard Index Summary
TNT Area C[a]
Plum Brook Ordnance Works, Sandusky, Ohio

Media	Terrestrial Receptor						
	Deer Mouse	Cottontail	Shrew	Marsh Wren	Raccoon	Deer	Hawk
Soil [b] EHI[c]	6,190–31,557	7,274–36,408	977–5,620	1,150–25,075	5,110–26,138	612–3,080	4–73
Risk Drivers:	TNT (plant intake) Aroclor-1260 (invertebrate intake)	TNT (plant intake)	TNT (soil intake) Aroclor-1260 (invertebrate intake)	TNT (invertebrate intake) Aroclor-1260 (invertebrate intake)	TNT (plant intake) Aroclor-1260 (invertebrate intake)	TNT (plant intake)	TNT (soil intake) Aroclor-1260 (shrew intake) (bird intake)
Surface Water EHI	0.2–2.0	0.2–2.0	0.2–1.3	0.3–1.7	0.3–2.5	2–20	0.004–0.02
Risk Drivers:	Aluminum (water intake)	Aluminum (water intake)	Aluminum (water intake)	Iron (water intake)	Aluminum (water intake)	Aluminum (water intake)	Iron (water intake)
Total Receptor EHI	6,190–31,559	7,274–36,410	977–5,621	1,150–25,077	5,110–26,141	614–3,100	4–73

[a] Details presented in the ecological risk assessment.
[b] All receptors exposed to surface soil, except burrowing shrew exposed to surface and subsurface soil via ingestion of soil and ingestion of terrestrial invertebrates, and deer exposed to surface and subsurface soil via ingestion of plants (e.g., tree leaves) that have translocated COPEC(s) via deep feeder roots.
[c] Lower end of range indicates the CT-based values, and higher end of range is the RME-based values.

Notes :

(1) EHI values are generally interpreted as follows:
- <1 – No probable adverse ecological effects
- 1 to 10 – Low potential for adverse ecological effects
- 10 to 100 – Substantial potential for adverse ecological effects
- >100 – Highest potential for adverse ecological effects.

(2) Central tendency and reasonable maximum exposure (RME) approach assumptions include differences in exposure point concentrations; toxicity values; interclass toxicity uncertainty factor; and method of calculation of site-specific soil- to-invertebrate biological accumulation factors.

COPEC – Constituent of potential concern.
EHI – Ecological hazard index.
CT – Central tendency.
RME – Reasonable maximum exposure.
TNT – 2,4,6-Trinitrotoluene.

Table 2-20

Aquatic Ecological Hazard Index Summary
TNT Area C [a]
Plum Brook Ordnance Works, Sandusky, Ohio

Media	Aquatic Receptor	
	Mallard Duck	**Raccoon**
Sediment EHI[b]	97–2,350	265–1,130
Risk Drivers:	TNT (invertebrate intake)	TNT (invertebrate intake)
	2-ADNT (invertebrate intake)	Selenium (invertebrate intake)
	4-ADNT (invertebrate intake)	Aluminum (sediment intake)
		Aroclor-1260 (invertebrate intake)
Surface Water EHI	0.01–0.07	0.06–0.5
Risk Drivers:	Iron (water intake)	Aluminum (water intake)
Total Receptor EHI	97–2,350	265–1,130

[a] Details presented in ecological risk assessment.
[b] Lower end of the range is the CT-based value; upper end of the range is the RME-based value.

Notes:
(1) EHI values are generally interpreted as follows:
<1 – No probably adverse ecological effects
1 to 10 – Low potential for adverse ecological effects
10 to 100 – Substantial potential for adverse ecological effects
>100 – Highest potential for adverse ecological effects.
(2) CT and RME approach assumptions include differences in exposure-point concentrations; toxicity values; interclass toxicity uncertainty factors; and method of calculation of site-specific surface-water-to-fish and sediment-to-invertebrate biological accumulation factors.
(3) Risk driver percentage is based on intake pathway indicated.
EHI – Ecological hazard index.
CT – Central tendency.
RME – Reasonable maximum exposure.
2-ADNT– 2-Amino-4,6-dinitrotoluene.
4-ADNT– 4-Amino-2,6-dinitrotoluene.
TNT – 2,4,6-Trinitrotoluene.

Table 2-21

Remedial Goals for Total Soil
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

COC	Proposed RG (mg/kg)	Basis	HQ	ILCR
2-Amino-4,6-Dinitrotoluene	1.7	RBRC	0.4	NA
4-Amino-2,6-Dinitrotoluene	1.3	RBRC	0.3	NA
2,4,6-Trinitrotoluene	8.0	RBRC	0.2	6E-7[a]
2,4-Dinitrotoluene	6.5	RBRC	0.04[b]	9E-6
2,6-Dinitrotoluene	1.0	RBRC	0.01[b]	1E-6
Aroclor 1260[c]	1.0	ARAR[d]	NA	3E-6 (5E-7)[e]
Aroclor 1254[c]	1.0	ARAR[d]	0.6 (0.1)[f]	3E-6 (6E-7)[g]
PAHs	1.0	TBC[h]	NA	NA[i]
Lead	400	TBC[j]	NA	NA
Total HI/ILCR			1.0[k]	1.0E-5 (1.3E-5)[l]

[a] RG derived on the basis of noncancer effects; cancer risk is de minimis (<1E-6).
[b] RG derived on the basis of carcinogenicity; noncancer effects are de minimis (HQ<0.1).
[c] ARAR value of 1.0 mg/kg is for combined Aroclor 1254 and 1260 concentrations.
[d] 40 CFR 761.3
[e] Value shown in parentheses is the ILCR for the highest detected concentration (0.15 mg/kg) among the areas not proposed for remediation based on the nitroaromatic RGs; this value is *de minimis* (i.e., <1E-6).
[f] HQ value shown in parentheses is for the highest detected concentration (0.176 mg/kg) among the areas not proposed for remediation based on the nitroaromatic RGs.
[g] ILCR value shown in parentheses is for the highest detected concentration (0.176 mg/kg) among the areas not proposed for remediation based on the nitroaromatic RGs; this value is *de minimis* (i.e., <1E-6).
[h] OEPA policy for combined carcinogenic PAHs.
[i] Although carcinogenic, the ILCR would be based on the specific combination of PAHs present in a given sample.
[j] EPA Soil screening value for average lead concentration.
[k] Total HI reflects the additive effects of the nitroaromatics. The effects of Aroclor 1254 are not regarded as additive with those of the nitoraromatics, so its HQ is not added into the HI for nitroaromatic effects.
[l] Value outside of parentheses is for nitroaromatics and the maximum detected concentration among the remaining samples for residual PCBs; value shown in parentheses is the total ILCR assuming the combined Aroclor 1254 and 1260 concentration is equal to the RG.

ARAR - Applicable or reasonable and appropriate requirement.
COC - Chemical of concern.
HQ - Hazard quotient.
ILCR - Incremental lifetime cancer risk.
mg/kg - Milligrams per kilogram.
NA - Not applicable.
PAH - Polynuclear aromatic hydrocarbon.
RBRC - Risk-based remediation concentration.
RG - Remedial goal.
TBC - To be considered criterion.

Table 2-22

Ecological Implications of Human Health Soil RGs on Total Soil Receptors
TNT Area C
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical[a]	Human Health RG (mg/kg)	Expected Residual Conc.[b] (mg/kg)	Critical Ecological NOAEL Hazard Quotient (and receptor) [c]	EPC for Critical [d] Ecological Receptor (mg/kg)	Scaled [e] Ecological NOAEL Hazard Quotient Using Expected Residual Conc.	Estimated Reduction in Ecological Hazard [f]	Lowest Reported Detection Limit [d] (mg/kg)
2,4,6-Trinitrotoluene	8	1.41	4,120 shrew	41,300	0.1	29291	0.1
Aroclor 1260	1	0.15	1,420 shrew	1.71	125	11	0.08
Lead	400	134	45 shrew	578	10	4	NA

Chemical[a]	Human Health RG (mg/kg)	Expected Residual Conc.[b] (mg/kg)	Critical Ecological LOAEL Hazard Quotient (and receptor) [c]	EPC for Critical [d] Ecological Receptor (mg/kg)	Scaled [e] Ecological LOAEL Hazard Quotient Using Expected Residual Conc.	Estimated Reduction in Ecological Hazard [f]	Lowest Reported Detection Limit [d] (mg/kg)
2,4,6-Trinitrotoluene	8	1.41	823 shrew	41,300	0.03	29291	0.1
Aroclor 1260	1	0.15	142 shrew	1.71	12	11	0.08
Lead	400	134	5 shrew	578	1	4	NA

[a] Chemicals shown are those having the highest ecological HQ values in the Remedial Investigation Report Ecological Risk Assessment (ERA) (IT, 2001c). All chemicals shown are human health COCs.

[b] Residual concentrations in total soil were estimated by removing the soil samples from the ecological data base that were within the proposed excavation footprint and recalculating the exposure point concentration following the methodology used in the ERA. Value shown for each chemical except 2,4,6-trinitrotoluene (TNT) is the remaining maximum detected concentration; value shown for TNT is 0.5 X the maximum reporting limit. Dilution from clean backfill was not considered in estimating the residual concentrations.

[c] Value and corresponding receptor shown are for the highest HQ value among receptors evaluated in the ERA.

[d] Value shown is from the ERA.

[e] Estimated using the following scaling relationship:

Scaled HQ = Residual Conc. x (pre-remediation HQ/pre-remediation EPC).

Note that calculations were performed using unrounded HQ values, but that the resultant scaled quotients are rounded to one significant figure.

[f] Estimated by dividing pre-remediation EPC by expected residual concentration (note that HQs are linear with concentration). Ecological hazard reduction factors are rounded to the nearest whole number.

Notes:

COC = chemical of concern
Conc. = Concentration
EPC = exposure point concentration (original EPC used in ERA for surface soil exposure)
ERA = Ecological Risk Assessment
HQ = ecological hazard quotient from ERA.
LOAEL = lowest-observed-adverse-effect level
mg/kg = milligram per kilogram
NA = not applicable
NOAEL = no-observed-adverse-effect level
RG = remedial goal.

Table 2-23

Remedial Goals for Sediment
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

COC	RBRC Based on Resident (mg/kg)	RBRC Based on Construction Worker (mg/kg)	Proposed RG (mg/kg)	HQ of Proposed RG[a]	ILCR of Proposed RG[a]
2-Amino-4,6-Dinitrotoluene	12.1	5.0	5.0	0.3	NA
4-Amino-2,6-Dinitrotoluene	12.1	5.0	5.0	0.3	NA
2,4,6-Trinitrotoluene	101	41	41	0.3	9E-7[b]
Total HI/ILCR				1.0	9E-7

[a] Based on the construction worker scenario.
[b] RG derived on the basis of noncancer effects; cancer risk is de minimis (<1E-6).

COC - Chemical of concern.
HQ - Hazard quotient.
ILCR - Incremental lifetime cancer risk.
mg/kg - Milligrams per kilogram.
NA - Not applicable.
RBRC - Risk-based remediation concentration.
RG - Remedial goal.

Table 2-24

Ecological Implications of Human Health Sediment RGs on Sediment Receptors
TNT Area C
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical[a]	Human Health RG (mg/kg)	Expected Residual Conc.[b] (mg/kg)	Critical Ecological NOAEL Hazard Quotient (and receptor)[c]	EPC for Critical[d] Ecological Receptor (mg/kg)	Scaled[e] Ecological NOAEL Hazard Quotient Using Expected Residual Conc.	Estimated Reduction in Ecological Hazard[f]	Lowest Reported Detection Limit[d] (mg/kg)
2-Amino-4,6-Dinitrotoluene	5.0	3.25	42 mallard	12.8	11	4	0.0833
4-Amino-2,6-Dinitrotoluene	5.0	2.79	37 mallard	11.2	9	4	0.0833
2,4,6-Trinitrotoluene	41	2.9	2,240 mallard	1,496	4	516	0.0833
Aroclor 1260	NA	0.71	67 raccoon	0.77	62	1	0.084
Selenium	NA	1.84	119 raccoon	1.77	124	1	1.19
Aluminum	NA	11,000	82 raccoon	11,000	82	1	NA

Chemical[a]	Human Health RG (mg/kg)	Expected Residual Conc.[b] (mg/kg)	Critical Ecological LOAEL Hazard Quotient (and receptor)[c]	EPC for Critical[d] Ecological Receptor (mg/kg)	Scaled[e] Ecological LOAEL Hazard Quotient Using Expected Residual Conc.	Estimated Reduction in Ecological Hazard[f]	Lowest Reported Detection Limit[d] (mg/kg)
2-Amino-4,6-Dinitrotoluene	5.0	3.25	2 mallard	12.8	0.4	4	0.0833
4-Amino-2,6-Dinitrotoluene	5.0	2.79	2 mallard	11.2	0.4	4	0.0833
2,4,6-Trinitrotoluene	41	2.9	169 raccoon	1,496	0.3	516	0.0833
Aroclor 1260	NA	0.71	7 raccoon	0.77	6	1	0.084
Selenium	NA	1.84	79 raccoon	1.77	82	1	1.19
Aluminum	NA	11,000	8 raccoon	11,000	8	1	NA

[a] Chemicals shown are those having the highest ecological hazard quotient (EHQ) values in the Remedial Investigation Report Ecological Risk Assessment (ERA) (IT, 2001c). Human health COCs are bolded.

[b] Residual concentrations in sediment were estimated by removing the sediment samples from the ecological data base that were within the proposed excavation footprint and recalculating the exposure point concentration following the methodology used in the ERA. Value shown for each chemical except 2,4,6-trinitrotoluene (TNT) is the remaining maximum detected concentration; value shown for TNT is 0.5 X the maximum reporting limit. Dilution from clean backfill was not considered in estimating the residual concentrations.

[c] Value and corresponding receptor shown are for the highest HQ value among receptors evaluated in the ERA.

[d] Value shown is from the ERA.

[e] Estimated using the following scaling relationship:

Scaled HQ = Residual Conc. x (pre-remediation HQ/pre-remediation EPC)

Note that calculations were performed using unrounded HQ values, but that the resultant scaled quotients are rounded to one significant figure.

[f] Estimated by dividing pre-remediation EPC by expected residual concentration (note that HQs are linear with concentration). Ecological hazard reduction factors are rounded to the nearest whole number.

Notes:

COC = chemical of concern
Conc. = Concentration
EPC = exposure point concentration (original EPC used in ERA for surface soil exposure)
ERA = Ecological Risk Assessment
LOAEL = lowest-observed-adverse-effect level
mg/kg = milligram per kilogram
NA = not applicable
NOAEL = no-observed-adverse-effect level
RG = remedial goal.

Table 2-25

Comparative Analysis of Remedial Alternatives
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

Criteria	**Alternative 1:** No Action	**Alternative 2:** Excavation, Windrow Composting, and On-Site/Off-Site Disposal	**Alternative 3:** Excavation and Off-Site Disposal	**Alternative 4:** Excavation, Windrow Composting, Ex-Situ Stabilization, and On-Site/Off-Site Disposal	**Alternative 5:** Excavation, Alkaline Hydrolysis, Ex-Situ Stabilization, and Off-Site Disposal
Overall Protectiveness					
Human Health Protection	No reduction in risk.	Reduces the concentration of COCs to levels below RGs.	Reduces the concentration of COCs to levels below RGs.	Reduces the concentration of COC to levels below RGs.	Reduces the concentration of COC to levels below RGs.
Environmental Protection	No reduction in risk.	Significantly reduces the hazard quotients calculated for ecological receptors, and lowers the likelihood of contaminant spread to other media.	Significantly reduces the hazard quotients calculated for ecological receptors, and lowers the likelihood of contaminant spread to other media.	Significantly reduces the hazard quotients calculated for ecological receptors, and lowers the likelihood of contaminant spread to other media.	Significantly reduces the hazard quotients calculated for ecological receptors, and lowers the likelihood of contaminant spread to other media.
Compliance with ARARs					
Chemical-Specific ARARs	No chemical-specific ARARs.	No chemical-specific ARARs.	No chemical-specific ARARs.	No chemical-specific ARARs.	No chemical-specific ARARs.
Location-Specific ARARs	No location-specific ARARs.	Complies with all location-specific ARARs.	Complies with all location-specific ARARs.	Complies with all location-specific ARARs.	Complies with all location-specific ARARs.
Action-Specific ARARs	No action-specific ARARs.	Complies with all action-specific ARARs.	Complies with all action-specific ARARs.	Complies with all action-specific ARARs.	Complies with all action-specific ARARs.

Table 2-25

Comparative Analysis of Remedial Alternatives
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

Criteria	**Alternative 1:** No Action	**Alternative 2:** Excavation, Windrow Composting, and On-Site/Off-Site Disposal	**Alternative 3:** Excavation and Off-Site Disposal	**Alternative 4:** Excavation, Windrow Composting, Ex-Situ Stabilization, and On-Site/Off-Site Disposal	**Alternative 5:** Excavation, Alkaline Hydrolysis, Ex-Situ Stabilization, and Off-Site Disposal
Other Criteria and Guidance	Permits exposures to soil exceeding the USEPA 400 mg/kg screening level for lead in soil.	Prevents exposures to soil exceeding the USEPA 400 mg/kg screening level for lead in soil.	Prevents exposures to soil exceeding the USEPA 400 mg/kg screening level for lead in soil.	Prevents exposures to soil exceeding the USEPA 400 mg/kg screening level for lead in soil.	Prevents exposures to soil exceeding the USEPA 400 mg/kg screening level for lead in soil.
Long-Term Effectiveness and Permanence					
Magnitude of Residual Risk	Existing risk will remain.	Residual risk will be within the risk management range.	Residual risk will be within the risk management range.	Residual risk will be within the risk management range.	Residual risk will be within the risk management range.
Adequacy and Reliability of Controls	No controls over remaining contamination. No reliability.	No long-term controls required at site.	No long-term controls required at site.	No long-term controls required at site.	No long-term controls required at site.
Reduction of Toxicity, Mobility, or Volume through Treatment					
Treatment Process Used	None	Biological treatment of nitroaromatic compounds and PAHs using windrow composting.	No on-site treatment.	Biological treatment of nitroaromatic compounds and PAHs using windrow composting. Ex-situ chemical stabilization of lead.	Chemical and biological treatment of nitroaromatic compounds and PAHs using alkaline hydrolysis and windrow composting. Ex-situ chemical stabilization of lead.

Table 2-25

Comparative Analysis of Remedial Alternatives
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

Criteria	**Alternative 1:** No Action	**Alternative 2:** Excavation, Windrow Composting, and On-Site/Off-Site Disposal	**Alternative 3:** Excavation and Off-Site Disposal	**Alternative 4:** Excavation, Windrow Composting, Ex-Situ Stabilization, and On-Site/Off-Site Disposal	**Alternative 5:** Excavation, Alkaline Hydrolysis, Ex-Situ Stabilization, and Off-Site Disposal
Amount Destroyed or Treated	None	25% of contaminated soil treated on-site.	No on-site treatment.	25% of contaminated soil treated on-site.	25% of contaminated soil treated on-site.
Irreversible Treatment	None.	Research has demonstrated that a high percentage (>80%) of TNT-carbon is irreversibly bound to the soil through covalent binding with humic substances.	No on-site treatment.	Research has demonstrated that a high percentage (>80%) of TNT-carbon is irreversibly bound to the soil through covalent binding with humic substances. Stabilization may not be an irreversible process, but placement of stabilized waste in an engineered disposal cell minimizes the possibility that conditions conducive to leaching will be created.	Alkaline hydrolysis irreversibly transforms NACs in soil to less toxic end products. Research has demonstrated that a high percentage (>80%) of TNT-carbon is irreversibly bound to the soil through covalent binding with humic substances. Stabilization may not be an irreversible process, but placement of stabilized waste in an engineered disposal cell minimizes the possibility that conditions conducive to leaching will be created.

Table 2-25

Comparative Analysis of Remedial Alternatives
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

Criteria	**Alternative 1:** No Action	**Alternative 2:** Excavation, Windrow Composting, and On-Site/Off-Site Disposal	**Alternative 3:** Excavation and Off-Site Disposal	**Alternative 4:** Excavation, Windrow Composting, Ex-Situ Stabilization, and On-Site/Off-Site Disposal	**Alternative 5:** Excavation, Alkaline Hydrolysis, Ex-Situ Stabilization, and Off-Site Disposal
Type and Quantity of Residuals Remaining after Treatment (all volumes are based on in-place, consolidated soil)	Contaminated soil remains.	8,805 cy of treated and untreated soil for offsite disposal as a nonhazardous waste at a solid waste landfill. 400 cy lead-contaminated soil for off-site treatment and disposal at a Subtitle C TSDF.	6,805 cy of untreated soil for offsite disposal as a nonhazardous waste at a solid waste landfill. 2,310 cy 2,4-DNT and lead-contaminated soil for off-site treatment and disposal at a Subtitle C TSDF.	9,205 cy of treated and untreated soil for offsite disposal as a non-hazardous waste at a solid waste landfill.	7,295 cy of treated and untreated soil for offsite disposal as a non-hazardous waste at a solid waste landfill.
Short-Term Effectiveness					
Community Protection	May present future risk to community.	Normal safeguards would be required during transportation of waste materials offsite.	Normal safeguards would be required during transportation of waste materials offsite.	Normal safeguards would be required during transportation of waste materials offsite.	Normal safeguards would be required during transportation of waste materials offsite.

Table 2-25

Comparative Analysis of Remedial Alternatives
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

Criteria	**Alternative 1:** No Action	**Alternative 2:** Excavation, Windrow Composting, and On-Site/Off-Site Disposal	**Alternative 3:** Excavation and Off-Site Disposal	**Alternative 4:** Excavation, Windrow Composting, Ex-Situ Stabilization, and On-Site/Off-Site Disposal	**Alternative 5:** Excavation, Alkaline Hydrolysis, Ex-Situ Stabilization, and Off-Site Disposal
Worker Protection	No risk to workers	Safeguards would be required to protect workers from chemical exposures during windrow turning operations. Dust released during excavation, screening, amendment mixing, and windrow turning may require controls.	Dust released during excavation and screening may require controls.	Safeguards would be required to protect workers from chemical exposures during windrow turning operations. Dust released during excavation, screening, amendment mixing, windrow turning, and stabilization may require controls.	Chemicals used in the treatment process are very corrosive. Material handling processes must be carefully designed to protect workers from chemical exposures. Safeguards would be required to protect workers from chemical exposures during windrow turning operations. Dust released during excavation, screening, amendment mixing, windrow turning, and stabilization may require controls.

Table 2-25

Comparative Analysis of Remedial Alternatives
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

Criteria	**Alternative 1:** No Action	**Alternative 2:** Excavation, Windrow Composting, and On-Site/Off-Site Disposal	**Alternative 3:** Excavation and Off-Site Disposal	**Alternative 4:** Excavation, Windrow Composting, Ex-Situ Stabilization, and On-Site/Off-Site Disposal	**Alternative 5:** Excavation, Alkaline Hydrolysis, Ex-Situ Stabilization, and Off-Site Disposal
Environmental Impacts	Continued impact from existing conditions.	Design of staging piles (contaminated soil and amendments) would require safeguards to prevent migration of contaminants. Treatment area would be bermed and a contact water retention system provided to control stormwater run-on and run-off.	Design of staging piles would require safeguards to prevent migration of contaminants.	Design of staging piles would require safeguards to prevent migration of contaminants. Treatment area would be bermed and a contact water retention system provided to control stormwater run-on and run-off.	Design of staging piles would require safeguards to prevent migration of contaminants. Treatment area would be bermed and a contact water retention system provided to control stormwater run-on and run-off. Hazardous chemicals would be managed to segregate incompatible chemicals and prevent uncontrolled releases to the environment.
Time Until Action is Complete	Not applicable	16 to 22 months	10 to 16 months	16 to 22 months	16 to 22 months

Table 2-25

Comparative Analysis of Remedial Alternatives
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

Criteria	**Alternative 1:** No Action	**Alternative 2:** Excavation, Windrow Composting, and On-Site/Off-Site Disposal	**Alternative 3:** Excavation and Off-Site Disposal	**Alternative 4:** Excavation, Windrow Composting, Ex-Situ Stabilization, and On-Site/Off-Site Disposal	**Alternative 5:** Excavation, Alkaline Hydrolysis, Ex-Situ Stabilization, and Off-Site Disposal
Implementability					
Ability to Construct and Operate	No construction or operation.	Technology well developed and implemented on a full-scale basis at numerous sites.	No significant issues.	Technologies well developed and implemented on a full-scale basis at numerous sites.	Alkaline hydrolysis using caustic soda to treat NACs in soil is a relatively new process, but has been field tested at one site. Composting is a contingency component of remedial alternative that will be used to treat soil that does not meet RGs or LDR criteria after alkaline hydrolysis. Composting is a well developed technology implemented on a full-scale basis at numerous sites.
Ease of Doing More Action if Needed	May require ROD amendment if future problems arise.	Does not preclude additional remedial action for soil.	Does not preclude additional remedial action for soil.	Does not preclude additional remedial action for soil.	Does not preclude additional remedial action for soil.

Table 2-25

Comparative Analysis of Remedial Alternatives
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

Criteria	**Alternative 1:** No Action	**Alternative 2:** Excavation, Windrow Composting, and On-Site/Off-Site Disposal	**Alternative 3:** Excavation and Off-Site Disposal	**Alternative 4:** Excavation, Windrow Composting, Ex-Situ Stabilization, and On-Site/Off-Site Disposal	**Alternative 5:** Excavation, Alkaline Hydrolysis, Ex-Situ Stabilization, and Off-Site Disposal
Ability to Monitor Effectiveness	No monitoring required.	Effectiveness of excavation is evaluated by confirmatory soil sampling and analysis. Effectiveness of composting is evaluated by post-treatment sampling and analysis of compost	Effectiveness of excavation is evaluated by confirmatory soil sampling and analysis.	Effectiveness of excavation is evaluated by confirmatory soil sampling and analysis. Effectiveness of stabilization process evaluated through leaching tests. Effectiveness of composting is evaluated by post-treatment sampling and analysis of treated soil.	Effectiveness of excavation is evaluated by confirmatory soil sampling and analysis. Effectiveness of stabilization process evaluated through leaching tests. Effectiveness of alkaline hydrolysis and composting is evaluated by post-treatment sampling and analysis of treated soil
Ability to Obtain Approvals and Coordinate with Other Agencies	None required	OEPA approval of disposal facility would be required.	OEPA approval of disposal facility would be required.	OEPA approval of disposal facility would be required.	OEPA approval of disposal facility would be required.
Availability of Equipment, Specialists, and Materials	None required	Equipment, technical specialists, and materials available locally.	Equipment, technical specialists, and materials available locally.	Equipment, technical specialists, and materials readily available.	Equipment, technical specialists, and materials available locally.

Table 2-25

Comparative Analysis of Remedial Alternatives
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

Criteria	**Alternative 1:** No Action	**Alternative 2:** Excavation, Windrow Composting, and On-Site/Off-Site Disposal	**Alternative 3:** Excavation and Off-Site Disposal	**Alternative 4:** Excavation, Windrow Composting, Ex-Situ Stabilization, and On-Site/Off-Site Disposal	**Alternative 5:** Excavation, Alkaline Hydrolysis, Ex-Situ Stabilization, and Off-Site Disposal
Availability of Technologies	None required	Available	Available	Available	Available
Cost					
Capital Cost	None	$3.3 million	$2.9 million	$3.2 million	$2.4 million
Annual O&M Cost	None	None	None	None	None
Present Worth Cost	None	$3.3 million	$2.9 million	$3.2 million	$2.4 million
State Acceptance	Not acceptable	To be determined	To be determined	To be determined	To be determined
Community Acceptance	Not acceptable	To be determined	To be determined	To be determined	To be determined

ARAR - Applicable or relevant and appropriate requirement.
COC - Contaminant of concern.
cy - Cubic yard.
mg/kg - Milligrams per kilogram.
O&M - Operation and maintenance.
OEPA - Ohio Environmental Protection Agency.
PAH - Polynuclear aromatic hydrocarbon.
RCRA - Resource Conservation and Recovery Act.
RG - Remedial goal.
ROD - Record of decision.
TNT - Trinitrotoluene.
TSDF - Treatment, storage, and disposal facility.
USEPA - U.S. Environmental Protection Agency.

Table 2-26

Cost Estimate of Selected Remedy
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

Alternative 5
Excavation/Alkaline Hydrolysis/Windrow Composting/
Stabilization/Onsite and Offsite Disposal
Site Restoration Cost Estimate

Site: TNT Area C
Plum Brook Ordnance Works
Date: 10/31/2008

Scope:
1. Prepare work plans and closeout report, and complete procurement.
2. Mobilize/demobilize equipment and personnel.
3. Prepare site for remedial activity.
4. Excavate contaminated soil, perform confirmation sampling & characterize waste.
5. Alkaline hydrolysis and neutralization of soil that is hazardous due to 2,4-DNT TCLP.
6. Windrow composting of 60% of the alkaline hydrolysis treated soil.
7. Maectite chemical stabilization of soil that is hazardous due to lead TCLP.
8. On site disposal of soil treated via alkaline hydrolysis and windrow composting.
9. Off-site disposal of non-hazardous untreated soil.
10. Site restoration.

1.0 Treatability Study, Work Plans, Reports and Procurement

Includes:
1. Labor to generate work plans, including engineering specifications and Health and Safety Plan, along with the Final Report.
2. Procure equipment and materials.

Service	Unit	Unit Cost		Subtotal	
Work Plans and Final Report	1	$15,000.00	/ls	$15,000.00	
Procurement	1	$10,000.00	/ls	$10,000.00	
				Subtotal	**$25,000.00**

2.0 Mobilization/Demobilization of Equipment and Personnel

Includes:
1. Mobilization and demobilization of local equipment and personnel.
2. Set-up/tear down office trailer.

Assumptions:
1. Labor and equipment are available locally.
2. Pressure washer to be purchased for use during project.

Service/Materials	Unit	Unit Cost		Subtotal	
Labor/Equipment:					
Mobe/Demobe	1	$5,000.00	/ls	$5,000.00	
Office Trailer (set up/tear down)	1	$500.00	/ls	$500.00	
Pressure Washer	1	$500.00	/ls	$500.00	
				Subtotal	**$6,000.00**

Table 2-26

Cost Estimate of Selected Remedy
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

3.0 Site Preparation

Assumptions:
1. Existing site can be used and no additional site preparation costs are required.

4.0 Excavation of Contaminated Soil

Includes:
1. Excavation of soil with contaminants exceeding RGOs.
2. Screen oversize material.
3. Collect confirmatory samples to verify extent of excavation.
4. Staging and characterizing waste stream.

Assumptions and Calculations:

1. Cubic yards of consolidated soil excavated =	9205
2. Swell factor for soil upon excavation =	1.3
3. Cubic yards of unconsolidated soil =	11967
4. Density of unconsolidated soil (tons/cy) =	1.1
5. Mass of unconsolidated soil (tons) =	13163
6. Capacity of screening plant (tons/hr) =	100
7. Excavator: hydraulic backhoe, 1 cy bucket.	
8. Excavator output (cy/day) =	600
9. Days to excavate soil =	24
10. Dump truck capacity (cy) =	12
11. Dump truck haul distance (mi.) =	0.5
12. Dump truck output (cy/day) =	250
13. No. of required dump trucks per day =	2
14. Soil sample collected for waste characterization / cy =	300
15. No. of soil samples collected for waste characterization =	40
16. Number of excavation crew =	2
17. Number of screening crew =	3
18. Lineal foot of excavation per confirmation sample =	20
19. Resampling factor for confirmation sampling =	1.1
20. No. of confirmatory samples from excavated area =	286
21. Excavation area (ft^2) =	35583
22. Cost multiplier for 1-week turnaround on analytical data =	1.25
23. Fraction of excavation work performed in Level C PPE =	0.10
24. Labor productivity factor for Level C work =	0.67
25. Days excavation crew in Level C =	3
26. Days screening crew in Level C =	2
27. Perimeter of excavation area (ft) =	3415
28. Excavation area (sf) =	35583
29. Volume of pit water requiring offsite disposal (gal) =	20000

30. Standard work week is 5 days per week at 8 hours per day. Thus, assuming 22 working days per 31 day month.

Service/Materials	Unit	Unit Cost		Subtotal
Labor:				
Site Superintendent	192	$49.00	/hr	$9,408.00
QA (Sampling) Coordinator	192	$36.00	/hr	$6,912.00
H&S Coordinator	192	$49.00	/hr	$9,408.00
Chemist (home office)	48	$51.00	/hr	$2,448.00
Equipment Operator	24	$406.00	/day	$9,744.00
Equipment Operator	20	$406.00	/day	$8,120.00
Equipment Operator	20	$406.00	/day	$8,120.00
Laborers	44	$341.60	/day	$15,030.40
Truck Drivers	48	$341.60	/day	$16,396.80

Table 2-26

Cost Estimate of Selected Remedy
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

4.0 Excavation of Contaminated Soil (continued)

Equipment:					
Excavator	2	$4,000.00	/mo	$8,000.00	
100-ton/hr Screening Plant	4	$1,800.00	/wk	$7,200.00	
Radial Stacking Conveyor	4	$1,222.00	/wk	$4,888.00	
Dozer	1	$3,500.00	/mo	$3,500.00	
Dump Truck	2	$3,890.00	/mo	$7,780.00	
Dump Truck	2	$3,890.00	/mo	$7,780.00	
3000 gal. Water Truck	24	$402.00	/day	$9,648.00	
21,000 gal Frac Tank	8	$1,400.00	/mo	$11,200.00	
150 gpm Pump	2	$2,439.00	/ea.	$4,878.00	
300 gpm Pump	2	$3,749.00	/ea.	$7,498.00	
Office Trailer	2	$800.00	/mo	$1,600.00	
Porta Jon	2	$175.22	/mo	$350.44	
Generator	2	$170.35	/mo	$340.70	
P/U Truck	2	$1,800.00	/mo	$3,600.00	
Analytical:					
TCLP Extraction	40	$12.88	/ea	$515.00	
SVOCs (8270C)	326	$300.00	/ea	$97,800.00	
NACs (8330)	326	$197.50	/ea	$64,385.00	
Lead	326	$30.00	/ea	$9,780.00	
PCBs	326	$103.75	/ea	$33,822.50	
NAC field analyses	286	$40.00	/ea	$11,440.00	
Lead field analyses	2	$4,200.00	/mo.	$8,400.00	
Shipping	87	$40.00	/ea	$3,477.33	
Materials & Services:					
Level D PPE	96	$10.00	/day	$960.00	
Level C PPE	12	$35.00	/day	$420.00	
PID rental	2	$974.00	/mo.	$1,948.00	
CGI rental	2	$380.00	/mo.	$760.00	
Pit Water Disposal	20	$1.62	/kgal	$32.40	
				Subtotal	**$397,591.00**

Table 2-26

Cost Estimate of Selected Remedy
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

5.0 Alkaline Hydrolysis and Neutralization of Contaminated Soil

Includes:

1. Treat the 2,4-DNT contaminated soil with caustic soda pellets and 30% ferric chloride solution.
2. Neutralize alkaline hydrolysis treated soil with ferrous sulfate.
3. Temporary storage for the caustic soda pellets, 30% ferric chloride, and ferrous sulfate.

Assumptions and Calculations:

1. Volume of consolidated 2,4 DNT soil to be treated (cy) =		2103	
2. Swell factor for soil upon excavation =		1.3	
3. Cubic yards of unconsolidated soil =		2734	
4. Soil shall be treated via alkaline hydrolysis using caustic acid in 300 cy batches within the treatment area.			
5. Each 300 cy area =	52 ft Wide	52 ft Long	
6. Batch size (cy) =		300	
7. Soil to be spread out to a depth of (ft) =		3	
8. Treatment chemical requirements based on treatability study conducted by Shaw E&I Technology Dev. Lab			
9. Caustic soda required for treatment =		61	lb/cy soil
10. Water, used to saturate soil with water =		37	gal/cy soil
11. Ferric chloride 30% solution =		1	gal/cy soil
12. NaOH mol wt =		40	lb/lb mol
14. Ferrous sulfate needed to neutralize NaOH =		108	lb/cy soil
16. Number of days for completed treatment with neutralization =		10	
17. Number of batches =		10	
18. Number of batches during one treatment cycle =		5	
19. Number of treatment cycles =		2	
20. Standard work week is 5 days per week at 8 hours per day. Thus, assuming 22 working days per 31 day month.			
21. Number of field days =		20	
22. Number of field crew =		12	
23. Mass of caustic soda (lb) =		166774	
24. Volume of ferric chloride, 30% solution (gal) =		2734	
25. Density of 30% ferric chloride solution (lb/gal) =		10.77	
26. Volume of water (gal) =		101158	

28. Confirmation sampling for alkaline hydrolysis prior to neutralization shall consist of nitroaromatics, nitrate and nitrite, and pH, one sequence per batch.
29. Upon neutralization with ferrous sulfate confirmation sampling shall be performed for nitrate and nitrite, and pH, one sequence per batch.
30. Temporary storage is required for the caustic soda pellets, 30% ferric chloride, and ferrous sulfate preventing exposure to inclement weather and release into the environment. The duration for the alkaline hydrolysis is 20 days. Therefore assume equipment rental for 1 month.
31. The caustic soda pellets come in 2000 pound super sacks at approximately 4-feet by 4-feet by 3-feet high.

32. Number of caustic soda super sacks (ea) =	84
33. Required storage capacity for caustic soda pellets (cf) =	4032

34. The 30% ferric chloride solution comes in 330 gallon totes at approximately 46.5-inches by 46.5-inches by 48-inches high.

35. Number of 30% ferric chloride solution totes (ea) =	9
36. Required storage capacity for 30% ferric acid solution (cf) =	541

37. The ferrous sulfate comes in 2,000 pound super sacks at 4-feet by 4-feet by 3-feet high or a 48 cubic feet pallet.

38. Number of ferrous sulfate super sacks or pallets (ea) =	149
39. Required storage capacity for ferrous sulfate (cf) =	7152

40. Temporary storage shall be provided utilizing a 48-foot swing open-door land-sea cargo trailer. The trailer is 45.42-feet long by 8.25 -feet wide by 9-feet high. 40 super sacks per trailer. The monthly rental is $100/mo.

41. Available capacity in the Land-Sea Cargo Trailer (cf) =	1920

Table 2-26

Cost Estimate of Selected Remedy
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

5.0 Alkaline Hydrolysis with Neutralization (continued)

42. Number of Land-Sea Cargo Trailers for caustic soda pellets (ea) 3
43. Number of Land-Sea Cargo Trailers for 30% ferric chloride solution (ea) = 1
44. Number of Land-Sea Cargo Trailers for ferrous sulfate (ea) = 4

Service/Materials	Unit	Unit Cost		Subtotal	
Labor:					
Site Superintendent	160	$49.00	/hr	$7,840.00	
QA (Sampling) Coordinator	160	$36.00	/hr	$5,760.00	
H&S Coordinator	160	$49.00	/hr	$7,840.00	
Sampling Technician	160	$28.00	/hr	$4,480.00	
Equipment Operator	20	$406.00	/day	$8,120.00	
Equipment Operator	20	$406.00	/day	$8,120.00	
Equipment Operator	20	$406.00	/day	$8,120.00	
Equipment Operator	20	$406.00	/day	$8,120.00	
Equipment Operator	20	$406.00	/day	$8,120.00	
Equipment Operator	20	$406.00	/day	$8,120.00	
Laborer	20	$341.60	/day	$6,832.00	
Laborer	20	$341.60	/day	$6,832.00	
Equipment:					
Dozer	1	$3,500.00	/mo	$3,500.00	
Excavator	2	$4,000.00	/mo	$8,000.00	
Front End Loader	1	$5,000.00	/mo	$5,000.00	
Fork Lift	2	$6,480.00	/mo	$12,960.00	
4000 gal. Water Truck	1	$402.00	/day	$402.00	
21,000 gal Frac Tank	2	$1,400.00	/mo	$2,800.00	
Air Monitoring	1	$750.00	/ls	$750.00	
Office Trailer	1	$800.00	/mo	$800.00	
Porta Jon	1	$175.22	/mo	$175.22	
Generator	1	$170.35	/mo	$170.35	
P/U Truck	1	$1,800.00	/mo	$1,800.00	
Materials:					
Caustic Soda	166774	$0.45	/lb	$75,048.30	Brenntag - Pgh
Ferric Chloride 30% Solution	29446	$0.15	/lb	$4,416.90	Brenntag - Pgh
Water	101	$9.40	/1000 gal	$949.40	
Ferrous Sulfate	296366	$0.11	/lb	$32,303.89	Crown Technology
Level C PPE	240	$35.00	/day	$8,400.00	
PID rental	2	$974.00	/mo.	$1,948.00	
CGI rental	2	$380.00	/mo.	$760.00	
Chem. Storage - NaOH pellets	3	$100.00	/mo.	$300.00	
Chem. Storage - 30% $FeCl_3$	1	$100.00	/mo.	$100.00	
Chem. Storage - $FeSO_4$*$7H_2O$	4	$100.00	/mo.	$400.00	
Analytical:					
Pre-Compliance Sampling:					
pH meter	1	$1,800.00	/ea	$1,800.00	
Compliance Sampling for Alkaline Hydrolysis:					
NACs (8330)	10	$145.00	/ea	$1,450.00	
TCLP 2,4-DNT	10	$173.00	/ea	$1,730.00	
E300 - Nitrite and Nitrate	10	$15.00	/ea	$150.00	
Compliance Sampling Following Neutralization with Ferrous Sulfate:					
E300 - Nitrite and Nitrate	10	$15.00	/ea	$150.00	
				Subtotal	**$254,568.00**

Table 2-26

Cost Estimate of Selected Remedy
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

6.0 Windrow Composting of Contaminated of Soil

Includes:
1. Rental of composting equipment.
2. Procurement & stockpiling of composting amendments.
3. Mix and compost soil and amendments.
4. Pre-compliance testing: after compost formation & at end of treatment.
5. Pre-compliance testing using definitive field analysis for NAC.

Assumptions:

1. Laydown area is 260' feet wide x 800 feet long.		
2. 75% of laydown area is available for windrows ad 25% is available for stockpiling amendments.		
3. Compost recipe is 25% soil, 2.9% agricultural amendment (manure) and 72.1% bulking amendment (straw).		
4. Widrows are spaced 5 feet apart from one another.		
5. There is a 35-foot space at each end of the windrow allotting for movement of the windrow turner.		
6. Duration per batch (wk) =	2	
7. The windrows will be staggered by 1 week.		
8. Fraction of alkaline hydrolysis treated soil to be composted =	20%	
9. Volume of alkaline hydrolysis treated soil to be composted (cy) =	421	
10. Fraction of remaining soil treated via alkaline hydrolysis only =	80%	
11. Volume of remaining alkaline hydrolysis treated soil (cy) =	1682	
12. Swell factor for soil upon excavation =	1.3	
13. Volume of unconsolidated soil to be treated (cy) =	547	(composted material)
14. Compost treatment duration (weeks) =	4	
15. Each windrow is 6 feet high x 16 feet wide x 530 feet long, trapezoidal configuration.		
16. Capacity of windrow turner (tons/hr) =	3,200	
17. Operating life of flails (hrs) =	25	
18. Number of flails on windrow turner =	172	
19. Volume of compost per windrow (cy) =	1,178	
20. Per windrow the soil volume is, at 25% (cy) =	294	
21. Per windrow the manure volume is, at 2.9% (cy) =	34	
22. Per windrow the straw volume is, at 72.1% (cy) =	849	
23 . Number of required windrows (ea) =	1.9	
24. Volume of manure (cy) =	63	
25. Volume of straw (cy) =	1577	
26. Compost additive volume correction factor =	0.8	
27. Total volume of compost prior to treatment (cy) =	1,750	
28. Bulk density of compost (tons/cy) =	0.368	
29. Number of field crew =	6	
30. Tractor and straw blower are in-use 1 day/week and on stand-by the rest of the week.		
31. Pre-compliance testing shall weekly per windrow and consist of:		
- EnSys TNT 20, one per batch. Number of samples =	4	
- EnSys TNT 20, no. of samples per kit =	19	
- Total NAC, one per batch. Number of samples =	4	
32. Compliance testing shall be performed per windrow and upon compost treatment. Sampling shall consist of:		
- Total Semivolatiles. Number of samples =	2	
- Total NACs. Number of samples =	2	
-TCLP 2,4-DNT. Number of samples =	2	
33. Standard work week is 7 days per week at 8 hours per day. Thus, assuming 30 working days per month.		

Table 2-26

Cost Estimate of Selected Remedy
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

6.0 Windrow Composting of Contaminated of Soil (continued)

Service/Materials	Unit	Unit Cost		Subtotal		
Labor:						
Site Superintendent	224	$49.00	/hr	$10,976.00		
QA (Sampling) Coordinator	224	$36.00	/hr	$8,064.00		
H&S Coordinator	224	$49.00	/hr	$10,976.00		
Windrow Turner Operator	28	$567.20	/day	$15,881.60		
Equipment Operator	28	$406.00	/day	$11,368.00		
Equipment Operator	28	$406.00	/day	$11,368.00		
Equipment Operator	28	$406.00	/day	$11,368.00		
Laborer	28	$341.60	/day	$9,564.80		
Environmental Tech	28	$200.00	/day	$5,600.00		
Equipment:						
Windrow Turner (6' x 19')	1	$45,000.00	/mo	$45,000.00		
Dozer	1	$3,500.00	/mo	$3,500.00		
Excavator	1	$4,000.00	/mo	$4,000.00		
Wheel Loader	1	$5,000.00	/mo	$5,000.00		
Tractor	32	$50.00	/hr	$1,600.00	In-use	
Tractor	192	$30.00	/hr	$5,760.00	Stand-by	
Straw Blower	32	$40.00	/hr	$1,280.00	In-use	
Straw Blower	192	$20.00	/hr	$3,840.00	Stand-by	
21000 gallon Frac Tank	1	$1,400.00	/mo	$1,400.00		
21000 gallon Frac Tank	1	$1,400.00	/mo	$1,400.00		
Trash/Pump Hose	1	$3,749.00	/ea	$3,749.00		
Office Trailer	1	$800.00	/mo	$800.00		
Porta Jon	1	$175.22	/mo	$175.22		
Generator	1	$170.35	/mo	$170.35		
P/U Truck	1	$1,800.00	/mo	$1,800.00		
Spectrophotometer	1	$3,012.00	/ls	$3,012.00		
Materials:						
Repl. Flails for Windrow Turner	344	$9.50	/ea	$3,268.00		
Straw	1577	$11.25	/cy	$17,740.28		
Manure	63	$25.00	/cy	$1,585.66		
Water	1027	$9.40	/kgal	$9,653.80		
Level C PPE	168	$35.00	/day	$5,880.00		
Air Monitoring Screening Kits	1	$2,500.00	/ls	$2,500.00		
Moisture/Temp Probes	1	$700.00	/ea	$700.00		
Analytical:						
Pre-Compliance Sampling:						
EnSys Kit (TNT 20) - 19 samples per kit	1	$572.00	/ea	$572.00		
Total NACs	4	$145.00	/ea	$580.00		
Compliance Sampling:						
TCLP Semivolatiles	2	$175.00	/ea	$350.00		
Total NACs	2	$145.00	/ea	$290.00		
TCLP 2,4-DNT	2	$175.00	/ea	$350.00		
				Subtotal		**$221,123.00**

Table 2-26

Cost Estimate of Selected Remedy
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

7.0 Chemical Stabilization of Lead-Contaminated Soil

Includes:

1. Stabilization of lead contaminated soil utilizing Maectite chemical stabilization technology.

Assumptions and Calculations:

1. Volume of in-place lead contaminated soil to be stabilized (cy)= 400
2. Swell factor for soil upon excavation = 1.3
3. Volume of unconsolidated lead-contaminated soil (cy) = 520
4. Density of soil (ton/cy) = 1.1
5. Lead contaminated soil remains in-place for chemical stabilization.
6. An excavator will make depressions in the soil for Maectite chemical application.
7. The excavator will turn the soil and the chemical for ample mixture.
8. Time required to stabilize soil (days) = 2
9. The lump sum price for the Maectite chemical and technician is $10,000 per Serverson Environmental.
10. Number of field crew = 1
11. Standard work week is 5 days per week at 8 hours per day. Thus, assuming 22 working days per 31 day month.
12. The 400 cy of in-place lead soil included 193 cy of in-place soil also containing 2-4, DNT.
13. Volume of in-place soil to receive treatment via alkaline hydrolysis and Maectite chemical stabilization (cy) = 193
14. The soil treated via alkaline hydrolysis and Maectite chemical stabilization shall be disposed on-site.
15. Volume of soil to receive Maectite chemical stabilization only (cy) = 207
16. The soil treated via Maectite chemical stabilization shall be disposed off-site at a non-hazardous facility, all 400 cy.

Service/Materials	Unit	Unit Cost		Subtotal	
Labor:					
Site Superintendent	16	$49.00	/hr	$784.00	
QA (Sampling) Coordinator	16	$36.00	/hr	$576.00	
H&S Coordinator	16	$49.00	/hr	$784.00	
Sampling Technician	16	$28.00	/hr	$448.00	
Equipment Operator	2	$406.00	/day	$812.00	
Equipment:					
Excavator	0.1	$4,000.00	/mo	$400.00	
Office Trailer	0.1	$800.00	/mo	$80.00	
Porta Jon	0.1	$175.22	/mo	$17.52	
Generator	0.1	$170.35	/mo	$17.04	
P/U Truck	0.1	$1,800.00	/mo	$180.00	
Materials:					
Maectite Chemical Stabilization	1	$10,000.00	/ls	$10,000.00	(Sevenson tech incl)
Level D PPE	2	$10.00	/day	$20.00	
PID rental	0.1	$974.00	/mo.	$97.40	
CGI rental	0.1	$380.00	/mo.	$38.00	
Analytical:					
TCLP Extraction	1	$10.30	/ea	$10.00	
Lead	1	$24.00	/ea	$24.00	
SVOCs (8270C)	1	$175.00	/ea	$175.00	
NACs (8330)	1	$145.00	/ea	$145.00	
PCBs	1	$83.00	/ea	$83.00	
Shipping	1	$40.00	/ea	$40.00	
				Subtotal	**$14,731.00**

Table 2-26

Cost Estimate of Selected Remedy
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

8.0 On-Site Disposal

Includes:

1. Load treated compost, truck to site, spread compost with dozer.
2. Load alkaline hydrolysis treated soil and stockpile for use as backfill material. The material shall be used as backfill and is addressed in Section 10.0.
3. Confirmation testing under contaminated soil stockpiles.

Assumptions and Calculations:

Composted material (treated via alkalyne hydrolysis and windrow composting):

1. Total volume of compost before treatment (cy) =	1,750
2. Bulk density of compost (tons/cy) =	0.368
3. Weight of treated compost, non-haz waste (ton) =	644
4. Loader output (cy/day) =	1735
5. Days to load treated compost =	2
6. Dump truck capacity (cy) =	12
7. Dump truck haul distance (mi.) =	0.5
8. Dump truck output (cy/day) =	300
9. No. of dump trucks per day =	6
10. Dozer (D-6H) capacity (cy/day) =	595
11. Number of dozers =	2
12. Days to spread treated compost =	2

13. The loading and hauling activities shall be performed consecutively. The spreading activity shall commence 2 days after loading/hauling commences.

14. The duration to load, haul, and spread composted material (days) =	10

Remaining treated soil via alkaline hydrolysis only:

15. Volume of alkaline hydrolysis treated soil (cy) =	1,682
16. Less the volume of lead soil treated via alkaline hydrolysis and Maectite chemical stabilization (cy) =	193
17. Volume of alkalyne hydrolysis treated soil for on-site disposal (cy) =	1,489
18. Swell factor for soil upon excavation =	1.3
19. Volume of unconsolidated soil used as backfill material (cy) =	1936
20. Loader output (cy/day) =	1735
21. Days to load alkaline hydrolysis treated soil =	2
22. Dump truck capacity (cy) =	12
23. Dump truck haul distance (mi.) =	0.5
24. Dump truck output (cy/day) =	300
25. No. of dump trucks per day =	6

26. The treated soil via alkaline hydrolysis only shall be stockpiled prior to use as backfill material as part of Site Restoration.
27. The loading and hauling activities shall be performed consecutively.

28. The duration to load, haul, and spread composted material (days) =	2

Service/Materials	Unit	Unit Cost		Subtotal
Labor:				
Site Superintendent	96	$49.00	/hr	$4,704.00
QA Coordinator	96	$36.00	/hr	$3,456.00
Equipment Operator	4	$406.00	/day	$1,624.00
Equipment Operator	2	$406.00	/day	$812.00
Equipment Operator	2	$406.00	/day	$812.00
Laborer/Oiler	4	$293.00	/day	$1,172.00
Laborer/Oiler	2	$293.00	/day	$586.00
Laborer/Oiler	2	$293.00	/day	$586.00
.Truck Drivers	24	$341.60	/day	$8,198.40

Table 2-26

Cost Estimate of Selected Remedy
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

8.0 On-Site Disposal (continued)					
Equipment:					
Wheel Loader	1	$5,000.00	/mo	$5,000.00	
Dump Truck (6 ea)	1	$3,890.00	/mo	$4,279.00	
Dozer (2 ea)	1	$3,500.00	/mo	$3,500.00	
Office Trailer	0	$800.00	/mo	$240.00	
Porta Jon	1	$175.22	/mo	$175.22	
Generator	1	$170.35	/mo	$170.35	
P/U Truck	1	$1,800.00	/mo	$1,800.00	
Material:					
PID rental	1	$974.00	/mo.	$974.00	
CGI rental	1	$380.00	/mo.	$380.00	
Level D PPE	40	$10.00	/day	$400.00	
				Subtotal	**$38,869.00**

Table 2-26

Cost Estimate of Selected Remedy
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

9.0 Off-Site Disposal

Includes:

1. Dispose untreated and lead-stabilized soil at a non-hazardous facility.

Assumptions and Calculations:

1. Consolidated volume of D008 soil for haz disposal (cy) =	0	
2. Consolidated volume of D030 soil for haz disposal (cy) =	0	
3. Consolidated volume of PCB soil for haz disposal (cy) =	0	
4. Consolidated (in-place) volume of treated soil (cy) =	2310	Table 2-9
5. Unconsolidated volume of treated soil (cy) =	3003	
6. Weight of treated soil (tons) =	3303	
7. Unconsol vol untreated soil for non-hazardous disposal (cy) =	8964	
8. Weight of untreated soil (ton) =	9860	
9. Consolidated volume of lead -contaminated soil treated via Maectite chemical stabilization (cy) =	400	
10. Swell factor for soil upon excavation =	1.3	
11. Volume of unconsolidated lead-contaminated soil via only Maectite chemical stabilization for non-hazardous disposal (cy) =	520	
12. Total volume of non-haz waste for disposal (cy) =	9484	
13. Weight of lead-contaminated soil via only Maectite chemical stabilization (ton) =	572	
14. Total weight of non-haz waste for disposal (tons) =	10432	
15. Non-haz waste transportation cost ($/hr) =	72	
16. Non-haz waste disposal costs ($/ton) =	24.5	Erie County Landfill
17. Non-haz waste regulatory fees ($/ton) =	0	included in disposal
17. Haz waste transportation cost ($/ton) =8	35	
19. D008 Haz waste disposal cost ($/ton) =	75	EO Environmental
20. D030 Haz waste disposal cost ($/ton) =	150	EO Environmental
21. PCB Haz waste disposal cost ($/ton) =	75	EO Environmental
22. Haz waste regulatory fees ($/ton) =	10	
23. No. of field crew =	4	
24. Load capacity of a 20 ton truck (tons) =	15	
25. Round trip travel time to non-haz waste landfill (hr) =	1	
26. Loads of non-haz waste or trips (hrs)=	696	
27. Output of wheel loader (cy/day) =	550	
28. No. of wheel loaders on site =	2	
29. No. of field days =	9	
30. No. of truckloads of stormwater for off-site disposal =	4	
31. Volume of water truck (gal) =	4000	
32. Volume of stormwater requiring off-site disposal (gal) =	16000	

33. Stormwater shall be analyzed for TCLP semivolatiles prior to transport.
34. At one sample per truckload, number of samples (ea) = 4
35. Excavated soil is staged in 500 ton piles.
36. One 10-point composite sample shall be collected from each 500-ton pile as part of compliance testing.
37. Standard work week is 5 days per week at 8 hours per day.

Table 2-26

Cost Estimate of Selected Remedy
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

9.0 Off-Site Disposal (continued)					
Service/Materials	**Unit**	**Unit Cost**		**Subtotal**	
Labor:					
Site Superintendent	72	$49.00	/hr	$3,528.00	
QA Coordinator	72	$36.00	/hr	$2,592.00	
H&S Coordinator	72	$49.00	/hr	$3,528.00	
Equipment Operator	9	$406.00	/day	$3,654.00	
Equipment Operator	9	$406.00	/day	$3,654.00	
Laborer/Oiler	9	$293.00	/day	$2,637.00	
Laborer/Oiler	9	$293.00	/day	$2,637.00	
Materials:					
Level D PPE	36	$10.00	/day	$360.00	
Equipment:					
Wheel Loader	0.5	$5,000.00	/mo	$2,500.00	
Wheel Loader	0.5	$5,000.00	/mo	$2,500.00	
Office Trailer	0.5	$800.00	/mo	$400.00	
Porta Jon	0.5	$175.22	/mo	$87.61	
Generator	0.5	$170.35	/mo	$85.18	
P/U Truck	0.5	$1,800.00	/mo	$900.00	
Disposal Costs:					
Transportation (Non-Haz Waste)	696	$72.00	/hr	$50,112.00	truck & driver
Disposal Cost (Non-Haz waste)	10432	$24.50	/ton	$255,584.00	
Transportation (Haz Waste)	0	$35.00	/ton	$0.00	
Disposal Cost (D008 haz waste)	0	$85.00	/ton	$0.00	
Disposal Cost (D030 haz waste)	0	$160.00	/ton	$0.00	
Disposal Cost (PCB haz waste)	0	$85.00	/ton	$0.00	
Stormwater Disposal	16000	$0.25	/gal	$4,000.00	Enviro-Tank Clean
Analytical:					
Compliance Sampling:					
TCLP SVOC/NAC/metals	20	$400.00	/ea	$7,888.00	
Stormwater Sampling:					
TCLP 2,4-DNT	4	$175.00	/ea	$700.00	
				Subtotal	**$347,347.00**

Table 2-26

Cost Estimate of Selected Remedy
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

10.0 Site Restoration

Includes:
1. Backfill excavated areas with alkaline hydrolysis traded soil and clean backfill.
2. Re-seed site.
3. Perform road repair.

Assumptions and Calculations:

1. Required volume of consolidated soil for excavated area (cy) =	9205	
2. Compaction factor =	1.15	
3. Volume of soil required for backfill (cy) =	10586	
4. Volume of alkaline hydrolysis treated soil (cy) =	1936	(less the lead contaminated soil)
5. Volume of required clean backfill (cy) =	8650	
6. Cost of clean backfill soil delivered to site ($/cy) =	12	
7. Output of front-end loader (cy/day) =	550	
8. Field days required to backfill soil =	20	
9. No. of field crew =	3	

10. Upon completion of remedial action soil samples shall be taken within the laydown area to determine if any soil removal is required.
11. The laydown area shall be divided into 4 quarters and a 5-point composite collected (4 samples total).
12. No. of soil samples (ea) = 4
13. Allow 1 week for reseeding site and road repair.
14. Task duration (days) = 25
15. Standard work week is 5 days per week at 8 hours per day. Thus, assuming 22 working days per month.

Service/Materials	Unit	Unit Cost		Subtotal	
Labor:					
Site Superintendent	200	$49.00	/hr	$9,800.00	
QA Coordinator	200	$36.00	/hr	$7,200.00	
H&S Coordinator	200	$49.00	/hr	$9,800.00	
Equipment Operator	20	$406.00	/day	$8,120.00	
Equipment Operator	20	$406.00	/day	$8,120.00	
Laborer	20	$341.60	/day	$6,832.00	
Reseeding	1	$5,000.00	/area	$5,000.00	
Road Repair	1	$175,000.00	/ls	$175,000.00	Erie Blacktop
Equipment:					
Dozer	1	$3,500.00	/mo	$3,500.00	
Wheel Loader	1	$5,000.00	/mo	$5,000.00	
Office Trailer	2	$800.00	/mo	$1,600.00	
Porta Jon	2	$175.22	/mo	$350.44	
Generator	2	$170.35	/mo	$340.70	
P/U Truck	2	$1,800.00	/mo	$3,600.00	
Material:					
Backfill	8650	$12.00	/cy	$103,794.36	delivered to site
PID rental	1	$974.00	/mo.	$974.00	
CGI rental	1	$380.00	/mo.	$380.00	
Level D PPE	75	$10.00	/day	$750.00	
Analytical:					
SVOCs	4	$175.00	/ea	$700.00	
NACs (8330)	4	$145.00	/ea	$580.00	
Shipping	4	$40.00	/ea	$160.00	
				Subtotal	**$351,602.00**

Table 2-26

Cost Estimate of Selected Remedy
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

11.0 Overall Cost	
Total Capital Cost	**$1,656,831.00**
Contingency (30%)	**$497,049.00**
PM Multiplier (7.5%)	**$124,262.00**
Fee/Profit (10%)	**$165,683.00**
Total Cost	**$2,444,000.00**

*This is an order-of-magnitude engineering cost estimate that is expected to be within +50 to -30 percent of the actual project cost.

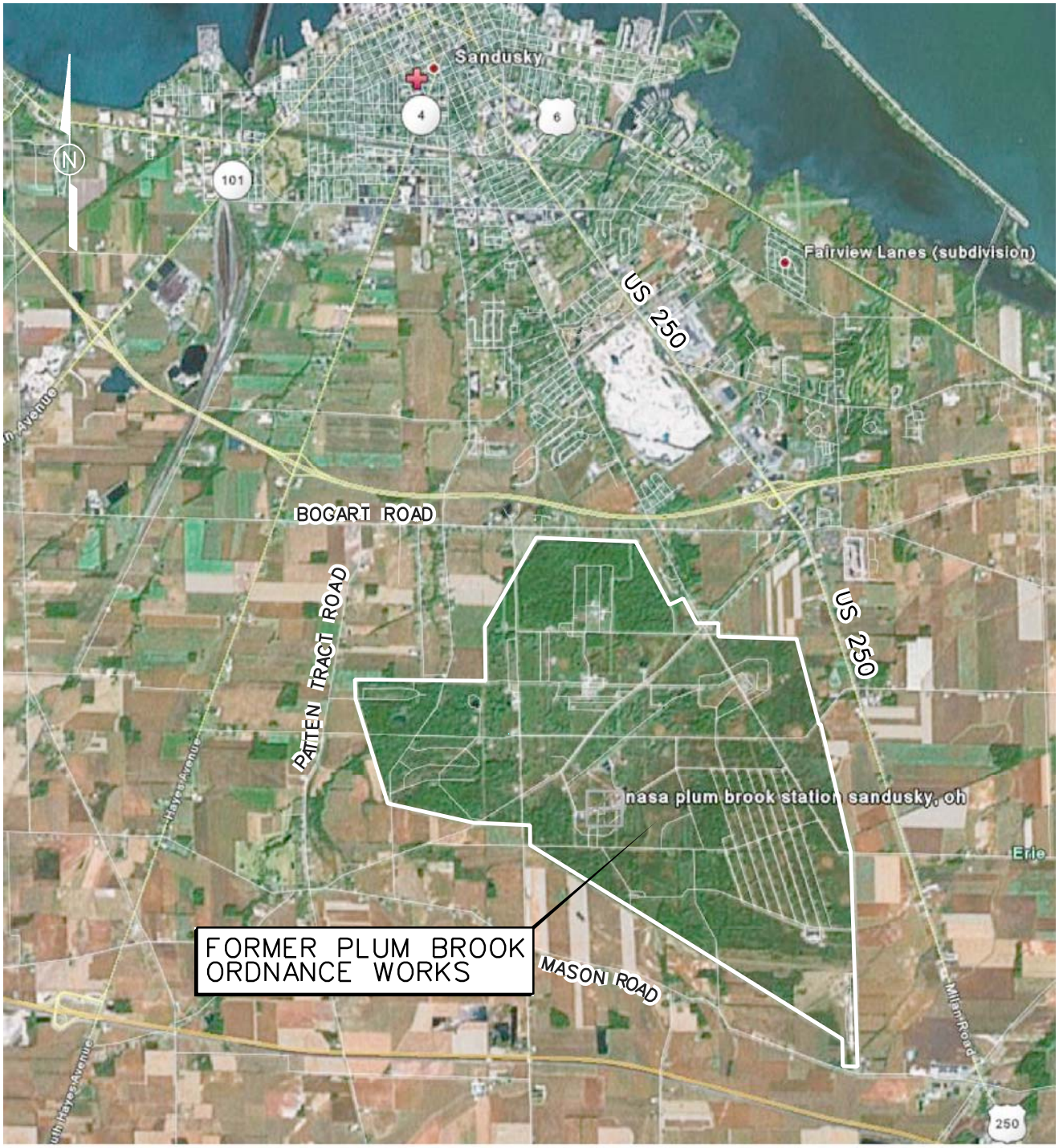
Table 2-27

Applicable or Relevant and Appropriate Requirements
TNT Area C, Former Plum Brook Ordnance Works
Sandusky, Ohio

Action	Requirement(s)	Prerequisite(s)	Regulatory Citation	Comments
Characterization of remediation waste	Generators of waste must make a hazardous waste determination. Must characterize waste by using prescribed testing methods or applying generator knowledge based on information regarding material or processes used.	Generation of remediation waste - **Applicable**	OAC 3745-52-11(A-D)	Remedial activities may generate hazardous remediation waste. Excavated soil will not be classified as a listed hazardous waste.
	Must determine if the waste is restricted from land disposal by testing in accordance with prescribed methods or use of generator knowledge of waste.		OAC 3745-270-07(A)(1)	
Alternative Treatment Standards for Contaminated Soil	If soil does not meet treatment standards when generated, soil must be treated prior to land disposal. Treatment must achieve 90% reduction in hazardous constituents or a concentration that is 10 x UTS level.	Hazardous waste that does not meet treatment standards when generated – **Applicable**	OAC 3745-270-49(A-E)	Excavated soil will be treated to alternative treatment standards prior to returning soil to AOC.
Accumulation of hazardous waste in containers	Provides for the accumulation of hazardous waste on-site for 90 days or less without a permit. Waste containers must be properly marked and labeled, and inspected weekly. Waste must be moved out of 90-day area at the end of 90 day limit.	Accumulation of hazardous remediation waste in containers – **Applicable.**	OAC 3745-52-34(A)(1)(a) OAC 3745-52-34(A)(2-4)	Applicable to the accumulation of hazardous remediation waste in containers, such as decontamination water or water generated as a result of treatment.
Storage of Remediation Waste in Staging Piles	Provides design and operating requirements for use of staging piles to temporarily store solid, non-flowing hazardous remediation waste. Staging piles must be designed to prevent or minimize releases of hazardous wastes/constituents and are generally operated for 2 years or less.	Temporary storage of hazardous remediation waste – **Applicable.**	OAC 3745-57-74(D)(1) OAC 3745-57-74(H) OAC 3745-57-74(J)	Staging piles may be used to store hazardous remediation waste (e.g., soil) prior to returning soil to AOC of origination or offsite disposal.
PCB Remediation	The cleanup level for bulk PCB remediation waste in high occupancy areas (residential exposure scenario) is <= 1 ppm without further conditions.	PCB contamination in soil at concentrations in excess of 1 ppm – **Relevant and Appropriate.**	40 CFR 761.61(a)(4)(i)(A)	PCB cleanup standard for unrestricted use (1 ppm) will be used as TNTC soil cleanup standard.
Disposal of PCB Remediation Waste	Provides disposal requirements for bulk PCB remediation waste contaminated with PCBs at concentrations < 50 ppm and > 50 ppm.		40 CFR 761.61(a)(5)(ii)-(iii)	Bulk PCB remediation waste is non-liquid waste (e.g., soil, sediments, mud)

AOC - Area of Contamination
CFR - Code of Federal Regulations
OAC - Ohio Administrative Code
PCB - polychlorinated biphenyl
TNTC - TNT Area C
UTS - Universal Treatment Standard

FIGURES



NOT TO SCALE

FIGURE 2-1
VICINITY MAP

TNT AREA C DECISION DOCUMENT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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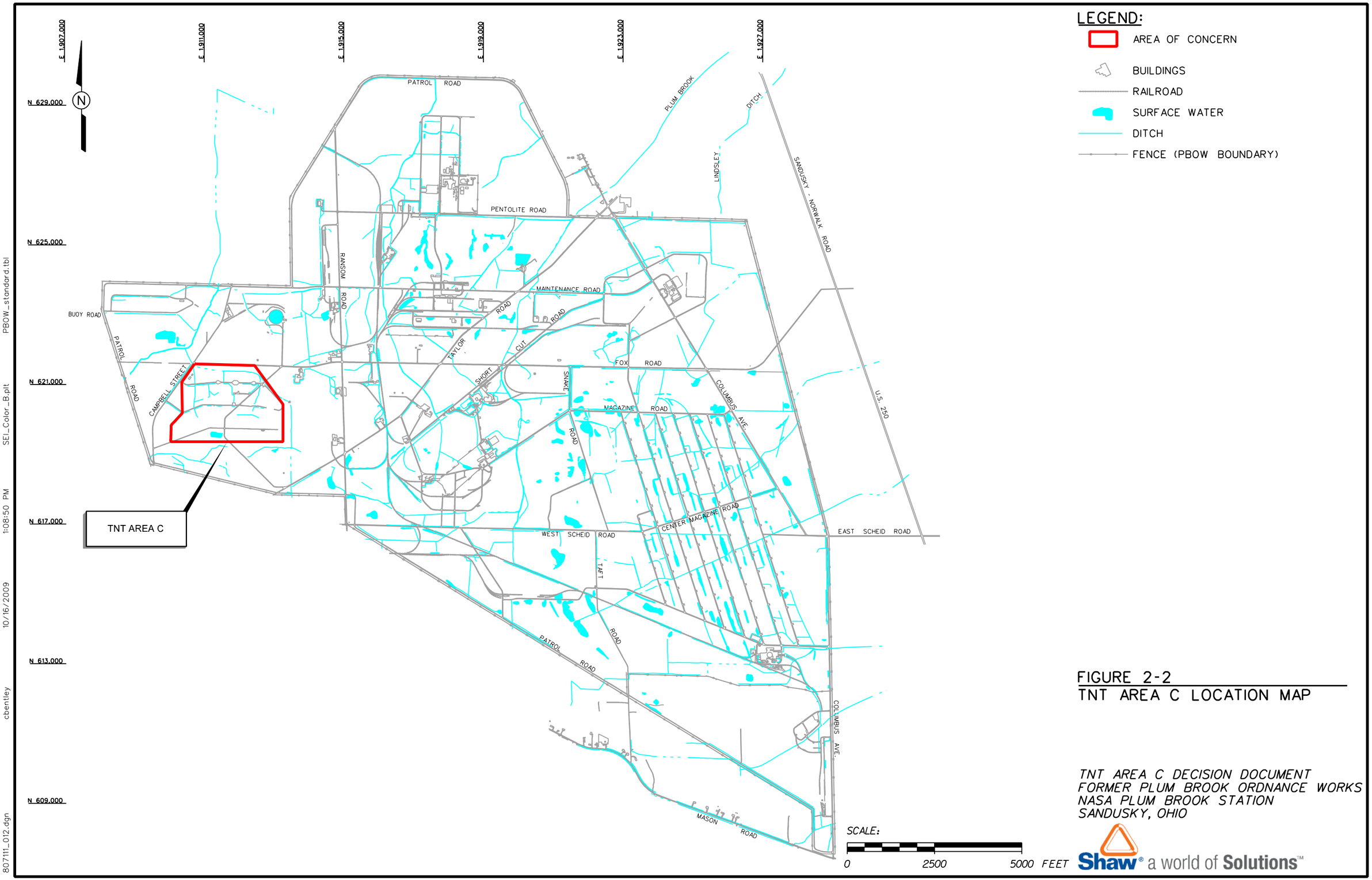

FIGURE 2-2
TNT AREA C LOCATION MAP

TNT AREA C DECISION DOCUMENT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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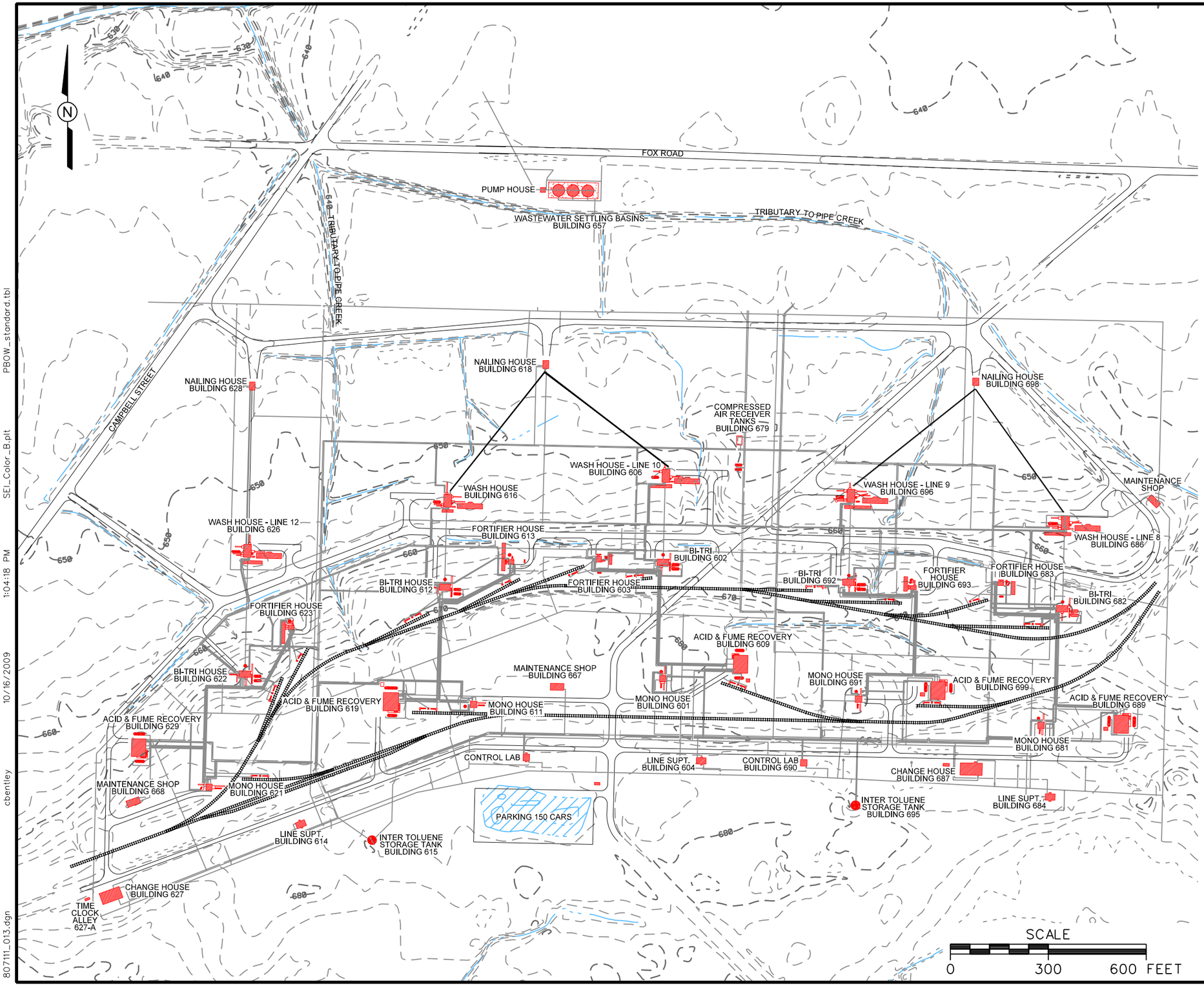

LEGEND:

- DRAINAGE
- LOW, WET AREA
- STONE-LINED DRAINAGE DITCH
- ROAD
- HISTORICAL BUILDING OR STRUCTURE
- TANK
- HISTORICAL PROCESS LINE
- 650 TOPOGRAPHIC CONTOUR LINE (FEET-MSL)
- RAILROAD

FIGURE 2-3
TNT AREA C
GENERAL SITE FEATURES MAP

TNT AREA C DECISION DOCUMENT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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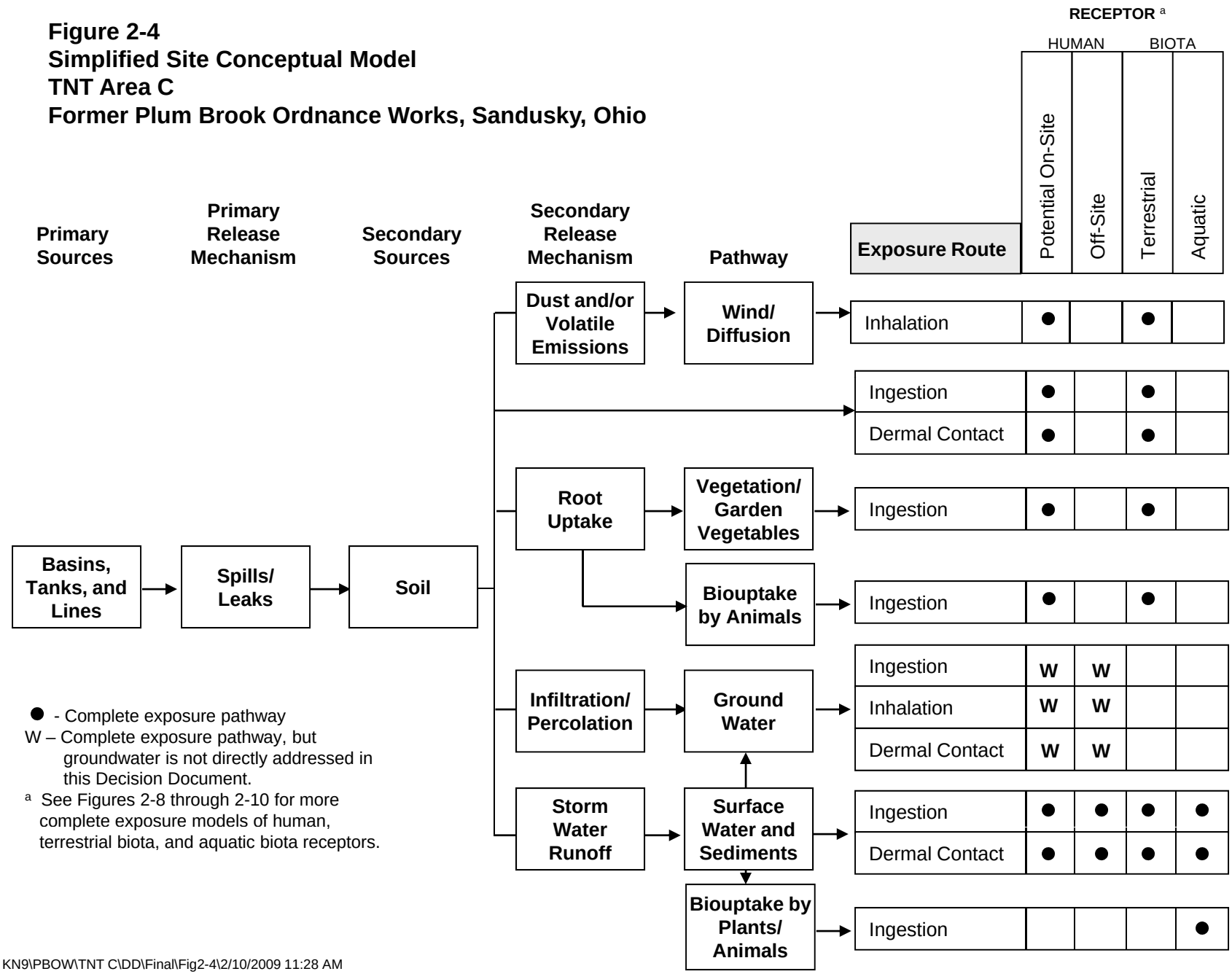
Figure 2-4
Simplified Site Conceptual Model
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio



● - Complete exposure pathway
W – Complete exposure pathway, but groundwater is not directly addressed in this Decision Document.
[a] See Figures 2-8 through 2-10 for more complete exposure models of human, terrestrial biota, and aquatic biota receptors.

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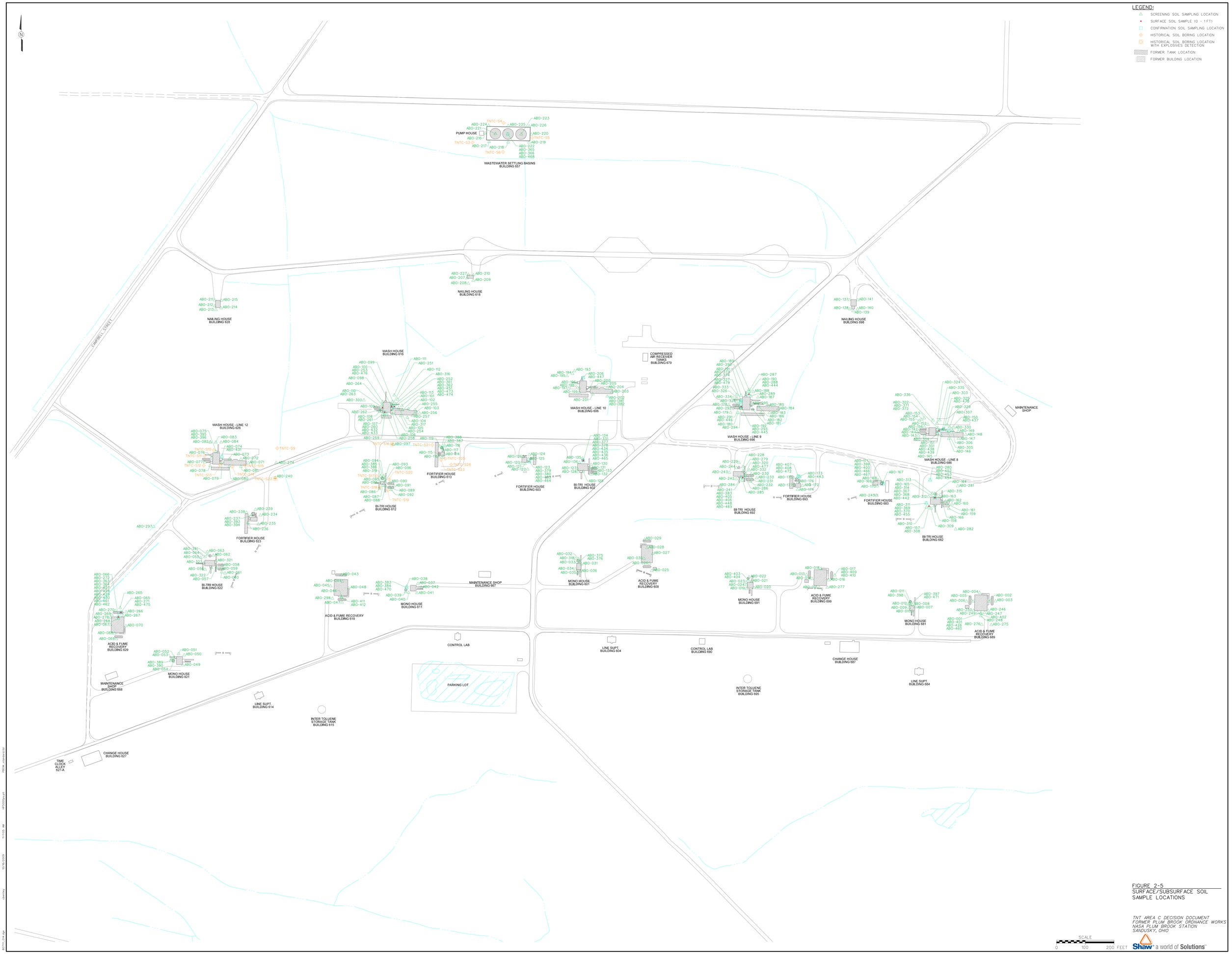
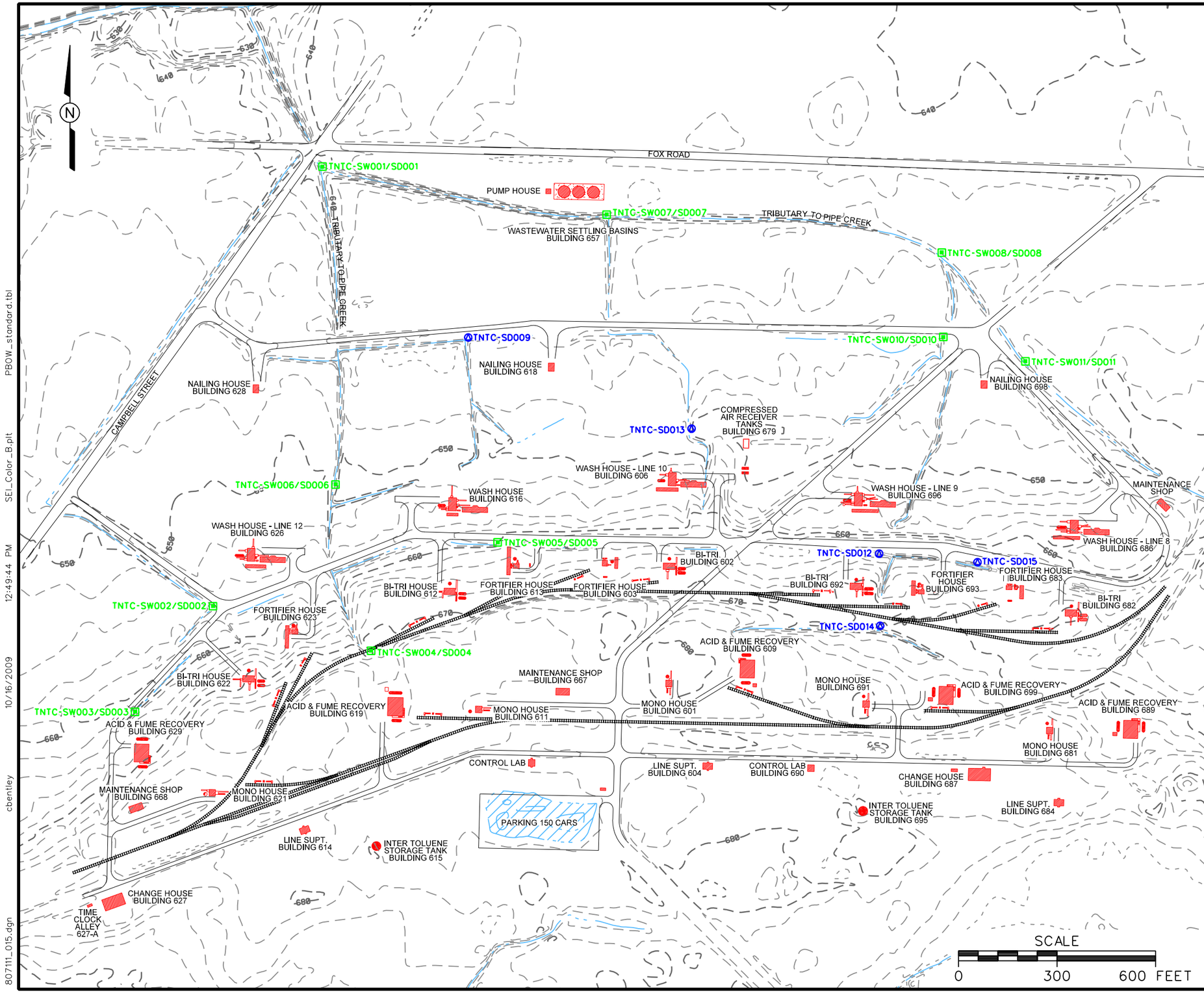


FIGURE 2-5
SURFACE/SUBSURFACE SOIL SAMPLE LOCATIONS

TNT AREA C DECISION DOCUMENT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO



LEGEND:

- DRAINAGE
- LOW, WET AREA
- ROAD
- HISTORICAL BUILDING OR STRUCTURE
- TANK
- HISTORICAL PROCESS LINE
- 650 TOPOGRAPHIC CONTOUR LINE (FEET-MSL)
- RAILROAD
- SURFACE WATER/SEDIMENT SAMPLING LOCATION
- SEDIMENT SAMPLING LOCATION

FIGURE 2-6
SURFACE WATER AND SEDIMENT SAMPLE LOCATIONS

TNT AREA C DECISION DOCUMENT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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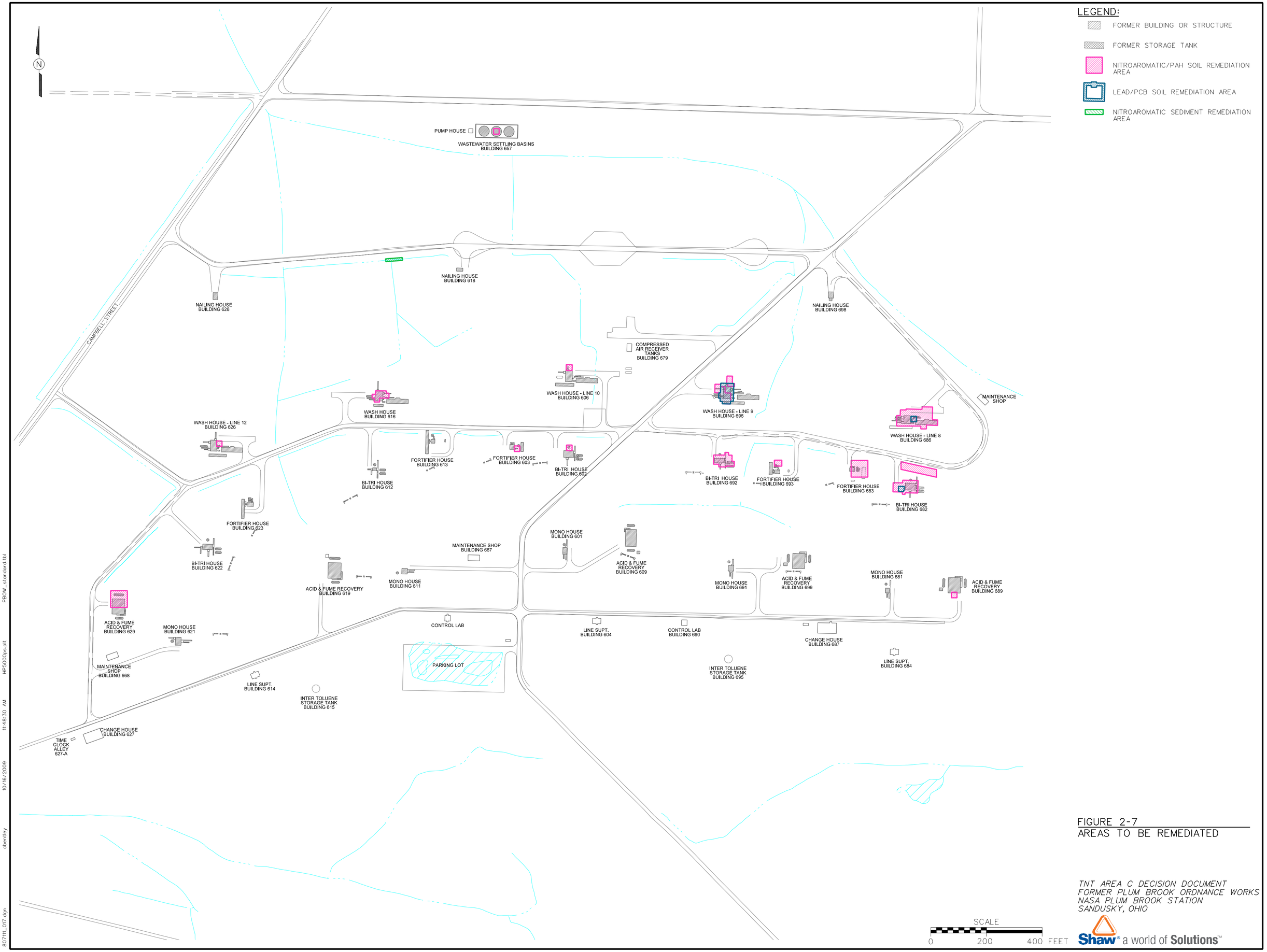

FIGURE 2-7
AREAS TO BE REMEDIATED

TNT AREA C DECISION DOCUMENT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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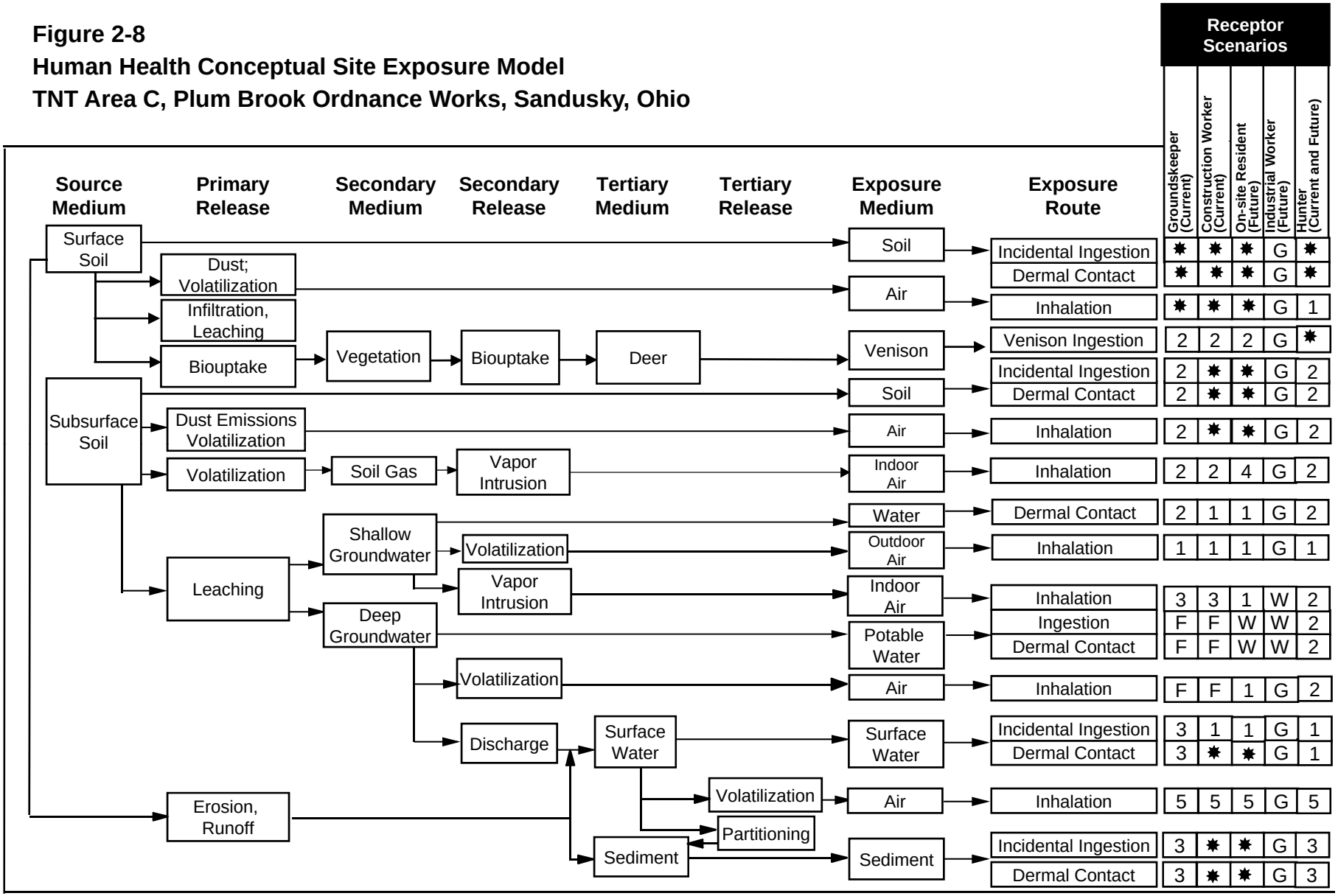
Figure 2-8
Human Health Conceptual Site Exposure Model
TNT Area C, Plum Brook Ordnance Works, Sandusky, Ohio



✸ = Complete exposure route quantified in the risk assessment
1 = Although theoretically complete, this pathway is not quantified as explained in risk assessment.
2 = There is no plausible pathway for exposure to this medium.
3 = Contact with this medium, although plausible, is not part of this receptor's normal or expected activities; therefore contact would be sporadic and is not quantified.
4 = Pathway not quantified because no volatile compounds were identified as chemicals of potential concern (COPC).
5 = Pathway not quantified because no volatile compounds were identified as COPC, and for reasons explained in the risk assessment.
G = Receptor evaluated for exposure to deep groundwater only; groundwater is not directly addressed in this Decision Document.
F = No current exposure. Exposure of future industrial worker to groundwater would be representative of future groundwater exposure for this receptor.
W = Complete pathway evaluated in the groundwater risk assessment; groundwater is not directly addressed in this Decision Document.

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Figure 2-9
Simplified Terrestrial Food Web Site Model
TNT Area C
Plum Brook Ordnance Works, Sandusky, Ohio

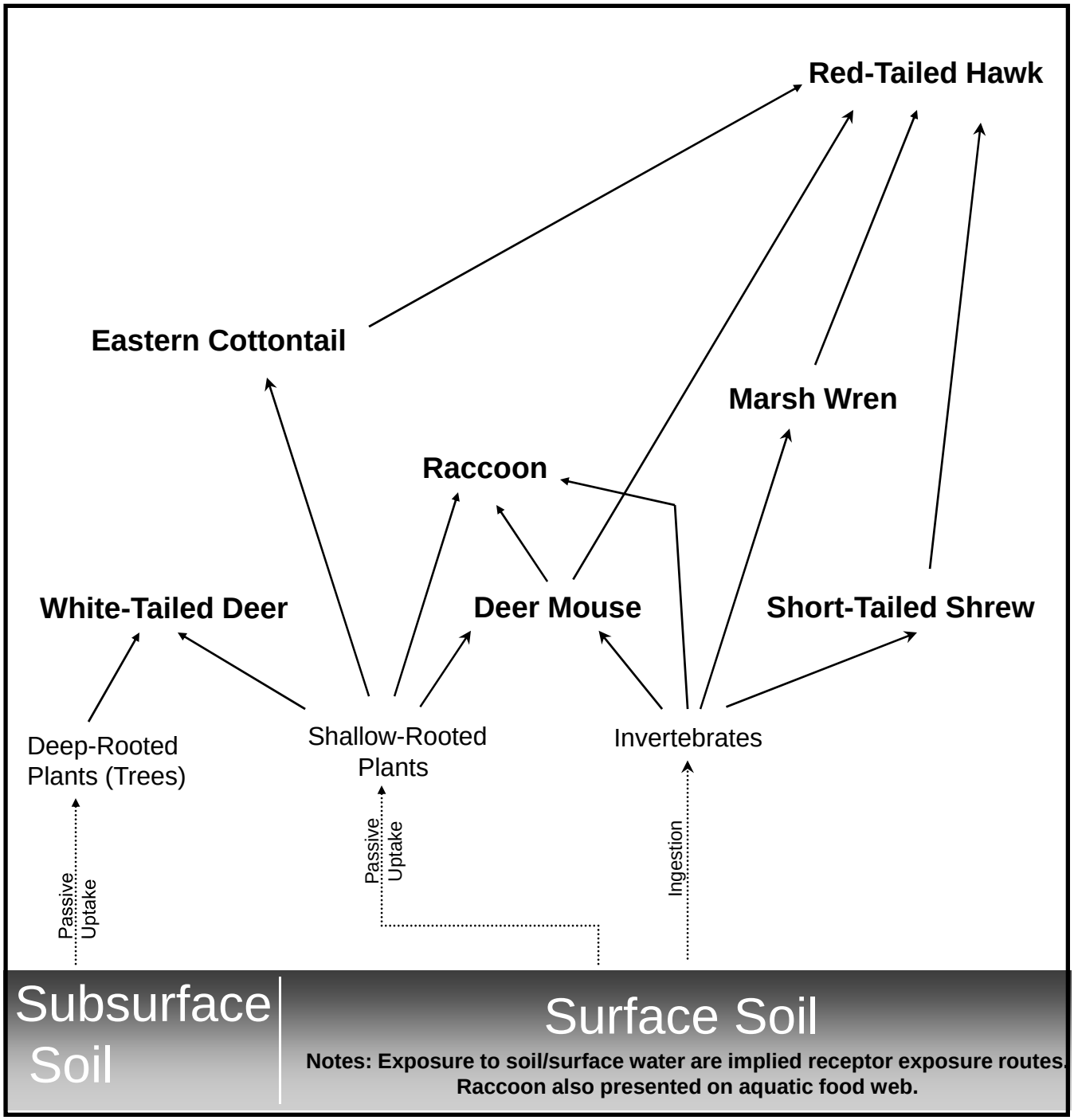
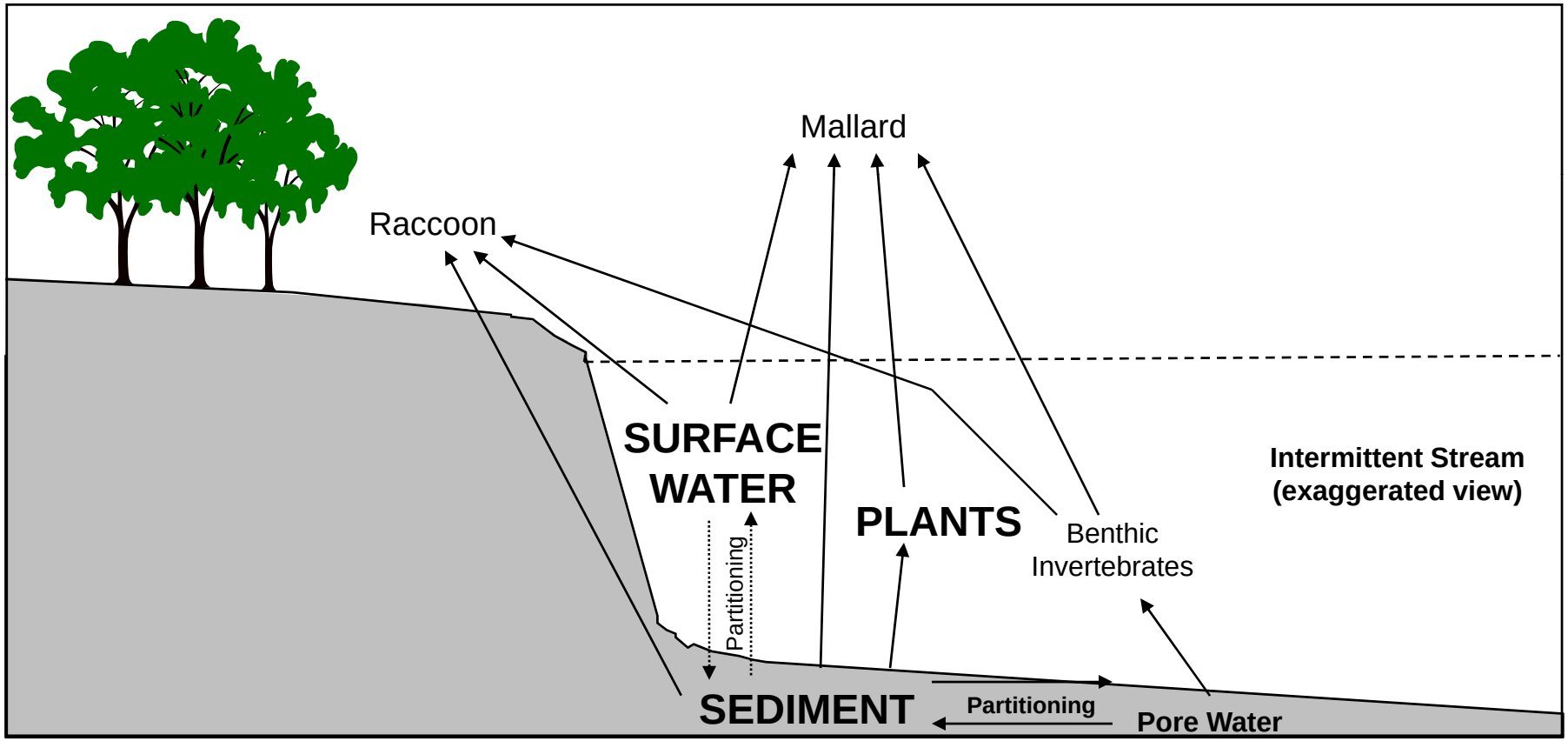


Figure 2-10

Simplified Aquatic Food Web Site Model
TNT Area C
Plum Brook Ordnance Works, Sandusky, Ohio



Note: Raccoon also presented on terrestrial food web.

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ATTACHMENT 1

FURTHER DETAIL AND CALCULATIONS IN SUPPORT OF THE RESPONSE TO COMMENT NO. 2A OF THE RESPONSIVENESS SUMMARY

The response to Comment No. 2A of the Responsiveness Summary (Section 3.0 of this Decision Document) addresses the concern as to whether the composted materials originating from Plum Brook Ordnance Works and used by the Erie County Landfill as daily cover material may pose a hazard to nearby residents. The commenter questioned whether this cover material may become airborne and result in exposure to unsafe levels of aminodinitrotoluenes (ADNT) in this material. This attachment provides the assumptions and calculations associated with inhalation exposure in support of the response to Comment No. 2A.

As discussed in the response to Comment No. 2A, the Erie County Landfill operator described the dust control measures in place to mitigate and largely prevent potential wind erosion of the daily cover material. The assumptions and calculations used to derive conservative air concentrations assume that no dust control measures are in place.

Assumptions. Soil may become entrained in air as dust through wind erosion or dust-raising activities. Because heavy equipment is used to emplace the daily cover, dust-raising activities were assumed to be responsible for concentrations of dust in air. A dust-loading factor of 1E-7 kilograms of soil per cubic meter of air (kg/m^3) was used for the groundskeeper in the TNTC baseline human health risk assessment (BHHRA) (IT, 2001). For comparison, a dust-loading factor resulting from wind erosion, which is typically used in a residential scenario, can be derived as the reciprocal of the wind erosion particulate emission factor (PEF), which is given in cubic meters of air per kilogram of soil (m^3/kg). The site-specific PEF used in the TNTC BHHRA is 1.56E+9 kg/m^3. Thus, the dust-loading factor based on this value would be 6.4E-10 kg/m^3, which is over 150 times less than the dust-loading factor used for the TNTC groundskeeper (1E-7 kg/m^3). In short, the air concentration of the nearest residence, which is over 0.5 mile away, is likely to be greatly overestimated by the use of the groundskeeper dust-loading factor as compared to the PEF approach typically taken under residential exposure. However, the activity-based dust loading factor is used in this evaluation for conservativeness.

The concentrations of the ADNT isomers that may result in the composted TNTC material cannot be known. However, the maximum ADNT concentration detected in the samples collected from the stockpiled TNTB material that was used as Erie County Landfill daily cover is 11.8 milligrams per kilogram (mg/kg) (Wastetron, Inc., 2006), and the maximum ADNT concentration among the TNTB stockpile samples was 2.4 mg/kg. This maximum concentration approximates the 4-ADNT concentration of 11.3 mg/kg used in the TNTC risk assessment for untreated soil. For conservativeness and simplicity of calculations, this value of 11.3 mg/kg is assumed in this evaluation as a conservative estimate of the average ADNT concentration that

might be associated with TNTC materials that could potentially be used as daily cover at the Erie County Landfill.

The 4-ADNT concentration of 11.3 mg/kg resulted in an inhalation intake rate to the groundskeeper of 2.21E-7 milligrams per kilogram per day (mg/kg-day) (Table B2-1 of the TNTC BHHRA [IT, 2001]). The young child is evaluated under a residential scenario for noncarcinogenic effects because, on a per-body-weight basis, the young child resident receives a greater intake rate than an adult resident. (Note that ADNTs are not known to be carcinogenic.) The groundkeeper intake rate from the TNTC BHHRA can be converted to the intake rate for a child resident by multiplying the groundkeeper by an exposure adjustment factor. This exposure adjustment factor is based on the differences of the exposure parameter values used for the groundskeeper versus the child resident.

Calculations. The following equation is used to estimate the inhaled intake rate of a chemical in air:

$$I_a = \frac{(C_a)(FI)(IR)(EF)(ED)}{(BW)(AT)} \qquad \text{Eq. 1}$$

Where:

I_a	=	inhaled intake rate of COPC (mg/kg-day, calculated)
C_a	=	concentration of COPC in air (mg/m^3)
FI	=	fraction of exposure attributed to site media (unitless)
IR	=	inhalation rate (m^3/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days).

The following parameter values differ for the child resident and groundskeeper: IR, EF, ED, BW, and AT. Because the AT is simply the ED multiplied by 365 days per year for noncarcinogens, these two values can be ignored for the sake of deriving the groundskeeper-to-child-resident exposure adjustment factor. The respective IR, EF, and BW used in the TNTC BHHRA are shown in the table below.

Pertinent Parameter Values for Deriving a Groundskeeper-to-Child Resident Exposure Adjustment Factor for Inhalation		
Parameter (units)	*Groundskeeper*	*Child Resident*
IR (m^3/hour)	20	10
EF (days/year)	250	350
BW (kg)	70	15

The exposure groundkeeper-to-child-resident exposure adjustment factor may be derived as follows:

$$EAF_{gk-cr} = \frac{\left(\frac{IR_{cr}}{IR_{gk}}\right)\left(\frac{EF_{cr}}{EF_{gk}}\right)}{\left(\frac{BW_{cr}}{BW_{gk}}\right)} \qquad \text{Eq. 2}$$

Where:

EAF_{gk-cr} = groundskeeper-to-child resident exposure adjustment factor (unitless)
IR_{cr} = inhalation rate for child resident (m^3/day)
IR_{gk} = inhalation rate for groundskeeper (m^3/day)
EF_{cr} = exposure frequency for child resident (days/year)
EF_{gk} = exposure frequency for groundskeeper (days/year)
BW_{cr} = body weight for child resident (kg)
BW_{gk} = body weight for groundskeeper (kg).

Using the exposure parameter values in the table above, Equation 2 results in a groundskeeper-to-child resident exposure adjustment factor of 3.3.

As discussed above, the maximum ADNT concentration in the TNTB stockpiles (11.8 mg/kg) approximates the 4-ADNT value (11.3 mg/kg) used in the TNTC BHHRA. If the associated TNTC groundskeeper intake rate for 4-ADNT of 2.21E-7 mg/kg-day is multiplied by the groundskeeper-to-child resident exposure adjustment factor of 3.3 calculated above, the resulting value of 7.3E-7 mg/kg-day would approximate the intake rate received by a resident child under the exposure assumptions described in this attachment.

Conclusions. A hazard quotient (HQ) is used as a metric of noncancer hazard. HQ values of up to 1 are regarded as unlikely to result in adverse human health effects. The HQ is derived by dividing the intake rate by the chemical-specific chronic reference dose (RfD). For the inhalation pathway, the RfD is derived from the chronic reference concentration (RfC). No RfC exists for ADNTs, but a provisional oral RfD of 2E-4 mg/kg-day) is available (EPA, 2003) and is used in this evaluation.

An HQ of 0.004 is calculated for inhalation exposure by the child resident by dividing the intake rate of 7.3E-7 mg/kg-day by the oral RfD of 2E-4 mg/kg-day. This value is (far) less than the HQ criterion of 1, indicating that adverse human health effects associated with exposure by a resident to this stockpiled material via inhalation exposure is unlikely.

Uncertainties. The following notable uncertainties are identified:

1. Dust control measures that are practiced by the Erie County Landfill were not considered in the derivation of the exposure estimate for the nearby resident. This confers a conservative bias.

2. Use of the groundskeeper dust-loading factor for a resident more than 0.5 mile from the landfill likely adds a conservative bias.

3. Use of an average ADNT soil concentration that approximates the maximum detected in the TNTB stockpiles likely adds a conservative bias.

4. Because no inhalation toxicity value is available for ADNTs, the provisional oral RfD was used to estimate noncancer hazard. It cannot be determined whether use of this oral value introduces a conservative or nonconservative bias for evaluation of inhalation health effects.

References

IT Corporation (IT), 2001, ***TNT Areas A and C Remedial Investigation, Volume II – Human Health Risk Assessment, Final, Former Plum Book Ordnance Works, Sandusky, Ohio,*** November.

U.S. Environmental Protection Agency (EPA), 2003, ***Risk Assessment Issue Paper for: Provisional Subchronic and Chronic RfDs for 2-Amino-4,6-Dinitrotoluene (CASRN 35572-78-2) and 4-Amino-2,6-Dinitrotoluene (CASRN 19406-51-0) by Analogy to 2,4,6-Trinitrotoluene***, National Center for Environmental Assessment, Cincinnati, OH, 23 January.

Wastetron, Inc., 2006, ***Interim Soil Removal Action Report, TNTB Soil Excavation and Ex-Situ Stabilization, Plum Brook Ordnance Works, Sandusky, Ohio***, May.

RESPONSES TO COMMENTS ON THE MARCH 26, 2009 DRAFT DECISION DOCUMENT

(Note that responses to comments on the Proposed Plan received during the public meeting and public comment period are presented in the Responsiveness Summary, included as Section 3.0 of the Decision Document.)

Responses to Comments on the Draft Decision Document for TNT Area C Soil and Sediment
Former Plum Brook Ordnance Works, Sandusky, Ohio
March 26, 2009

Comments by Julie Weatherington-Rice, Ph.D., RAB TAPP Coordinator received June 9, 2009.

General Comments

Comment 1: **These documents, like most of the documents developed for the Plum Brook Ordnance Works (PBOW) site are rift with acronyms and abbreviations. While this document contains the typical "List of Acronyms" in the Table of Contents, there are a number of terms that are not in the common usage (such as OEPA or VOC) which are easily recognized at this point in the process by the lay reader. I had a hard time remembering that "LOAEL" stood for "lowest-observed-adverse-effects level" and "NOAEL" stood for "no-observed-adverse-effects level" through the section where they were discussed (pages 2-27 and 2-28).**

While I can appreciate that the authors are so acclimated to writing these types of documents that the use of these less common acronyms and abbreviations are second nature to them, that is not the case with the lay reader. All documents for this site, especially the more arcane risk assessments, would greatly benefit from a final edit that replaced the less common acronyms and abbreviations with the actual phrase. This could be achieved simply by using the "Find All" and "Replace All" editing tool in their word processing program. For instance, all locations where the term "NOAEL" has been entered could be searched and replaced with the actual term "no-observed-adverse-effect level". If for some reason, there is a compelling need to keep the abbreviation, the replacement could be "NOAEL (no-observed-adverse-effect level)" as it was in the first listing. I am certain that many readers would appreciate that courtesy. I will continue to make this general comment on each subsequent document that I review that is riff with jargon and acronyms. If these documents are to be reviewed by the general public, they must strive to be more "lay reader friendly".

Response 1: We agree that the Decision Document contains numerous acronyms. However, the reviewer should understand that like the remedial investigation and feasibility study, the TNTC Decision Document is a technical document written consistent with U.S. Environmental

Protection Agency (EPA) (1999) guidance. Its audience includes regulators and technical specialists from the fields represented by its content. Given the technical members of the audience, it would be highly unusual to avoid the use of common acronyms in these technical fields. Note that of the four acronyms mentioned by the reviewer, three of these (VOC, LOAEL, and NOAEL) are highlighted in the EPA (1999) guidance as information that should be provided in a decision document. EPA includes acronyms in its recommended language, fully aware that the public reviews decision documents. We agree with EPA's recommendation and do not think that the use of acronyms reduces the readability of the documents to the average lay reader, provided that the acronyms are duly defined. It is our impression that the public RAB members are generally even more well-read and more highly educated than the average lay reader.

The main purposes of acronyms are to: 1) save print and paper, and 2) streamline the presentation, making it easier to read/scan. Acronyms have appeared for millennia, and they have been commonly used in the English language for more than a century. Their general acceptance is documented by the venerated Gregg Reference Manual (Sabin, 2001) writing style guide: "Because they have been deliberately coined to replace the longer expressions that they represent, acronyms are appropriate on all occasions."

The lay audience is highly familiar with the use of acronyms, as dozens of them appear in the typical newspaper each day. The TNTC Decision Document follows the standard technical style of: 1) making acronyms of appropriate terms only if they appear a minimum of three times in the document, 2) defining the acronym at its first occurrence and, 3) providing a list of acronyms as a "cheat sheet" immediately following the table of contents. Please note that the daily newspaper typically does not provide any of these three courtesies to assist the reader. The public is not only practiced at reading acronyms, but is often more familiar with the acronym than the term for which it stands (e.g., NASA, NATO, CD-ROM, UCLA, URL). Most individuals may not even recognize certain terms as acronyms (e.g., radar, laser, scuba).

As the reviewer points out, the TNTC Decision Document uses certain acronyms that are likely to be unfamiliar to the majority of the readers. This is precisely the reason why the authors of the document take care to clearly identify the acronyms used and provide a list of acronyms that is easily found. A few of the acronyms found during a quick scan of the local newspaper during the day of this response include GOP, NACDL, ETTAC, LEED, and PRIDE. In no case was the acronym identified in the newspaper as clearly as in the TNTC Decision

Document. The reviewer states that the lay reader is not familiar with the specific acronyms used in the TNTC Decision Document. This is agreed. However, the lay reader is probably not familiar with most of the five acronyms listed above from the newspaper; the reader understands that the terms are defined from the context of their usage. As mentioned, the TNTC Decision Document goes beyond the practice of letting the reader interpret the acronym by context, as it spells out the full term and, to communicate clearly, presents the acronym parenthetically and includes it in the full acronym list.

The reviewer states that she had difficulty remembering the definitions of LOAEL and NOAEL on pages 2-27 and 2-28. Both terms are specifically defined on page 2-27, so there is no need to remember the difference or even a need in this case to turn to the list of acronyms for clarification. It is more likely that her difficulty is related to the similarity of the two acronyms rather than a need of having to remember. However, this similarity arises from the similarity of the two terms, "lowest-observed-adverse-effect level" and "no-adverse-observed-effect level." If the spelled-out terms were used, mistakes could likewise be made as 29 of the 31 characters in "no-observed-adverse-effect level" are shared by "lowest-observed-adverse-effect level." Such mistakes would be even more likely if an individual were scanning the document rather than giving it full attention. Also, as noted above, the acronyms "LOAEL" and "NOAEL" are specifically identified in the EPA (1999) decision document guidance as information that should be provided in a decision document.

The reviewer correctly points out that the document contains numerous acronyms. However, other than the difficulty posed by the similarities of "NOAEL" and "LOAEL" discussed in the previous paragraph, she does not describe her perception of how the use of acronyms adversely affects the quality of the document. As demonstrated above, the use of acronyms is common to the lay reader and is acceptable (Sabin, 2001), even if these lay readers were never to pick up a technical document (such as a decision document written consistent with EPA guidance). Communication difficulties associated with the use of acronyms generally arise only if the acronyms are not adequately defined. All acronyms in the TNTC Decision Document are adequately defined and are also included on the list of acronyms. Further, given their common use and acceptance in daily communications as well as in technical writing, we are of the opinion that the proper use of acronyms streamlines the communication, and makes the document more readable. We think that "LOAEL," composed of 5 characters, may be easier to read (especially multiple times) than "lowest-observable-adverse-effect level," composed of 37 characters. Similarly, we think that an otherwise unfamiliar term such

as "TNTC" is easier to read than "the former 2,4,6-Trinitrotoluene Manufacturing Area C", especially multiple times. As such, we believe that the appropriate use and proper identification of acronyms provide a courtesy rather than a hindrance to the reader and thus help to improve the overall document quality.

Comment 2: **The document benefits from all the strengths of the previous documents, such as the excellent background description of historical activities at the site located in Section 2.2 "Site History and Regulatory Authority" and the excellent graphics.**

Response 2: Comment noted and appreciated.

Comment 3: **This proposed project clean-up effort, like the ones before, does not contain a set of control sites and control procedures by which is would be possible to determine just how effective the clean-up efforts are. A set of control practices are usually included as part of the QA/QC process. Since there was a level of QA/QC process built into the McTech lime and composting process for the treatment of the Pentolite Road Red Water Pond soils, failing to identify a full QA/QC protocol in this draft document, or at least the need for one, makes it difficult to determine how effective these five proposed remediation techniques will be and to determine after completion, just what worked and what didn't. There are some changes in the pre-composting process of alternative five, the preferred alternative, discussed below, that may or may not have impacts on the composting process. However, there is no mechanism built into the remediation techniques to determine if this change in pre-composting treatment will make a difference.**

We are being asked to move from a proven technology at the Pentolite Road Red Water Pond of slaked lime and then composting with chicken manure and straw to a technology that replaces the slaked lime with another alkaline chemical mixture of caustic soda and ferric chloride. This is a different chemical mix. Slaked lime is "calcium hydroxide" with a chemical composition of "$Ca(OH)_2$". This time the recommended mixture is "caustic soda" or "sodium hydroxide" or "lye" with a chemical composition of "NaOH" and "ferric chloride" with a chemical composition of "$FeCl_3$". This process removes the additional calcium that was added last time and instead replaces the mixture with sodium, iron, and chloride. The mixing of sodium and chloride may form salts in the treated soil and the iron will add an additional metal that needs to be reduced in mobility if it is not successfully bound up with the contaminants.

Maybe this mix will work better, maybe it won't. Do we have any idea what the impact will be on the composting part of the process? Will we see the same results from the chicken manure and straw additions that we saw at the Pentolite Road Red Water Pond clean-up? Will the composting process be enhanced? Will it be impeded? What will this mix do to the various microbiological communities that are so necessary for the composting process to be successful? We simply do not know. That information is not included in this document. In addition, we don't have any test piles using "slaked lime" as a control to be able to measure the differences. I have included more discussion on this issue in the "Specific Comments" section below.

There are five alternatives being considered for clean-up of the TNT Area C soils and sediments. The alternative of choice of Alternative 5 is a modification of the Alternative chosen for the clean-up of the Pentolite Road Red Water Pond site.

Response 3: Slaked lime was not used during remediation of the Pentolite Road Red Water Pond (PRRWP) Area remediation. Alkaline hydrolysis with NaOH is a proven technology for the reduction of nitroaromatics. It is especially effective on 2,4,6-trinitrotoluene (TNT) and does not generate aminodinitrotoluene (ADNT) isomers. There is good evidence to indicate that alkaline hydrolysis using NaOH will work based on the use of this technology at other sites and a treatability study conducted specifically for PBOW. The treatability study included the use of a control as well as treatments with various alkalizing agents including lime. The treatability study results will be submitted in July 2009.

The reviewer states: "…failing to identify a full QA/QC protocol in this draft document, or at least the need for one, makes it difficult to determine how effective these five proposed remediation techniques will be and to determine after completion, just what worked and what didn't." It appears that the reviewer believes that five different remedial alternatives (including Alternative No. 1 No Action) will be employed. This is not the case. The USACE solicited comments on Alternative 5 as the Preferred Alternative in the Proposed Plan. Neither the public nor the state expressed any objections during the public meeting or public comment period. Only the technologies described under Alternative 5, the selected remedy, will/may be employed. The other alternatives were considered, but as described in this decision document, were not selected.

The PBOW is a Defense Environmental Restoration Program (DERP) - Formerly Used Defense Site (FUDS) site. DERP-FUDS sites follow the site investigation, decision, and remediation process that is consistent with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). This process is described in the EPA National Oil and Hazardous Substances Pollution Contingency and Plan (NCP) under CERCLA (40 CFR 300). The NCP clearly describes that the decision document (Record of Decision) is submitted and signed [(300.430)(f)(5)] prior to the remedial design/remedial action stage [(300.435)]. The level of detail appropriate for the description of alternatives is, according to EPA (1999) guidance, the inclusion of "… enough information so that the comparative analysis of alternatives can focus on the differences or similarities among alternative with respect to the nine evaluation criteria." The section on the selected remedy should be expanded to "give a design engineer enough information to correctly interpret the technical intent of the (Decision Document)." This information is excerpted from the feasibility study. The level of detail and type of information described by the reviewer's first paragraph would be considered for inclusion in the remedial design stage.

Specific Comments

Comment 1: **Section 2.4 Scope and Role of TNTC, Red Water Pond Areas, page 2-8.**
"The USACE conducted field-scale and laboratory-scale treatability studies to determine the best approach to address this additional contamination at the PRRWP site." Would it be possible to list who did the laboratory-scale studies and the documents that they generated? If there were no documents, would it be possible to list contact information? Would it be possible to provide a quick summary of the laboratory-scale studies and what they used so it could be compared against this treatment recommendation?

Response 1: The treatability study report will be completed in July 2009. A copy will be sent to the PBOW Team, including the reviewer.

Comment 2: **Section 2.7.2.4 Ecological Risk Characterization, Predictive Risk Estimations for Terrestrial and Aquatic Wildlife, page 2-29**
In the last Jacobs report on the Reservoir No. 2 Burning Grounds, we enquired if it would be possible to screen the whole feeding range of the larger foragers and hunters to see how many acres of their total range(s) is/are impacted, not just the portion of their range located in the TNT Area C contaminated area. This review would help to put the total impacted area of their ranges in

perspective so not only would we know how much of their range(s) were impacted by the TNT Area C contaminated soils and sediments but how much more might be contributing to their total toxic loading. Typically, clean-ups are driven by human health issues, not ecological issues. If each clean-up site was placed in the middle or at the edge of a circle encompassing the typical large home ranges of grazing animals and hunting birds, it might be found that the cumulative exposures to all the contaminated locations in their home range resulted in an ecological risk driven clean-up. It would be useful information to try that broader screening approach when new ecological risk assessments are undertaken.

Response 2: For the TNTC ecological risk assessment (IT, 2001), a foraging factor of 100 percent was used. As described in Table 5-9 of the ecological risk assessment, this assumption tends to overestimate exposure and associated risks. Therefore, the concern regarding foraging range has no relevance for TNTC.

Comment 3: **2.7.3 Discussion of Human Health and Ecological Risk Results, page 2-32**

"Because of uncertainties associated with ecological toxicity and the fact that no areas of stress vegetation have been observed, RAOs based specifically on ecological risk were not recommended in the ERA or FFS for soil and sediment." There continues to be a misconception in these documents that vegetation must show signs of stress to be toxic. This is not necessarily the case when dealing with the bioaccumulation of heavy metals. Vegetative uptake can concentrate heavy metals out of the soil, rendering them toxic for grazers and rendering the soil cleaner. The only way to know if this condition is indeed true is to take tissue samples of the plants and have them run for heavy metal levels. Without that step and its documentation here, this is an unsupported conclusion.

Response 3: It is agreed that a lack of vegetative stress alone is not an indication of no cause for ecological concern. However, vegetative stress, if present, would most certainly suggest a cause for ecological concern. Thus, the lack of vegetative stress is indeed a positive indication of ecological health, but not a conclusive indication. The paragraph referenced by the reviewer goes on to state that the major risk drivers for ecological concerns are also the major risk drivers for human health and that, consequently, the attainment of human health remedial goals will also result in substantial reduction in ecological hazards. This paragraph also references Section 2.8.1 (and Table 2-22) where the estimated hazard quotient for TNT is reduced nearly 30,000-fold to an ecologically safe level. For further clarification, the referenced

sentence will be revised consistent with the following: Because of uncertainties associated with ecological toxicity, ~~and~~ the fact that no areas of stress vegetation have been observed, *and the assessment that the human health-based RGs adequately address ecological concerns,* RAOs based specifically on ecological risk were not recommended in the ERA or FFS for soil and sediment.",

Comment 4: **<u>2.12.2 Description of Selected Remedy, last paragraph page 2-46</u>. "It is assumed that the compost will consist of 25 percent by volume (74.7 percent by weight) contaminated soil, 72 percent by volume (19.6 percent by weight) straw, and 3 percent by volume (5.7 percent by weight) chicken manure" The ideal Carbon/Nitrogen ratio will depend on the initial level of and types of contaminations to be composted. This is NOT a one size fits all formula for best results. If this statement is added to the text to be used in the cost formulation, then there should be a note to that affect. If this is the actual blend determined to be applied, then what are the implications to the formula from the change in the composting pre-treatment program? If the answer is "none", how do you know that the formula is still successful?**

Response 4: The DD provides a general description of the selected remedy based on previous testing and experience at other areas within PBOW as well as other sites such as Naval Surface Warfare Center Crane. These percentages serve as a reasonable basis for the cost estimate based on effectiveness when used elsewhere at PBOW. The remedial action contract is planned to be a "performance-based" contract where the contractor is responsible for successful remediation and providing evidence that it was achieved.

Comment 5: **<u>Top of page 2-47</u>**
"After the compost is turned, microorganisms within the pile aerobically degrade organic compounds until the available oxygen within the pile is utilized. Beyond this point, further contaminant degradation is achieved through an anaerobic process." Are there actual studies that have been done on these materials that establish the microorganism communities and their rate of use of oxygen? How do the soils at those settings compare to the soils at Plum Brook? Do we know how long it takes to turn the piles anaerobic? Are there other microorganism communities that take over in the anaerobic conditions? How effective are they? Is there an optimum ratio of degradation to windrow turning that maximizes the decomposition process and minimizes the composting time?

Response 5: Optimization of the treatment process will be established during remedial design and initial treatment. In general, monitoring of temperature and moisture are the best indicators for establishing turning frequency.

Comment 6: **<u>Middle and third paragraphs page 2-47</u>**
There are no windrow controls proposed to determine the effectiveness of the chosen processes, only the collections of samples from the windrows in treatment.

Response 6: Please see the last paragraph of the response to the reviewer's General Comment No. 1.

Comment 7: **<u>4.0 References, page 4-1</u>**
Most of the technical non-site specific references are old. Is this because no new references have been written or is it because Shaw has not updated the references? A short section discussing this would be helpful.

Response 7: Typically, early in the investigation process, an attempt is made to procure background information. Unless such information is later proven to be inaccurate or incomplete, this information is used to describe this same background information in subsequent documents. Thus, the original PBOW document in which the information first appears is appropriately treated as the primary source.

Comment 8: **<u>Table 2-25 Alternative 5, page 3 of 9</u>.**
Alternative 4 discusses the binding of TNT-carbon to humic substances and basically says that if the bonds break down, the soil will be in a landfill anyway, so it won't matter. But basically the same claim is made for Alternative 5. Since Alternative 5 recommends on-site use of the treated soils and since humic substances in a natural environment do not last forever, what happens to the TNT-carbon once the humic bonds are broken with time? Has anyone looked at this issue? Is there a long term problem that is not being addressed here?

Response 8: The statement is made on Table 4, page 3 of 9, under Alternative 4 (as well as Alternatives 2 and 5) that through composting "… a high percentage (>80%) of TNT-carbon is irreversibly bound to the soil through covalent binding with humic substances." The text within the table for Alternative 4 (or 2 or 5) does not state or in any way imply that the binding in reversible. The table mentions that stabilization, used as described for lead-contaminated soil, may not be an irreversible process, but this statement is also made for Alternatives 2,

4, and 5. Therefore, the comment does not reflect the verbiage that is actually in Table 2-25.

Comment 9: **<u>Front page for "Figures"</u>**
There is a typo on the label on the front page.

Response 9: The font problem will be corrected.

Comment 10: **<u>Figure 2-4, Simplified Site Conceptual Model TNT Area C Former Plum Brook Ordnance Works, Sandusky, Ohio.</u>**
This is a good graphic to show how the studies were preformed to determine who would be impacted and by what routes. I appreciate the pathway of "Vegetation/Vegetable Garden" after root uptake, recognizing the role that gardens can play in contaminant transport to future residents. One question, however. Why is there no potential on-site consideration of biouptake by animals through ingestion? Is the table missing a black dot for that classification or was there no consideration? See comments for point 3.

Response 10: The human health risk assessment evaluated the ingestion of animals by a hunter and his family members. A black dot will be added to this figure for on-site human ingestion of "Biouptake by Animals".

Comments by Janusz Byczkowski, Ph.D., Risk Assessor, Ohio Environmental Protection Agency, received June 9, 2009.

Comment 1: **Since I have no expertise in chemical/environmental engineering I would like to see in this document some basic explanations of the chemistry involved in "alkaline hydrolysis and windrow composting" of nitroaromatics and PAHs as well as a better explanation of physicochemical interaction between lead and Maectite. This additional information could help to understand if the proposed remedy may or may not affect ground water. Otherwise, from risk assessor's point of view - I have no comments.**

Response 1: The inclusion of this level of detail in a decision document is not consistent with EPA (1999) decision document guidance. This information is provided in the FS (Shaw, 2003) and TNTC FS Addendum (Shaw, 2009). As a courtesy to the reviewer, information was excerpted from the TNTC Addendum and is provided below for composting and alkaline hydrolysis. Please refer to the TNTC Addendum for additional information. MAECTITE® is a proprietary product used for stabilization. An excerpt from the MAECTITE® website, describing its general chemical mechanism is provided below.

Composting

Composting utilizes solid-, liquid- and gas-phase processes. The solid phase provides physical support for biofilm growth, a source of organic and inorganic nutrients, a sink for metabolic products, and thermal insulation. The liquid phase provides a matrix for the interchange of gases, nutrients, and metabolic products. The gas phase delivers oxygen and provides a sink for gaseous metabolic products, such as carbon dioxide and ammonia. The gas phase also serves as the primary heat sink through evaporative cooling.

The composting process is mediated by microbial populations that are classified as either mesophiles or thermophiles. Mesophilic microbes are those with an optimum temperature range of 25 to 40 degrees Celsius (^{o}C). Thermophiles have an optimum temperature range of 40 to 60°C. Significant degradation of TNT has been reported within both temperature regimes, although slightly higher removals have been demonstrated under thermophilic conditions.

Composting can biologically degrade organic contaminants via aerobic, anaerobic, or a combination of anaerobic and aerobic processes. Research on TNT degradation using composting has shown that a combined anaerobic/aerobic process is the most effective in detoxifying TNT-contaminated soil. The first step in the biological degradation of TNT involves the reduction of one of the three aromatic nitro groups to an amino group through nitroso and hydroxylamino intermediates.

The sequential reduction of all three nitro groups, converting TNT to 2,4,6-triaminotoluene (TAT), can only be achieved under strict anaerobic conditions. Studies have shown that, in addition to the transformation of TNT to TAT, degradation of TNT may proceed through the condensation of amino-dinitrotoluenes to azoxy-tetranitrotoluenes.

Significant mineralization of TNT via composting has not been demonstrated. However, TNT degradation and transformation products can be stabilized through interaction with organic and inorganic soil components. The reduction of TNT in the presence of clay and humic substances has been shown to significantly increase the removal rate of nitroaromatics from soil. The TNT metabolites hydoxyamino-dinitrotoluenes and TAT strongly bind to clay minerals and humic substances.

Alkaline Hydrolysis
TNT is susceptible to treatment with alkali as the electronegative nitro groups of TNT reduce the electron density of the aromatic ring and make the molecule subject to nucleophilic attack. The hydroxide ion (OH^-) is a strong nucleophile and has been shown to react with TNT under basic conditions. Nucleophilic substitutions of the nitro and methyl groups of TNT by hydroxide ion are the initial steps in the degradation process that result in a variety of potential reaction products. Research performed to quantify the TNT-hydroxide reaction rate has identified a multiple step reaction process. Alkaline hydrolysis has been found to be an effective method of reducing the concentration of TNT in soil, provided enough alkali is added to raise the soil pH to about 12. It has also been shown effective on DNT and ADNT isomers, but its effectiveness for these compounds appears to be lower than for TNT.

Stabilization
MAECTITE® is one of several proprietary stabilization products on the market. Essentially, MAECTITE ® is a phosphate-containing substance that converts soluble Pb^{2+} to pyromorphite-type (lead phosphate) or apatite-type (lead calcium phosphate) crystals. These crystals are of extremely low solubility. The following description was excerpted from www.sevenson.com/innovative-technologies/maectite: "The MAECTITE® chemical process reagents from non-leachable mixed mineral species through induced nucleation form isomorphic reaction-series dynamics using problematic metal ions that are present in soil or waste. As a true chemical process MAECTITE® provides a classical approach to control problem metal and inorganic ions through the manipulation of non-problem inorganic ions."

References Used in these Responses:

IT Corporation (IT), 2001, ***TNT Areas A and C Remedial Investigation, Volume 3 – Ecological Risk Assessment***, Final, Former Plum Brook Ordnance Works, Sandusky, Ohio, November.

Sabin, W.A., 2001, ***The Gregg Reference Manual***, Ninth Edition, Glencoe-McGraw-Hill, Westerville, Ohio, p. 141.

Shaw Environmental, Inc. (Shaw), 2009, ***Addendum, TNT Area C, Focused Feasibility Study for Soil and Sediment, Draft, Former Plum Brook Ordnance Works, Sandusky, Ohio***, January.

Shaw Environmental, Inc. (Shaw), 2003, ***TNT Areas A and C Remedial Investigation, Former Plum Brooks Ordnance Works, Sandusky, Ohio, Volume 4 – Focused Feasibility Study for Soil and Sediment, Final***, October.

U.S. Environmental Protection Agency (EPA), 1999a, ***A Guide to Preparing Superfund Proposed Plans, Record of Decision, and Other Remedy Selection Decision Documents,*** Office of Solid Waste and Emergency Response, Washington, D.C., EPA-540-R-98-031, July.