Baseline Human Health Risk Assessment

TNT Area A to Waste Water Treatment Plant No. 1 Sewer Lines
Plum Brook Ordnance Works
Sandusky, Ohio

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Table of Contents

Page

List of Tables v
List of Figures vi
List of Acronyms vii
Executive Summary ES-1
1.0 Introduction 1-1
1.1 Facility Location and Description 1-1
1.2 Facility History and Background 1-2
1.3 TNTA/WWTP1 Sewer Lines Description and History 1-3
1.4 Groundwater Use and Site Use 1-4
1.5 Protocol for the Baseline Human Health Risk Assessment 1-5
1.6 Report Organization 1-6
2.0 Data Evaluation 2-1
2.1 Data Sources 2-1
2.2 Sorting the Analytical Data 2-1
2.3 Evaluation of Data Quality 2-4
2.4 Identification of Chemicals of Potential Concern 2-5
2.4.1 Risk-Based Screening 2-5
2.4.2 Frequency of Detection 2-8
2.4.3 Comparison to Background 2-8
2.4.3.1 Background Screening of Inorganics 2-9
2.4.3.2 Statistical Data Set Testing of Inorganics 2-10
2.4.3.3 Treatment of Organic Compounds 2-11
2.5 Data Evaluation Summary 2-11
3.0 Exposure Assessment 3-1
3.1 Conceptual Site Exposure Model 3-1
3.1.1 Physical Setting 3-2
3.1.1.1 Climate/Meteorology 3-3
3.1.1.2 Geology 3-3
3.1.1.3 Soils 3-4
3.1.1.4 Hydrology 3-5
3.1.1.5 Surface Water 3-6

Table of Contents *(Continued)*

Page

3.1.2 Contaminant Sources, Release Mechanisms, and Migration Pathways .. 3-7
3.1.3 Receptors and Exposure Pathways 3-7
3.1.3.1 Current Groundskeeper 3-9
3.1.3.2 Future Groundskeeper 3-10
3.1.3.3 Indoor Worker 3-11
3.1.3.4 Construction Worker 3-12
3.1.3.5 On-Site Resident 3-13
3.1.3.6 Hunter 3-17
3.1.3.7 Hunter's Child 3-18
3.1.3.8 Other Receptors Not Considered 3-18
3.2 Quantification of Exposure-Point Concentrations 3-19
3.2.1 Soil, Groundwater, Surface Water, and Sediment Concentrations 3-19
3.2.2 Exposure-Point Concentrations in Air 3-21
3.2.2.1 COPC Concentrations from Dust 3-21
3.2.2.2 Concentrations in Household Air from Groundwater Use 3-23
3.2.2.3 Concentrations of VOCs in Groundwater: Resident Dermal Uptake 3-23
3.2.2.4 Exposure-Point Concentrations of COPCs in Venison 3-24
3.3 Quantification of Chemical Intake 3-26
3.3.1 Inhalation of COPCs in Air 3-26
3.3.2 Incidental Ingestion of COPCs in Soil or Sediment 3-27
3.3.3 Incidental Ingestion of COPCs in Water 3-27
3.3.4 Dermal Contact with COPCs in Soil, Sediment, or Water 3-28
3.3.5 Consumption of Venison 3-31
4.0 Toxicity Evaluation 4-1
4.1 Evaluation of Carcinogenicity 4-1
4.2 Evaluation of Noncarcinogenic Effects 4-3
4.3 Dermal Toxicity Values 4-5
4.4 Target Organ Toxicity 4-5
4.5 Sources of Toxicity Information Used in the Risk Assessment 4-6
5.0 Risk Characterization 5-1

Table of Contents *(Continued)*

Page

5.1 Cancer Risk 5-1
5.2 Noncancer Effects of Chemicals 5-3
5.3 Risk Characterization Results 5-4
5.3.1 Current Groundkeeper 5-5
5.3.2 Future Groundskeeper 5-5
5.3.3 Indoor Worker 5-8
5.3.4 Construction Worker 5-10
5.3.5 Resident 5-10
5.3.6 Adult Hunter 5-13
5.3.7 Hunter's Child 5-14
5.4 Evaluation of Potential Hot Spot Areas 5-14
5.4.1 Evaluation of Potential Hot Spot TP-33 5-14
5.4.2 Evaluation of Potential Hot Spot TP-27 5-15
5.4.3 Evaluation of the TNTA/WWTP1 Sewer Lines Minus the Potential Hot Spot Areas 5-16
5.4.3.1 Current Groundkeeper 5-17
5.4.3.2 Future Groundkeeper 5-17
5.4.3.3 Indoor Worker 5-17
5.4.3.4 Construction Worker 5-17
5.4.3.5 Resident 5-17
5.4.3.6 Adult Hunter 5-18
5.4.3.7 Hunter's Child 5-18
5.5 Risk-Based Remediation Criteria 5-18
6.0 Uncertainty Analysis 6-1
6.1 Types of Uncertainty 6-1
6.2 Sources of Uncertainty 6-2
6.2.1 Sample Selection 6-2
6.2.2 Exposure-Point Concentration Estimates 6-2
6.2.3 Land-Use Assumptions/Receptor Selection 6-3
6.2.4 Groundwater Use 6-3
6.2.5 Exposure Assumption Values 6-4
6.2.6 Groundwater-to-Air Household Model 6-5
6.2.7 Toxicity Assessment 6-5

Table of Contents *(Continued)*

Page

6.2.8 Risk Characterization 6-6
6.2.9 Evaluation of Selected COPCs for Site Relatedness 6-7
7.0 Summary and Conclusions 7-1
7.1 Summary 7-1
7.2 Conclusions 7-3
8.0 References 8-1
Appendix A – Data Summary of Chemicals Detected in Overburden Groundwater Piezometers
Appendix B – ProUCL Output for Upper Confidence Limits on the Mean
Appendix C – Toxicological Profiles
Appendix D – Risk Characterization Spreadsheets
Appendix E – Analytical Data Sets Used in the BHHRA
Appendix F – Risk Evaluation and Calculations for the TNTA/WWTP1 Sewer Lines Minus the Potential Hot Spots

List of Tables

Table	*Title*	*Follows Tab*
2-1	Summary of Samples Evaluated in the Baseline Human Health Risk Assessment	
2-2	Background Screening Concentrations of Inorganics in Soil	
2-3	Background Screening Concentrations of Inorganics in Groundwater	
2-4	Statistical Summary and Selection of Chemicals of Potential Concern in Surface Soil (0-1 Foot)	
2-5	Statistical Summary and Selection of Chemicals of Potential Concern in Subsurface Soil	
2-6	Statistical Summary and Selection of Chemicals of Potential Concern in Total Soil	
2-7	Statistical Summary and Selection of Chemicals of Potential Concern in Bedrock Groundwater	
2-8	Statistical Summary and Selection of Chemicals of Potential Concern in Overburden Groundwater	
2-9	Statistical Summary and Selection of Chemicals of Potential Concern in Sediment	
3-1	Receptor/Exposure Scenarios	
3-2	Variables Used to Estimate Potential Chemical Intakes and Contact Rates for Receptors	
3-3	Physical Properties of Site-Related Chemicals	
4-1	Summary of Toxicity Assessment	
5-1	Summary of Risk for All Receptors	
5-2	Summary of Risk for Receptors Excluding Exposure to Groundwater	
5-3	Summary of Risk for All Receptors, TNTA/WWTP1 Sewer Lines Minus Potential Hot Spots	
5-4	Risk-Based Remediation Concentrations for Total Soil	

List of Figures

Figure	*Title*	*Follows Tab*
1-1	PBOW Vicinity Map	
1-2	Location of TNTA/WWTP1 Sewer Lines at PBOW	
2-1	TNTA/WWTP1 Sewer Lines Site Map with Sample Locations	
3-1	Human Health Conceptual Site Exposure Model	

List of Acronyms

2-ADNT	2-amino-4,6-dinitrotoluene
4-ADNT	4-amino-2,6-dinitrotoluene
ABS	dermal absorption factor
AF	soil-to-skin adherence factor
AP1	Ash Pit 1
bgs	below ground surface
BHHRA	baseline human health risk assessment
BSC	background screening concentration
BTEX	benzene, toluene, ethylbenzene, and xylenes
CDI	chronic daily intake
cm/hour	centimeters per hour
cm^2	square centimeter
COC	chemical of concern
COPC	chemical of potential concern
CSEM	conceptual site exposure model
°F	degrees Fahrenheit
DA	dose absorbed per unit body surface area per day
D&M	Dames and Moore, Inc.
DERP-FUDS	Defense Environmental Restoration Program–Formerly Used Defense Sites
DM	dry matter
DNT	dinitrotoluene
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
EPC	exposure-point concentration
ET	exposure time
FI	fractional term
FS	feasibility study
GAF	gastrointestinal absorption factor
gpm	gallons per minute
g	gram
g/kg-day	grams per kilogram of body weight per day
g/m^3	grams per cubic meter
HHEM	human health evaluation manual

List of Acronyms *(Continued)*

HI	hazard index
HQ	hazard quotient
ICI	International Consultants Incorporated
IEUBK	Integrated Exposure Uptake Biokinetic
ILCR	incremental lifetime cancer risk
IRIS	Integrated Risk Information System
IT	IT Corporation
kg	kilogram
kg/day	kilograms per day
LBA	Locomotive Building Area
LMS	linearized multistage
K_p	permeability coefficient
L/cm^3	liters per cubic centimeter
L/day	liters per day
m^3	cubic meter
m^3/day	cubic meters per day
m^3/hr	cubic meters per hour
m^3/kg	cubic meters per kilogram
m/second	meters per second
MDC	maximum detected concentration
$\mu g/m^3$	micrograms per cubic meter
mg/cm^2	milligrams per square centimeter
mg/cm^2-day	milligrams per square centimeter per day
mg/m^3	milligrams per cubic meter
mg/day	milligrams per day
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram per day
µg/L	micrograms per liter
mg/L	milligrams per liter
MPHS	minus potential hot spots
NASA	National Aeronautics and Space Administration
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
OEPA	Ohio Environmental Protection Agency
PAH	polycyclic aromatic hydrocarbon
PBOW	Plum Brook Ordnance Works

List of Acronyms *(Continued)*

PEF	particulate emission factor
ppm	parts per million
PRG	preliminary remediation goal
RBSC	risk-based screening concentration
RBRC	risk-based remedial concentration
RfC	reference concentration
RfD	reference dose
RI	remedial investigation
RME	reasonable maximum exposure
RSL	regional screening level
SF	cancer slope factor
Shaw	Shaw Environmental, Inc.
TNT	trinitrotoluene
TNTA	TNT Area A
TNTB	TNT Area B
TNTC	TNT Area C
UCL	95th percent upper confidence limit on the arithmetic mean
UF	uncertainty factor
USACE	U.S. Army Corps of Engineers
VOC	volatile organic compound
WRS	Wilcoxon Rank Sum
WWTP1	Waste Water Treatment Plant 1

Executive Summary

A baseline human health risk assessment (BHHRA) was conducted to evaluate risks associated with exposure to soil, groundwater, surface water and sediment along the former TNT Area A (TNTA) to Waste Water Treatment Plant 1 (WWTP1) sewer lines at the Plum Brook Ordnance Works (PBOW) in Sandusky, Ohio. The approach used in the BHHRA is consistent with methodologies described in the U.S. Environmental Protection Agency's primary risk assessment guidance documents, the site-specific work plan, and discussions and agreements between the Ohio Environmental Protection Agency, the U.S. Army Corps of Engineers Nashville and Huntington Districts, and Shaw Environmental, Inc.

Site History/Description. The PBOW facility was constructed on property comprising 9,009 acres in early 1941 as a manufacturing plant for 2,4,6-trinitrotoluene (TNT), 2,4-dinitroluene (DNT), and pentolite. 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. After plant operations ceased, the manufacturing process lines were decontaminated by the Army in late 1945. 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 1949, PBOW was transferred to the General Services Administration. The Department of the Army reacquired the 3,230 acres in 1954 and performed cleanup efforts from the mid-1950s until 1963.

Accountability and custody for the entire portion of the former PBOW property that had been under the accountability and custody of the Department of the Army were transferred to the National Aeronautics and Space Administration (NASA) on March 15, 1963. NASA performed further decontamination efforts during 1964. 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 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.

The two TNTA/WWTP1 sewer lines were located in the north-central portion of the PBOW facility. During PBOW manufacturing operations 1941 to 1944, the TNTA/WWTP1 sewer lines were used to transfer TNT manufacturing waste water from TNTA to WWTP1 for treatment. Both sewer lines were of wood-stave construction, and both were generally buried approximately 3 to 5 feet below the ground surface. The two TNTA/WWTP1 sewer lines ran two separate

courses: the more northern line ran due west from the TNTA settling basins for approximately 2,700 feet before angling southwest approximately 1,500 feet to WWTP1; the more southern line ran more directly west-southwest from the TNTA settling basins approximately 3,800 feet to WWTP1. During test pit excavation conducted in 2008, it became apparent that the sewer lines themselves had been previously removed. Thus, it is likely that the majority of any residual contamination within the sewer lines was consequently removed. The waste water transferred via these sewer lines contained spent sulfuric acid and nitric acids and red water from the TNT purification process. Chemicals in the waste streams may have included sodium salts of sulfite, sulfate, nitrite, and nitrate; sulfonates of unwanted TNT isomers; trinitrobenzoic acid; trinitrobenzaldehyde; trinitrobenzyl alcohol; nitrotoluenes; and dinitrotoluenes.

Approach. The BHHRA evaluated exposure to chemicals in bedrock groundwater, overburden groundwater, surface soil, subsurface soil, surface water, and sediment for cancer risks and noncancer hazards. Only validated analytical data were used in the BHHRA. Validated analytical data are from samples collected during 2008 through 2011, as reported in the site characterization report.

A screening for chemicals of potential concern (COPC) was used to focus the evaluation on those chemicals most likely to present a risk to potentially exposed individuals. This screening included a risk-based and, for inorganic chemicals in soil and bedrock groundwater, a background screening. This background screening protocol, which is based on PBOW Project Delivery Team agreement, differs somewhat from the current Ohio Environmental Protection Agency guidance.

Each COPC in each medium was evaluated for exposure via the relevant exposure pathways and the resultant risk and hazards were estimated. One or more COPCs were found in each environmental medium associated with the TNTA/WWTP1 sewer lines except for surface water, indicating that surface water does not contribute significantly to risks/hazards. The receptors listed below were quantitatively evaluated for exposure to the COPCs and their associated hazards and risks. The media that were quantitatively evaluated for each receptor are shown in parentheses.

- Current groundskeeper (surface soil)
- Future groundskeeper (combined surface and subsurface soil [referred to as “total soil”], bedrock groundwater, overburden groundwater)

- Indoor worker (surface soil, subsurface soil [air pathway only], bedrock groundwater, overburden groundwater)
- Construction worker (total soil, surface water, sediment)
- On-site resident (total soil, surface water, sediment, bedrock groundwater, overburden groundwater)
- Hunter (surface soil)
- Hunter's child (surface soil [venison pathway only]).

As mentioned above, no COPCs were found in surface water. If COPCs had been identified for this medium, then surface water also would have been quantitatively evaluated for the construction worker and resident receptors. Although no groundskeeping appears to have occurred along the former TNTA/WWTP1 sewer lines in recent years, except occasional mowing or burning, the current groundskeeper scenario is included because current land use does not prohibit the presence of a groundskeeper or other on-site workers. Even though hunting is not currently permitted in the vicinity of the TNTA/WWTP1 sewer lines, hunting is permitted in other areas within PBOW; therefore, future use of this area for hunting is evaluated in this BHHRA. No construction is planned for along the TNA/WWTP1 sewer lines, but a construction worker is assumed to be potentially exposed under current or future land use. The future groundskeeper, indoor worker, and resident are evaluated for future land use; these three receptors are also evaluated assuming groundwater use as potable water. Overburden groundwater and bedrock groundwater are evaluated for each receptor separately.

Results/Conclusions. Risks were characterized for each COPC identified in each medium for the relevant receptors. Noncancer hazards were evaluated against a target hazard index (HI) criterion of 1 and the PBOW team target incremental lifetime cancer risk (ILCR) goal of 1E-5 (i.e., 1 additional incidence of cancer per 100,000 individuals exposed). Cancer risk results are also compared to the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) acceptable cancer risk range of 1E-6 to 1E-4 (i.e., a rate of 1 additional incidence of cancer per 1,000,000 to 1 in 10,000 individuals exposed), which is referred to herein as the "NCP risk management range."

A target cancer risk goal of 1E-5 is used by the Ohio Environmental Protection Agency and was selected by the PBOW Project Delivery Team as a basis to consider remedial action. Use of this 1E-5 goal represents a departure from the Army's practice of generally using a cancer risk

exceeding a value of 1E-4 (the upper end of the NCP risk management range) to trigger remedial action considerations.

The overall HI and ILCR values are summarized in the following bullets; exceedances of the PBOW cancer risk goal (ILCR>1E-5) are shown as bold and exceedances of the noncancer hazard criterion (HI>1) or the NCP risk management range (1E-6 to 1E-4) are shown as bold italics:

- Current groundskeeper: ILCR = 1E-5; HI = 0.8
- Future groundskeeper – all pathways, including bedrock groundwater use: ***ILCR = 4E-4; HI = 4***
- Future groundskeeper – all pathways, including overburden groundwater use: ILCR = 7E-6; ***HI = 5***
- Future groundskeeper – all pathways, excluding groundwater use: ILCR = 7E-6; HI = 0.4
- Indoor worker – all pathways, including bedrock groundwater use: ***ILCR = 4E-4; HI = 4***
- Indoor worker – all pathways, including overburden groundwater use: ILCR = 4E-6; ***HI = 5***
- Future indoor worker – all pathways, excluding groundwater use: ILCR = 4E-6; HI = 0.3
- Construction worker: ILCR = 4E-7; HI = 1
- Resident – all pathways, including bedrock groundwater use: ***ILCR = 2E-3; child HI = 32; adult HI = 12***
- Resident – all pathways, including overburden groundwater use: ILCR =1E-5 (**2E-5**); ***child HI = 34; adult HI = 13***
- Resident – all pathways, excluding groundwater use: ILCR = 1E-5 (**2E-5**); ***child HI = 4;*** adult HI = 0.5
- Hunter: ILCR = 9E-7; HI = 0.4
- Hunter's child: ILCR = 2E-12; HI = 0.00001.

The ILCR and HI values for the two current exposure scenarios (current groundskeeper and construction worker) each meet the PBOW cancer risk goal (ILCR≤1E-5) and the noncancer hazard criterion (HI≤1).

For the resident exposed to overburden groundwater and the resident excluding exposure to groundwater, the ILCR is reported as 1E-5 and parenthetically as 2E-5. The value of 2E-5 is the total ILCR regardless of contaminant source. However, over 50 percent of the soil-related ILCR for this receptor is associated with polycyclic aromatic hydrocarbons (PAH) in surface soil. The PAHs are not part of any TNT manufacturing waste and are not found in subsurface soil as would be expected, had they been associated with the sewer line contents. A likely source of the PAHs is the controlled burning that has been used by NASA for years to control vegetation within the area occupied by the sewer line traces. If the apparently non-U.S. Department of Defense-related contributions of the PAHs are excluded, the ILCR for the resident is 1E-5, as shown above in parentheses. This value equals the PBOW cancer risk goal.

The cancer risks associated with the following future receptors assumed to use bedrock groundwater as a hypothetical source of tap water exceed the NCP risk management range and PBOW cancer risk goal: future groundskeeper, future indoor worker, and future resident. Each of these also exceeds the target HI criterion of 1. The HI value for each of these three receptors under the assumption of overburden groundwater use also exceeds the HI target goal.

The cancer risks and noncancer hazards associated with bedrock groundwater are almost entirely attributable to naturally occurring petroleum-related compounds and arsenic, which also does not appear to be related to former site activities. The noncancer hazards associated with overburden groundwater are entirely due to inorganics, especially thallium and cobalt, which do not appear to be associated with former site activities. Use of either the overburden or bedrock groundwater is regarded as implausible because of insufficient yield. Additionally, the naturally poor quality of the bedrock and overburden groundwater and the associated hydrogen sulfide off-gassing of the bedrock unit make the underlying groundwater unsuitable for potable use. The readily available municipal water supply obviates the need for use of groundwater as a potential source of tap water in the general vicinity of PBOW.

If the use of groundwater is excluded, only the HI value of 4 for the child resident exceeds the target HI of 1. This HI is almost entirely associated with TNT. Elevated TNT concentrations are not representative of the entire length of the sewer line traces, but instead are limited to reported concentrations near test pits TP-27 and TP-33. Therefore, these two test pit areas were further investigated and evaluated as potential hot spots.

Potential Hot Spots Evaluation. The HI and ILCR results presented above include those associated with soil samples that were collected from along the entire length of the former sewer lines. This includes two areas that were regarded as potential hot spot areas with respect to TNT, one at test pit TP-27 and one at test pit TP-33. Additional samples were collected in these areas to delineate the contamination. The results of the nine delineation samples collected near TP-33 indicate that the elevated detection of TNT (1,300 milligrams per kilogram [mg/kg]) in sample SB02 at TP-33 does not represent a hot spot area, as the highest concentration of TNT detected in the delineation samples was only 0.549 mg/kg. The subsequent delineation sample collected from the exact same location as SB02 yielded a TNT concentration of only 0.0793 mg/kg, and TNT was not detected in four of the nine delineation samples. Instead, the elevated TNT concentration reported at location SB02 is regarded as nonrepresentative of the TP-33 area.

Based on the results of the delineation sampling, additional contamination was found in the vicinity of the TP-27 test pit. Therefore, the test pit TP-27 location was found to represent a hot spot, with an area of approximately 1,200 square feet. This is one of only two locations revealed by the field test kit samples to have a total nitroaromatics concentration greater than the field screening value (10 mg/kg).

TNT was identified as a preliminary chemical of concern (COC) for total soil because exposure to TNT in this medium may result in an HI for the resident child that exceeds the target HIRBRCs were developed for TNT to aid in site management decisions. The RBRCs are described in Section 5.5 and presented in Table 5-4 of this report.

Evaluation of Sewer Lines Minus Potential Hot Spot Areas. Because the TP-27 area is regarded as a hot spot, the analytical results may be excluded from the general TNTA/WWTP1 sewer line data sets and addressed separately as described in the previous paragraphs. Likewise, data from TP-33, which had been identified as a potential hot spot, may be excluded from the data set, because the single elevated concentration was found to be clearly nonrepresentative of the TP-33 area. If both the TP-27 and the TP-33 data sets are removed from the risk characterization (and groundwater is excluded), none of the TNTA/WWTP1 sewer line receptors have an ILCR value that exceeds the PBOW cancer risk goal and none of these receptors have an HI that exceeds the target HI of 1. The results of this evaluation indicates that exposure to soil along the TNTA/WWTP1 sewer lines, outside of the TP-27 area, would not result in unacceptable cancer risks or noncancer hazard for any receptor.

1.0 Introduction

This baseline human health risk assessment (BHHRA) evaluates potential human health risks associated with exposure to soil, groundwater, surface water, and sediment associated with the sewer lines running from TNT Area A (TNTA) to Waste Water Treatment Plant 1 (WWTP1) (TNTA/WWTP1 sewer lines) at the former Plum Brook Ordnance Works (PBOW), Sandusky, Erie County, Ohio. This work is being conducted for the U.S. Army Corps of Engineers (USACE) under the Defense Environmental Restoration Program-Formerly Used Defense Sites, managed by the USACE Huntington District, and technically overseen by the USACE Nashville District.

This BHHRA is consistent with U.S. Environmental Protection Agency (EPA) guidance and with the procedures established in the BHHRA for TNTA and TNT Area C (TNTC) soil (IT Corporation [IT], 2001a), the BHHRA for groundwater at PBOW (Shaw Environmental, Inc. [Shaw], 2006) and, most specifically, the TNTA/WWTP1 sewer line BHHRA work plan (Shaw, 2010). The TNTA/WWTP1 sewer lines are administered under the Defense Environmental Restoration Program-Formerly Used Defense Sites (DERP-FUDS) program as part of WWTP1, which is administratively grouped with Waste Water Treatment Plant No. 3 to comprise DERP-FUDS Project No. G05OH001817.

In this BHHRA, the term “facility” refers to the entire former PBOW property, and the term “site” refers to an area within PBOW. Because of the linear shape of the area associated with the sewer lines, the associated area is referred to as the “sewer line trace.”

1.1 Facility Location and Description

PBOW is located approximately 4 miles south of Sandusky, Ohio, and 59 miles west of Cleveland (Figure 1-1). Although located primarily in Perkins and Oxford Townships, the eastern edge of the facility 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 areas surrounding PBOW are mostly agricultural and residential. The facility is currently surrounded by a chain-link fence, and the perimeter is regularly patrolled. Access by authorized personnel is limited to established checkpoints. Public access is restricted. Hunting is allowed by permit on portions of PBOW during the annual deer hunting season.

1.2 Facility History and Background

The PBOW facility was constructed on property comprising 9,009 acres in early 1941 as a manufacturing plant for 2,4,6-trinitrotoluene (TNT), 2,4-dinitroluene (DNT), and pentolite (International Consultants Incorporated [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 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.

After plant operations ceased, the 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 1949, PBOW was transferred to the General Services Administration. 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. In 1955, the Army completed further decontamination of the manufacturing process lines. This effort included removal of contaminated surface and subsurface soil around the building 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. The Army continued cleanup efforts until 1963.

Two property use agreements were entered into by the Army and the National Advisory Committee of Aeronautics, the predecessor of the National Aeronautics and Space Administration (NASA), in 1956 and 1958, respectively. Accountability and custody for the entire portion of the former PBOW property (6,030 acres) that had been under the accountability and custody of the Department of the Army were transferred to NASA on March 15, 1963. 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 covered with fill material. 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 excavated nitroaromatic-filled pipelines (Dames & Moore, Inc. [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 H. Glenn Research Center at Lewis Field, Cleveland, Ohio. Most of the aerospace testing facilities built in the 1960s at PBOW are currently on standby or inactive status. On April 18, 1978, NASA declared approximately 2,152 acres of PBOW as excess. This excess included former buffer areas that had not been used by the Army and were thus not subject to decontamination efforts. 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. The details of land transactions are listed in the site management plan (ICI, 1995).

1.3 TNTA-WWTP1 Sewer Lines Description and History

The former WWTP1 is located in the north-central portion of PBOW, approximately 200 feet northwest of the intersection of Maintenance Road and Taylor Road (Figure 1-2). During PBOW manufacturing operations from 1941 through 1944, WWTP1 received TNT manufacturing wastes from TNTA (located east of WWTP1) and TNTB (located south-southwest of WWTP1) through subsurface wood-stave waste water sewer lines for treatment and disposal (ICI, 1995). The traces of the TNTA/WWTP1 sewer lines are subject of this BHHRA. These traces were investigated during 2008 through 2011 as described in the site characterization report (Shaw, 2012). No previous investigations were conducted specific to the sewer lines.

The purpose of WWTP1 was to reduce the volume of waste water discharged from each of the manufacturing areas prior to incineration or disposal in the red water ponds. WWTP1 consisted of a raw waste storage tank, a caustic storage tank, a neutral storage tank, an equalization tank, a condensate storage tank, an evaporator building, an incinerator, and a thick liquid storage tank. WWTP1 received waste water from the TNTA and TNTB manufacturing settling basins and neutralized the waste water through a chemical depuration process.

The waste water that was transferred via the sewer lines from TNTB and TNTA to WWTP1 consisted of spent sulfuric acid and nitric acids and red water from the TNT purification process. Chemicals in the waste streams may have included sodium salts of sulfite, sulfate, nitrite, and nitrate; sulfonates of unwanted TNT isomers; trinitrobenzoic acid; trinitrobenzaldehyde; trinitrobenzyl alcohol; nitrotoluenes; and dinitrotoluenes (D&M, 1996).

The two TNTA/WWTP1 sewer lines ran two separate courses: the more northern line ran due west from the TNTA settling basins (Building 187) for approximately 2,700 feet before angling

southwest approximately 1,500 feet to WWTP1; the more southern line ran more directly west-southwest from the TNTA settling basins approximately 3,800 feet to WWTP1 (Figure 1-2). Portions of the former sewer line traces were observed in 2008 using aerial photographs. Based on historical information that is further described in the site characterization report (Shaw, 2012), the more northern sewer line was a 4-inch-diameter wood-stave pipe, and the southern sewer line was a 6-inch-diameter wood-stave pipe. Reportedly, the TNTA/WWTP1 sewer lines would often become plugged during operation, and the plugged portions of the lines were sometimes bypassed with replacement lines (USACE, 1995).

D&M (1997) reported that an approximately 1,050-foot section of the WWTP1 sewer line leading due west from the TNTA settling basins was removed and burned. It was also reported by D&M (1997) that the 6-inch wooden WWTP1 sewer line which extended several thousand feet west-southwest of the TNTA settling basins was intact. During the 2009-2011 investigation, only small pieces of intact sewer line (e.g., several inches long) were observed, as were miscellaneous pieces of metal banding which had held the staves together (Shaw, 2012). No intact sewer line was found west-southwest of the site or anywhere else. Because the observed small pieces of wood-stave lines were very well preserved, it is apparent that the wood-stave sewer lines were previously removed and that their absence is not due to deterioration. Thus, it is likely that the majority of any residual contamination within the sewer lines was likewise removed during sewer line removal.

1.4 Groundwater Use and Site Use

Two groundwater aquifer systems are utilized for drinking water in the region: a carbonate aquifer to the west and a shale aquifer to the east (Shaw, 2005). PBOW is located within the transition of the two systems. Upwards of 170 private drinking water wells permitted by the Erie County Health Department are located within 4 miles of PBOW. Groundwater is not used on the PBOW facility. Permits are not required for agricultural wells. The Erie County Health Department does not permit using surface water as private drinking water. A shallow discontinuous and variably saturated groundwater system exists within the unconsolidated material atop the bedrock under much of the site.

Current use of the PBOW facility is classified as industrial for the purpose of identifying plausible human receptors and exposure pathways for evaluation in the BHHRA. D&M (1997) describes potential future uses of all or portions of the facility as follows:

- Industrial use (NASA activities and programs) may continue.
- Portions of the site may be used for recreation by hunters and fishermen.
- Portions of the site may be sold to state or local government or private individuals (no land-use restrictions were mentioned).
- Parts of the facility may be used in the future for residential or agricultural purposes.
- Parts of the facility may be used for training by the National Guard.
- Construction activities may be performed during development of any of the sites.

In summary, future site uses of property that includes the TNTA/WWTP1 sewer line traces are considered to be industrial or residential for the purpose of developing receptor and exposure scenarios. There are no current NASA activities along the sewer line traces, but because PBOW is under NASA control, the potential for NASA activities exists. Even though hunting is not currently permitted in the area of the sewer line traces, hunting is permitted in other areas within PBOW; therefore, future use of the traces for hunting is evaluated in this BHHRA. It is conservatively assumed for purposes of this BHHRA that groundwater may be developed as a source of potable water in the future. Refer to Section 3.1.3 for a discussion of receptors and exposure scenarios.

1.5 Protocol for the Baseline Human Health Risk Assessment

The BHHRA was performed consistent with the TNTA/WWTP1 sewer line BHHRA work plan (Shaw, 2010). The TNTA/WWTP1 sewer line BHHRA work plan was developed consistent with previous PBOW BHHRAs and is based on EPA, USACE, and Ohio Environmental Protection Agency (OEPA) guidance, including, but not limited to, the following:

- Ohio Environmental Protection Agency (OEPA), 2009a***, Use of U.S. EPA's Regional Screening Levels as Screening Values in Human Health Risk Assessments***, Technical Decision Compendium, Division of Emergency and Remedial Response, August.
- Ohio Environmental Protection Agency (OEPA), 2009b***, Human Health Cumulative Carcinogenic Risk and Non-carcinogenic Hazard Goals for the DERR Remedial Response Program***, Technical Decision Compendium, Division of Emergency and Remedial Response, August.
- U.S. Army Corps of Engineers (USACE), 1999, ***Risk Assessment Handbook, Volume I: Human Health Evaluation***, Engineer Manual EM 200-1-4.

- U.S. Environmental Protection Agency (EPA), 1989a, ***Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)***, Interim Final, Office of Emergency and Remedial Response, Washington, D.C., EPA/540/1-89/002.

- U.S. Environmental Protection Agency (EPA), 1991a, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual Supplemental Guidance, Standard Default Exposure Factors***, Interim Final, Office of Solid Waste and Emergency Response, OSWER Directive: 9285.6-03.

- U.S. Environmental Protection Agency (EPA), 1992, ***Guidance on Risk Characterization for Risk Managers and Risk Assessors***, Memorandum from F. Henry Habicht II, Deputy Administrator, to Assistant Administrators, Regional Administrators, February.

- U.S. Environmental Protection Agency (EPA), 1997a, ***Exposure Factors Handbook***, Office of Research and Development, National Center for Environmental Assessment, Washington, D.C., EPA/600/P-95/002Fa, August.

- U.S. Environmental Protection Agency (EPA), 2002, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Office of Solid Waste and Emergency Response, Washington, D.C., 9355.4-24, December.

- U.S. Environmental Protection Agency (EPA), 2004a, ***Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part E - Supplemental Guidance for Dermal Risk Assessment)***, Final, Office of Superfund Remediation and Technology Innovation, Washington, D.C., EPA/540/R-99/005, July.

- U.S. Environmental Protection Agency (EPA), 2010a, ***ProUCL Version 4.01 Technical Guide***, Draft, Office of Research and Development, Technology Support Center Characterization and Monitoring Branch, Las Vegas, Nevada, EPA/600/R-07/041, May.

- U.S. Environmental Protection Agency (EPA), 2010b, ***ProUCL Version 4.01 User Guide***, Draft, Office of Research and Development, Technology Support Center Characterization and Monitoring Branch, Las Vegas, Nevada, EPA/600/R-07/038, May.

- U.S. Environmental Protection Agency (EPA), 2011a, ***ProUCL Version 4.01***, Office of Research and Development, Technology Support Center Characterization and Monitoring Branch, Las Vegas, Nevada, February, on line at http://www.epa.gov/esd/tsc/form.htm.

1.6 Report Organization

The remainder of this document is organized as follows:

- ***Chapter 2.0, Data Evaluation.*** Identifies data sources, evaluates data quality, identifies chemicals of potential concern (COPC), and provides a background screening and evaluation protocol. It is noted that the background screening protocol differs from the current OEPA (2009c) guidance, as explained in Section 2.4.3.

- ***Chapter 3.0, Exposure Assessment.*** Presents a conceptual site exposure model (CSEM), including contaminant sources, contaminant release mechanisms, receptors, and exposure pathways; describes exposure-point concentrations (EPC); and presents methods for calculating chemical intake and contact rates.

- ***Chapter 4.0, Toxicity Evaluation.*** Describes the potential for cancer and/or noncancer human health effects, provides an estimate of the quantitative relationship between the magnitude of dose or contact rate and the probability and/or severity of adverse effects, identifies the toxicity values that are used in the BHHRA, and describes the development of dermal toxicity values.

- ***Chapter 5.0, Risk Characterization.*** Combines the output of the exposure assessment and toxicity assessment to quantify the risk to each receptor at each site. Risks associated with exposure to all appropriate media for each site are evaluated.

- ***Chapter 6.0, Uncertainty Analysis.*** Identifies uncertainties in all phases of the BHHRA and discusses their individual effects on the risk assessment results, focusing on those issues that are most pertinent to the TNTA/WWTP1 sewer line traces and those most likely to have the greatest effect on risk estimates.

- ***Chapter 7.0, Summary and Conclusions.*** Provides a brief summary of the BHHRA, including quantitative results, uncertainties, and pertinent site information. Summary and discussion is focused on those results and issues that are most directly relevant to the risk assessment conclusions for the TNTA/WWTP1 sewer lines that are likely to directly affect site management decisions.

- ***Chapter 8.0, References.*** Presents the references used in the preparation of this document.

2.0 Data Evaluation

Data evaluation consists of a description of the appropriate data sources for each environmental medium sampled for each site, a discussion of data quality, a description of the methodology used for identification of the COPCs, and a summary of the COPCs for each WWTP1/TNTA sewer line environmental medium.

2.1 Data Sources

All soil, groundwater, sediment, and surface water samples from which the validated analytical data used in the BHHRA were derived are presented in Table 2-1. These data include surface soil, subsurface soil, surface water, sediment, overburden groundwater, and bedrock groundwater well samples. The sample summary table identifies each sample used in the BHHRA and the associated analytical suite. Samples include those collected as part of the remedial investigation (RI) conducted at various times from December 2008 through September 2011. It is noted that test kit screening samples and composite samples used to identify potential contamination were not quantitatively evaluated in this BHHRA. Further discussion of the specific sampling events and types of samples are provided in Section 2.2. All TNTA/WWTP1 sampling locations are shown on Figure 2-1.

2.2 Sorting the Analytical Data

Prior to initiation of BHHRA calculations, a database of chemicals present in site samples was compiled for each environmental medium. This database includes all chemicals detected as described in the site characterization report (Shaw, 2012). The surface soil and subsurface soil are considered separate media. Surface and subsurface soil data are typically combined to assess exposures under the construction worker, future groundskeeper, and residential site-use scenarios, which would likely occur after surface and subsurface soil had been excavated and/or mixed. Combined surface and subsurface soil data are termed “total soil” in the BHHRA. However, it is understood that a reference to the evaluation of exposure to total soil is actually an evaluation of exposure to both surface soil and subsurface soil. The total soil COPC list is created by combining the list of COPCs identified in surface and subsurface soil. If a chemical is either a surface soil COPC or a subsurface soil COPC (or both), then that chemical is a total soil COPC. The EPCs for total soil are typically generated from the combined data sets.

Two general types of soil sampling were employed during the RI: test pit sampling and direct-push sampling. Sampling locations for the test pit and direct-push samples are shown on Figure 2-1.

The test pit samples were collected in December 2008 from 18 test pits excavated along the sewer line trace, perpendicular to the trace. Test pits were typically 2 feet wide (the width of an excavator bucket) by approximately 10 feet long. These were analyzed for nitroaromatics only. Each test pit sample was collected beginning at the base of the former sewer line (as interpreted from soil disturbance along the test pit walls associated with sewer line installation) to a depth of 0.25 foot to 0.5 foot below this interface. Each of the test pit soil samples was collected at an interval of 4.0 to 4.25 to 5.0 to 5.5 feet below ground surface (bgs). Because they begin at a depth greater than 1 foot bgs, all of the test pit soil samples are regarded as subsurface soil.

A total of 22 direct-push soil samples (which includes 2 duplicates) were collected from 10 soil borings in January 2009 to augment the test pit soil results. These were analyzed for a more complete suite of chemicals, as shown in Table 2-1. One surface soil (0 to 1 foot bgs) and one subsurface soil sample were collected from each boring, except borings SL-SB09 and SL-SB10, from which soil samples from two depth intervals (5 to 6 feet and 8 to 10 feet) were collected. For borings SB-01 through SB-08, subsurface soil samples were collected from the beginning of the base of the sewer line (as interpreted from soil disturbance in the soil boring cores and test pit results) to a depth of 1 to 2 feet below this interface. Where the base of the sewer line could not be differentiated, samples were collected from a depth interval of 8 to 10 feet bgs, unless refusal (i.e., competent shale) was met using the direct-push method prior to the 10-foot depth. In these cases, a subsurface soil sample was collected from a 1- to 2-foot interval just above the competent shale. Among borings SB-01 through SB-08, only two (SB-02 and SB-05) were sampled at a depth of 8 to 10 feet bgs. The subsurface samples from the other seven of these borings were sampled at depth intervals ranging from 3.4 to 9.1 feet bgs (Table 2-1). Two samples each were collected from the other two borings, SB09 and SB10 (which were offset approximately 10 feet south and north of the sewer line, respectively), at depth intervals of 4 to 6 feet and 8 to 10 feet bgs in an effort to delineate potential TNT contamination potentially indicated by test pit soil sample TNTA-SL-TP33, collected in December 2008.

Subsurface soil samples were subsequently screened along the entire length of the sewer lines in October 2010 using test kits to further evaluate potential nitroaromatics contamination. Only two of the test kit sample results exceeded the screening criterion of 10 milligrams per kilogram (mg/kg) total nitroaromatics; one of these included test pit TP-27 and the immediate area (Shaw, 2012). Subsurface soil delineation samples were collected in October and November 2011, including those in the vicinity of TP-27, to confirm the results of test kits collected in 2010. Six of these confirmation samples collected in 2010 were grab samples taken from along the sewer line trace, and these were used quantitatively in the BHHRA. The other eight 2010 samples were

composite samples collected approximately 10 feet offset of the sewer lines. These composite samples were collected near test pit locations TP-27, TP-29, and TP30. Please note that the composite samples collected near TP-29 and TP-30 were found to be at low concentrations or nondetect. Each of these composite sample areas (see Figure 2-1) is also characterized by grab samples. Of these three locations, only at test pit TP-27 were nitroaromatics detected at elevated concentrations, especially TNT.

Additional soil samples were collected in August and September 2011 and sampled for nitroaromatics to delineate potential hot spot areas identified based on the previously collected analytical data results, especially for TNT, at test pit samples TP-27 and TP-33. A total of 26 samples were collected in 2011. This includes 17 surface soil samples (including 2 field duplicates) at TP-27 and 9 subsurface soil samples at TP-33. Eight of the surface soil samples collected near TP-27 and six of the subsurface soil samples collected near TP-33 were from locations offset 10 feet from the sewer line trace. Because each of these offset samples were nondetect or yielded very inconsequentially low concentrations of nitroaromatics (e.g., below 0.8 mg/kg TNT), these offset samples were not included in the TNTA/WWTP1 sewer line soil sample data set. However, these offset samples were evaluated as described in Section 5.4 to help delineate contamination at TP-27 and TP-33. The areas associated with TP-27 and TP-33 were further investigated as part of the RI to delineate the contamination, as summarized in Section 5.4. The area around TP-33 was found not to be a hot spot (Section 5.4.1). The TP-27 area was identified as a hot spot (Section 5.4.2).

In addition to soil samples, six collocated surface water and sediment samples were collected in October 2009 from Plum Brook, which flows south-southwest to north-northeast and intersects the western portion of the sewer line traces. These samples were collected near the portions of the stream which intersect with the former sewer lines. Overburden groundwater samples were collected from two wells in May 2009 and from three wells in November 2009. Groundwater could not be sampled from overburden well 1SLA-MW01 in May 2009 because the well was dry. Groundwater samples were collected from bedrock wells 1SLA-BEDMW-002 and 1SLA-BEDGW-003 in May 2009 and November 2009. Overburden groundwater samples collected from 4 of 10 piezometers; the other 6 piezometers were dry. As discussed in the site characterization report, a third well, 1SLA-BEDGW-001, was installed but could not be sampled during either sampling event because it did not produce sufficient water to sample. All of the sediment, surface water, and groundwater monitoring well samples were quantitatively evaluated in the BHHRA. The piezometer groundwater samples were not quantitatively evaluated in the BHHRA because they are regarded as being only of screening quality and to be used for purposes such as monitoring well placement.

2.3 Evaluation of Data Quality

The quality of the analytical data was evaluated to select data for inclusion in the BHHRA. Data quality is expressed by the assignment of qualifier codes during the analytical laboratory quality control process or during third-party data evaluation. Some of the more common qualifiers and their meanings are as follows (EPA, 1989a):

U - Chemical was analyzed for but not detected; the associated value is the sample quantitation limit.

J - Value is estimated, usually below the reporting limit.

N - The analysis indicates an analyte for which there is presumptive evidence to make a tentative identification.

NJ - The analysis indicates a "tentatively identified analyte" and the reported value represents its approximate concentration.

UJ - The analyte was not detected above the reporting limit. However, the reporting limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R - Quality control indicates that the data are unusable (chemical may or may not be present).

B - The concentration in the sample is not sufficiently higher than concentration in the blank, using the 5-times, 10-times (5x, 10x) rule, which states that a chemical is considered a nondetect unless its concentration exceeds 5 times the blank concentration. For common laboratory contaminants (acetone, 2-butanone [methyl ethyl ketone], methylene chloride, toluene, and the phthalate esters), the sample concentration must exceed 10 times the blank concentration to be considered a detection.

"J," "N," and "NJ" qualified data are treated in the BHHRA as detected concentrations; "R" data and "B" qualified chemical data are not used. "U" qualified data (nondetects) are treated in the BHHRA as nondetections. The use of data with other, less common qualifiers is evaluated on a case-by-case basis. Generally, data for which the identity of the chemical is unclear are not used in the BHHRA. If confidence that the chemical is present is reasonably high but the actual concentration is somewhat in question, the data generally are used in the BHHRA.

Some chemicals may be analyzed under two different analytical programs. For example, the DNT isomers are analyzed by EPA Method 8330 for nitroaromatics as well as EPA Method

8270C for semivolatile organic compounds. In these cases, the risk characterization (Chapter 5.0) includes the EPC of whichever analysis yields the higher value to convey a conservative bias. Risks associated with the reported values from both analyses are discussed as appropriate in the uncertainty analysis (Chapter 6.0), together with potential issues such as the relative sensitivities (i.e., differences in respective reporting limits) of the methods.

2.4 Identification of Chemicals of Potential Concern

A screening process is used to identify COPCs, which are the detected chemical analytes carried through the full risk assessment process. The objectives of COPC screening are to focus the risk assessment on those chemicals that may contribute significantly to overall risk and to remove from quantification those chemicals whose contribution is clearly inconsequential. COPC screening includes a risk-based screen which also considers status as a human nutrient (Section 2.4.1), a frequency-of-detection evaluation (Section 2.4.2), and a background screen (Section 2.4.3).

2.4.1 Risk-Based Screening

In the risk-based screen, the maximum detected concentration (MDC) of a chemical in a given medium is compared to the appropriate risk-based screening concentration (RBSC) for that chemical and medium. This is performed for each chemical in each medium. The units of the MDC and RBSC are the same for each chemical in a given medium. In groundwater, for example, both the MDC and RBSC have units of micrograms per liter (µg/L) in water.

If the MDC of a chemical is less than or equal to its RBSC, then the chemical is not considered further in the BHHRA for this medium because it is very unlikely that chemical concentrations at or below the RBSC would contribute substantially to risk. An analyte may be identified as a COPC if its MDC exceeds its RBSC. As indicated in Section 2.4, actual status as a COPC also depends on a chemical's frequency of detection (Section 2.4.2), concentration with respect to background (Section 2.4.3), and potential status as a nutrient. Groundwater RBSCs used in the BHHRA are derived from the EPA (2011b) regional screening level (RSL) table "tap water" values, and RBSCs for soil are derived from "residential soil" RSL values. This is a change in the source of the RBSCs for PBOW BHHRA work plans begun prior to March 2009 based on discussion between USACE and OEPA (2009c), and this change is consistent with recent OEPA (2009a) guidelines. Previously, the groundwater and soil RBSCs were derived from the corresponding EPA (2004b) Region 9 preliminary remediation goals (PRG). The soil RBSCs are applied to both surface and subsurface soil.

RSL values are based on a concentration equal to either an incremental lifetime cancer risk (ILCR) of 1E-6 or a noncancer hazard quotient (HQ) of 1, the threshold at (or below) which adverse noncancer effects are regarded as unlikely to occur. For the BHHRA, the noncancer values listed in the RSL tables are multiplied by a factor of 0.1 to provide additional protection for simultaneous exposure to multiple chemicals (OEPA, 2009a; EPA, 2011c). This adjustment results in RBSC values associated with an HQ of 0.1. For cancer risk, the RSL values based on an ILCR of 1E-6 were used directly as RBSCs in the BHHRA. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) identifies acceptable exposure levels that are generally associated with concentration levels that represent an excess upper bound lifetime cancer risk to an individual of 1E-6 to 1E-4 (EPA, 1990). This range is hereinafter referred to as the "NCP risk management range." Cancer risks associated with RSL values represent the lower end of this range. The OEPA recognizes an overall cancer risk of 1E-5, which represents the logarithmic midpoint of the EPA risk management range, as a remedial goal (OEPA, 2009b). The RBSC for a chemical that elicits both cancer and noncancer health effects is selected based on either a cancer risk of 1E-6 or an HQ of 0.1, whichever associated concentration is lower.

Risks associated with exposure to sediment and surface water in Plum Brook, which intersects the western portion of the TNTA/WWTP1 sewer line traces, are also evaluated in the BHHRA. Although RSLs have not been developed specifically for sediment and surface water, RBSCs can be derived from the RSLs based on site conditions at PBOW and the types of exposure to these media that may reasonably be anticipated. The routes by which receptors may be exposed to sediment (i.e., incidental ingestion, dermal contact) are similar to those by which receptors may be exposed to soil. However, sediment contact is expected to be appreciably less intense than soil contact, due to the lower duration and frequency of contact with sediment as compared with soil. Similarly, surface water exposure is expected to be much less intense than hypothetical exposure to groundwater, as surface water from Plum Brook is not regarded as a plausible source of drinking water, largely because the Erie County Health Department does not permit using surface water as private drinking water. Consequently, the exposure frequency is expected to be much lower for surface water, and the incidental ingestion of surface water would be much lower than the assumed intentional ingestion and use of groundwater from the tap. For these reasons, OEPA (1999) stated that unadjusted tap water PRG values (i.e., HQ = 1; ILCR = 1E-6) should be used for screening PBOW surface water. This screening protocol was adopted specifically because it was agreed that the magnitude of exposure associated with PBOW surface water exposure would be far less than that associated with household tap water. In other words, it was agreed that analytes with a maximum concentration at the PRG level would not contribute appreciably to overall risks and hazards for PBOW sites based on the exposure pathways of the surface water exposure scenarios for PBOW. The same agreement was reached for screening

sediment against unadjusted residential soil PRGs. This protocol has been updated to base sediment and surface water RBSCs on RSLs rather than PRGs, just as soil and groundwater RBSCs are currently based on RSLs. Even though the sediment and surface water RBSCs are an order of magnitude higher for noncarcinogens than the respective soil and groundwater RBSCs, these sediment and surface water RBSCs are regarded as protective of sediment and surface water receptors for screening because of the lower exposure rate to these media. Note that this previously made PBOW Team agreement for screening surface water and sediment (OEPA, 1999), which considered site-specific conditions, takes precedence over current OEPA (2009b) guidance, which simply states that adjusted RSLs (i.e., RBSCs) for soil may be used to screen contaminants in sediment, and those for groundwater may be used to screen surface water. The surface water RBSCs also meet the outside-of-the-mixing-zone average non-drinking water concentrations for the Lake Erie Basin.

The screening of lead in soil and groundwater is a special case. The EPA (2011d) Office of Water treatment technique action level of 15 µg/L for lead is listed in the RSL table, and the RSL user's guide recommends this level for use as an RSL (EPA, 2011c). Lead exposure and risk is evaluated separately from other chemicals using the EPA (2004c) Integrated Exposure Uptake Biokinetic (IEUBK) model. The selection of the action level as the drinking water RSL is based partly on the IEUBK model. Section 5.2 of the RSL user's guide states that if the average tap water concentration exceeds 15 µg/L and the average soil concentration exceeds a value of 250 mg/kg, then more than the IEUBK target (EPA, 2004c) of 5 percent of the population of exposed children would exceed 10 micrograms per deciliter of lead in blood. Because the RSL of 15 µg/L can be used to screen for a potential average concentration of 15 µg/L, the RSL of 15 µg/L is used as the RBSC. However, it is possible that the residential soil RSL of 400 mg/kg, which is selected as the soil RBSC, may not screen for an average soil concentration of 250 mg/kg within a given data set. Therefore, the following conditions were placed on the screening of lead: 1) If either the soil RBSC or groundwater RBSC is exceeded, then the IEUBK blood-lead model is run using both average soil and groundwater concentrations, and 2) if the average soil concentration exceeds 250 mg/kg, then the IEUBK model is run, even if neither RBSC is exceeded, using average concentrations of lead in both soil and groundwater. Note that for TNTA/WWTP1 sewer line total soil, the MDC for lead (28.3 mg/kg) is less than both the RBSC (400 mg/kg) and the criterion for average concentration (250 mg/kg). Likewise, the lead MDC in TNTA/WWTP1 sewer line overburden groundwater (2.7 µg/L) is less than the RBSC (15 µg/L), and lead was not detected in bedrock groundwater. Therefore, the IEUBK model was not run for TNTA/WWTP1 sewer line soil and groundwater.

There are no RSLs for sulfate in tap water, but the drinking water outside-of-the-mixing-zone average value of 250 milligrams per liter (mg/L) for the Lake Erie Basin is used as the RBSC. This value is the same as the secondary drinking water regulation of 250 mg/L (EPA, 2011a). Secondary drinking water regulations are nonpromulgated values, based on aesthetic characteristics, which are used as guidelines for public water systems. A health-based advisory level of 500 mg/L also exists for sulfate (EPA, 2011d).

The evaluation of essential nutrients is a special form of risk-based screening applied to certain ubiquitous elements that are generally considered to be required human nutrients. Essential nutrients such as calcium, chloride, iodine, magnesium, phosphorous, potassium, and sodium are generally considered innocuous at levels found in environmental media. There are no RSLs listed for these nutrients. Should any of these chemicals be identified as site related, an exposure analysis is performed whereby a daily dose of chemical from ingestion of the medium in question is calculated. The dose is compared with levels known or expected to be safe or toxic, and/or with recommended daily allowances, depending on the availability of data.

2.4.2 Frequency of Detection

When confidence is high that a given chemical is present, the data generally are used in the BHHRA. For most chemicals, their detection is presumptive evidence of their presence. As suggested by EPA (1989a), chemicals that are reported infrequently may be artifacts in the data that do not reflect the actual presence of the chemical in question. For the BHHRA, chemicals that are reported only at low concentrations in less than 5 percent of the samples from a given medium are excluded from further consideration, unless the presence of a given chemical is expected based on historical information about the site. Chemicals detected infrequently at high concentrations may identify the existence of contaminant plumes or limited “hot spots” and are retained as COPCs. No examples of infrequently detected samples indicative of potential hot spots were observed in the TNTA/WWTP1 sewer line data sets.

2.4.3 Comparison to Background

A number of the chemicals detected in PBOW environmental media may have MDCs that exceed RBSCs but are part of normal background concentrations. Such chemicals may include inorganics and polycyclic aromatic hydrocarbons (PAH), a class of organic compounds which form from natural or anthropogenic combustion of organic matter, including fossil fuels, and are generally ubiquitous in the environment. Airborne PAHs associated with non-U.S. Department of Defense sources may be deposited on soil and leach to groundwater. Benzene, toluene, ethylbenzene, and xylenes (BTEX) compounds, as well as PAHs, may also be associated with

background concentrations due to the presence of natural petroleum-derived compounds present in the vicinity of PBOW (Section 3.1.1).

Site concentrations of inorganic chemicals in site environmental media may be compared to those of PBOW background using a two-step approach: 1) background screening and 2) statistical data set testing. This second step (Section 2.4.3.2) is initiated only in cases where the concentration used for background screening is exceeded (Section 2.4.3.1) and is performed after the risk characterization (Chapter 5.0). The results of the statistical data testing are discussed in the uncertainty analysis (Chapter 6.0). No suitable background data set exists for overburden groundwater, so no background screening or statistical comparisons to background concentrations can be made for overburden groundwater samples. Similarly, no background screening or statistical evaluation can be performed for surface water or sediment analytical data, as these media lack PBOW background data sets.

Inorganics and organics are treated similarly from a quantitative perspective. However, all organics not eliminated on the basis of RBSC exceedance (Section 2.4.1) or infrequent detection (Section 2.4.2) are carried through the risk calculation process (exposure assessment, toxicity assessment, and risk characterization). As presented in Section 2.4.3.3, organic compounds are quantitatively eliminated as background related only through the uncertainty analysis if applicable.

2.4.3.1 Background Screening of Inorganics

Background screening is applied to each inorganic whose MDC in soil or limestone bedrock groundwater exceeds the RBSC and that cannot be characterized as an infrequently detected analyte. In background screening, the MDC is compared to the PBOW chemical-specific background screening concentration (BSC). The background data set and derivation of soil BSCs for all PBOW soil investigations are described in IT (1998) (Table 2-2), and the background data set and derivation of BSCs for PBOW bedrock groundwater are described in the 2004 groundwater report (Shaw, 2005) (Table 2-3). It is noted that the method agreed upon for the development of BSCs, as recorded in the September 11, 2002 PBOW team meeting minutes, differs from that shown in current OEPA (2004a) guidance. This PBOW team agreement, which has been used for all PBOW risk assessments to date, takes precedence over the subsequent OEPA (2004a) guidance. Summary tables of the background data sets for soil and groundwater are provided as Tables 2-2 and 2-3, respectively. The background soil samples were collected from near the property boundary, away from any potential source areas, and the background groundwater wells were installed in off-site areas upgradient of PBOW sources. Briefly, BSCs were calculated for use at PBOW based on concentrations found in these background soil and

bedrock monitoring well samples. Each BSC is either the MDC or the calculated 95th percent upper tolerance limit of the background data set, whichever value is lower (IT, 1998; Shaw, 2005). The background monitoring well samples were collected using low-flow samples and were unfiltered.

The background screening consists of comparing the MDC of the site data set to the BSC. The chemical may be regarded as a COPC if its MDC exceeds the BSC for that chemical or if no BSC can be determined due to a lack of detections in the background data set. COPCs are fully evaluated in the exposure assessment, toxicity assessment, and risk characterization. An inorganic analyte is not regarded as a COPC if its MDC is equal to or less than the BSC.

2.4.3.2 Statistical Data Set Testing of Inorganics

Statistical testing is performed to compare data sets of site inorganics data against the appropriate PBOW background data sets. As described in Section 2.4.3.1, the background data set for groundwater is presented in the 2004 groundwater report (Shaw, 2005), and the background data set for soil is presented in the site investigation for the acid areas (IT, 1998). As mentioned previously, background data sets do not exist for overburden groundwater, surface water, or sediment; therefore, a statistical background evaluation for COPCs in these media cannot be performed. The method for statistical comparison of the site data sets to the background data sets, described in Appendix M of Shaw (2005), is the Wilcoxon Rank Sum (WRS) statistical test (also known as the Mann-Whitney U test). WRS testing is performed for inorganics having MDCs that exceed the respective BSCs and are identified as COPCs based on RBSC comparison (Section 2.4.1) and frequency of detection (Section 2.4.2). All COPCs are carried through the risk characterization process; thus, statistical testing results are not used to screen out any chemicals.

Site data sets are interpreted as being significantly different from PBOW background if the associated p-level is less than 0.05. WRS statistical output and box-and-whisker plots of the various inorganic COPC data sets are appended to the BHHRA for each inorganic data set evaluated against the appropriate site background data set; the WRS results are discussed as part of the uncertainties. Analytes shown by the WRS results to exceed background (or for which the WRS testing was not run) are assumed to be site related, unless a qualitative chemical-specific explanation is presented in the uncertainties analysis as to why the analyte should not be regarded as site related. The WRS is not run if the COPC was not detected in the PBOW background data set. Data sets for which the WRS results do not suggest site relatedness (i.e., site data and background data are not statistically different) are still evaluated for risks and hazards in the risk characterization (Chapter 5.0).

2.4.3.3 Treatment of Organic Compounds

As mentioned in Section 2.4.3, certain organic compounds (e.g., BTEX and PAHs) in site media may be attributable to background conditions. However, no organic compounds are summarily screened out. Instead, all detected organic compounds are carried through the risk assessment process (i.e., exposure assessment, toxicity assessment, and risk characterization) unless screened out on the basis of comparison to RBSCs (Section 2.4.1) or characterized as infrequently detected (Section 2.4.2). Background contributions of organics are discussed in the uncertainties analysis, as applicable.

2.5 Data Evaluation Summary

Data summary tables are provided for the following TNTA/WWTP1 sewer line media: surface soil (Table 2-4), subsurface soil (Table 2-5), total soil (Table 2-6), bedrock groundwater (Table 2-7), overburden groundwater (wells) (Table 2-8), and sediment (Table 2-9). None of the chemical analytes were detected in surface water so no COPCs were identified for this medium. These tables provide the following information for each detected chemical in each environmental medium:

- Chemical name
- Frequency of detection
- Range of detected concentrations
- Range of detection limits
- Arithmetic mean of site concentrations
- 95th percent upper confidence limit on the arithmetic mean (UCL) (for COPCs only)
- Appropriate RBSC
- Appropriate BSC
- Selection/exclusion of chemical as a COPC
- EPC (for COPCs only).

The estimation of the UCL values for COPCs is discussed in Section 3.2.1. For duplicate samples, the associated values are averaged in the data summary, if both samples are detects or if both are nondetects; if only one of the duplicates is a detect, then this detected value is used in the data summary.

An analogous summary table for the overburden groundwater piezometer samples is appended (Appendix A). Note that these direct-push groundwater samples are collected for nature-and-extent purposes to determine groundwater flow direction and the placement of monitoring wells. These data are not sufficiently representative of groundwater conditions for use in risk assessment. Therefore, they are not used to identify COPCs and are not quantitatively evaluated

in the BHHRA. This piezometer groundwater summary table is appended only to provide ancillary information.

The COPCs for each of the TNTA/WWTP1 sewer line media are identified as follows:

- ***Surface Soil*** – Aroclor 1016, 2-amino-4,6-dinitrotoluene (2-ADNT), 4-amino-2,6-dinitrotoluene (4-ADNT), 2,4-DNT, 2,6-DNT, TNT, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene

- ***Subsurface Soil*** – 2,4-DNT, TNT

- ***Total Soil*** – Aroclor 1016, 2-ADNT, 4-ADNT, 2,4-DNT, 2,6-DNT, TNT, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene

- ***Bedrock Groundwater*** – Aluminum, arsenic, chromium, iron, selenium, 2-methylnaphthalene, naphthalene, benzene, chloroform, chloromethane, trans-1,3-dichlorpropene, ethylbenzene, toluene, xylenes, cyanide, and nitrate-nitrite

- ***Overburden Groundwater*** – Cobalt, nickel, thallium, and sulfate

- ***Sediment*** – Aroclor 1254

- ***Surface Water*** – (none).

As discussed in Section 2.2, the total soil COPCs include all surface soil and subsurface soil COPCs. For the TNTA/WWTP1 sewer line data sets, the list of surface soil COPCs is the same as the list of total soil COPCs .

3.0 Exposure Assessment

Exposure is the contact of a receptor with a chemical or physical agent. An exposure assessment estimates the type and magnitude of potential exposure of a receptor to COPCs found at or migrating from a site (EPA, 1989a). An exposure assessment includes the following steps:

- Characterize the physical setting.
- Identify the contaminant sources, release mechanisms, and migration pathways.
- Identify the potentially exposed receptors.
- Identify the potential exposure pathways.
- Estimate exposure concentrations.
- Estimate chemical intakes or contact rates.

The BHHRA characterizes potential exposures to COPCs in TNTA/WWTP1 sewer line environmental media as portrayed by the CSEM in Section 3.1. Note that these environmental media include soil, surface water, sediment, and groundwater.

3.1 Conceptual Site Exposure Model

The CSEM provides the basis for identifying and evaluating the potential risks to human health in the BHHRA. The CSEM, graphically depicted on Figure 3-1, includes the receptors appropriate to all plausible site-use scenarios and the potential exposure pathways. This presentation of all possible pathways by which a potential receptor may be exposed, including all sources, release and transport pathways, and exposure routes, facilitates consistent and comprehensive evaluation of risk to human health and helps to ensure that potential pathways are not overlooked. The elements of a CSEM include the following:

- Source
- Source media (i.e., initially contaminated environmental media)
- Contaminant release mechanisms
- Contaminant transport pathways
- Intermediate or transport media
- Exposure media
- Receptors
- Routes of exposure.

Contaminant release mechanisms and transport pathways are not relevant for direct receptor contact with a contaminated source medium (e.g., ingestion or dermal contact).

The receptors and pathways on Figure 3-1 reflect scenarios developed from information regarding site background and history, topography, climate, and demographics as presented by

D&M (1997) and the sitewide groundwater investigation (IT, 1997). On Figure 3-1, asterisks identify exposure pathways that are complete and addressed in this BHHRA. Justification for exclusion of other pathways is provided in the Figure 3-1 footnotes, and the exclusion of other potential receptors is discussed in Section 3.1.3.8. No current or future exposure by off-site residents is evaluated. Most of the off-site residents are serviced by municipal water from surface water sources. Although there are numerous private groundwater wells in the vicinity, including eight within 1 mile of the facility boundary, none of these is used as a potable source. Based on the investigations of other PBOW sites, natural hydrocarbons and hydrogen sulfide are known to be present within the bedrock limestone, and shale formation groundwater generally provides low yields and is of low quality (Shaw, 2008); however, the groundwater underlying the vicinity of the TNTA/WWTP1 sewer lines is not summarily excluded for consideration as a tap water source based on natural water quality parameters or general assumptions concerning yield. Therefore, given the presence of numerous off-site wells and the assumption of unrestricted future land use on site, the development of groundwater for on-site residential (or on-site worker) use as tap water is initially regarded as plausible for purposes of this BHHRA. Groundwater quality and potential use is discussed further in the risk characterization (Chapter 5.0) and uncertainty analysis (Chapter 6.0).

3.1.1 Physical Setting

The topography in the vicinity of the TNTA/WWTP1 sewer line traces is essentially flat, with topography differences ranging in elevation approximately 10 feet. The highest point is a slightly mounded area, just east of the midpoint of the northern sewer line, and the lowest point is along the northern portion of the Plum Brook, a small stream which runs generally south-southwest to north-northeast in this area. There are currently no structures above grade along the sewer line traces, although foundations at the TNTA settling basins and WWTP1 have been covered with a sandy fill material. The current vegetation types along the TNTA/WWTP1 sewer line traces mostly consist of infrequently mowed field, with some areas of wet meadows. This area has been historically mowed only once annually or less. Currently, NASA plans to let it develop as a tall grass prairie with controlled burning. This area is also part of a proposed wind farm. West of Plum Brook, the vegetation is upland old field and shrub thicket.

The following subsections further describe the physical setting of the TNTA/WWTP1 sewer line traces, including the climate and meteorology of the Sandusky region (Section 3.1.1.1), and geology (Section 3.1.1.2), soil (3.1.1.3), hydrology (Section 3.1.1.4), and surface water characteristics (Section 3.1.1.5) of the area and of TNTA/WWTP1 sewer line traces in particular. A general description of the former TNTA/WWTP1 sewer lines is provided in Section 1.3.

3.1.1.1 Climate/Meteorology

The climate in the Sandusky area is continental and strongly affected by Lake Erie. July is generally the warmest month (average high and low temperatures of 82 and 65 degrees Fahrenheit [°F], respectively), and January is generally the coldest (average high and low temperatures of 32 and 19°F, respectively) (The Weather Channel, 2004). On average, the first freezing day (low of 32°F or less) occurs in late October (average of three per month), and the last freezing day falls in early May (average of one per month) (National Oceanic and Atmospheric Administration, 1990). The average annual precipitation for Sandusky is 34.5 inches per year, with a monthly average of more than 3 inches per month falling in April through September and less than 3 inches in each of the other seven months (The Weather Channel, 2004). Precipitation is fairly evenly distributed throughout the year, with the fewest precipitation days (0.01 inch or greater) per month (10) occurring during July, August, September, and October, and the most (15) occurring in December and January (City-Data.com, 2004). The mean annual wind speed is 10.3 miles per hour (City-Data.com, 2004), with winds predominantly from the southwest (Science Applications International Corporation, 1991). Sandusky area winters are cloudy, with 33 percent sunshine during November through February, as compared with up to 65 percent sunshine during the summer months (City-Data.com, 2004).

3.1.1.2 Geology

Three formations, all of Devonian Age, outcrop across PBOW, each of which was encountered in the upper 100 feet of bedrock at PBOW (Shaw, 2005). The Delaware Limestone is the lowermost formation screened by site wells. It is characterized as a hard, dense, finely crystalline limestone and dolomite. The unit is typically buff colored and usually is described as fossiliferous.

For the TNTA/WWTP1 sewer lines, the settling tank at the beginning of the line is located above the Prout Limestone (Olentangy Shale), very near to the interpreted Prout Limestone and Plum Brook Shale (Olentangy Shale) boundary. Approximately 200 feet west toward WWTP1, the geologic horizon changes to the Plum Brook Shale and remains above this bedrock unit past WWTP1. Below the shale horizon, the Delaware Limestone was encountered in all three of the bedrock borings drilled during the investigation. Shale thicknesses from the three bedrock borings vary from depths of approximately 36 to 22 feet.

In the vicinity of PBOW, quarries mine limestone from the Delaware. Traces of natural petroleum-derived hydrocarbons are common in area quarries (Shaw, 2005). Petroleum hydrocarbon odors and/or staining were observed at depth during the drilling of all three TNTA/WWTP1 sewer line wells. At 1SLA-BEDGW-001, the upgradient well which could not

be sampled because of insufficient water yield, petroleum hydrocarbon staining was observed on the cores at 52.8 to 58.2 feet bgs. Well 1SLA-BEDGW-002 exhibited strong hydrocarbon odors from 50 to 65 feet bgs. This well also produced extremely high levels of hydrogen sulfide (i.e., more than 200 parts per million [ppm]) and could not be developed because the high levels of natural occurring hydrogen sulfide. Petroleum hydrocarbon staining was also observed at depth on the cores of 1SLA-BEDGW-003 at 63.8 to 71.7 feet bgs; petroleum hydrocarbon odors were also observed at this depth range. Note that hydrogen sulfide has also been observed at high concentrations in bedrock wells at nearby PBOW sites, notably in Ash Pit 1 (AP1) well AP1-BEDGW-002 and in Locomotive Building Area (LBA) monitoring well MNTA-BEDGW-001 (more than 200 ppm) (Shaw, 2011a). Also, in upgradient well TNTA-BEDGW-001, 14 feet of free product of petroleum hydrocarbons was observed on the surface of the water, and at nearby AP1 well AP1-BEDGW-001 to the southwest, approximately 1 to 2 feet of free petroleum hydrocarbon product has been found on the surface of the water during sampling (Shaw, 2008; 2011b). Petroleum hydrocarbons were also found at depth in four of the six bedrock wells in the nearby LBA (Shaw, 2011a) to the west (side gradient), indicating the prevalence of petroleum contamination in the bedrock zone within this general area of PBOW. These observations provide evidence that petroleum hydrocarbons and elevated levels of hydrogen sulfide are naturally occurring in this general area of PBOW.

3.1.1.3 Soils

The overburden in Erie County is predominantly glacial till, glacial outwash, or glacial lacustrine (lake) deposits. In the vicinity of PBOW, the soil has been interpreted to be lacustrine. In many areas, the overburden also consists of highly weathered bedrock. The thickness of the overburden ranges from less than 1 foot to more than 25 feet. Overburden is thickest on the northern portion of the PBOW facility in the vicinity of the Reactor Facility Area, where it has filled in a bedrock low (Shaw, 2005). In the vicinity of the TNTA/WWTP1 sewer line traces, the overburden thickness ranges from 8.5 feet (well 1SLA-MW01) to 18.9 feet (well 1SLA-MW03), based on boring logs.

Native soil in borings drilled along and near the TNTA/WWTP1 sewer line traces consists of a glacial till, glacial outwash, or a glacial lacustrine (lake) deposit. In general, along the northern half of the field (Figure 3-1), soil consisted of a stiff, olive-brown, mottled brown, silty clay overlying a fine-grain, homogeneous, well-sorted sand, overlying a very stiff, dark gray, silty clay. This area is within a topographic high and represents a different depositional environment than was found in the southern portion of the site. In the southern portion of the field, no sand lenses were encountered and refusal occurred at a shallower depth. Drilling at each of the piezometer borings was continued until refusal by bedrock (Olentangy Shale). The average depth

of the shale as determined by geoprobe drilling and monitoring well installation was 12.5 feet bgs.

3.1.1.4 Hydrology

The two main water-bearing zones at PBOW are located in the overburden/shale unit and the limestone bedrock and are thus called the overburden/shale and bedrock water-bearing zones. The overburden and shale groundwater units show similar water levels, suggesting substantial vertical communication. Therefore, these two geologic units are combined for purposes of PBOW groundwater evaluation. Data collected during the more recent investigations (Shaw, 2005; IT, 1997, 1999, 2001b) indicate that groundwater in the overburden is in discontinuous pockets during dry time periods. The shallow overburden generally has low yields over most of PBOW due to the high percentage of silt and clay. In contrast, the limestone bedrock water-bearing zone yields groundwater year round, although specific locations may not produce water due to limited bedrock fractures in some areas. During periods of low precipitation, only limited migration of contaminants would occur in the overburden due to less infiltration.

Regional groundwater flow in both the overburden/shale and the limestone bedrock is to the north-northeast towards Lake Erie, although local flow may vary due to local topography. A hydrogeological study by the U.S. Geological Survey (1992) conducted in the glacial deposits of Sandusky in 1990 reported a horizontal hydraulic conductivity of 0.046 feet per day and a vertical hydraulic conductivity of 1.2 feet per day.

A total of three overburden wells were installed to monitor overburden groundwater in the vicinity of the TNTA/WWTP1 sewer line traces during the RI. These wells were placed north to south in the eastern portion of the sewer lines traces. Monitoring well 1SLAMW01 did not produce enough water to sample in May 2009, though it could be sampled via the low-flow method in November 2009. Monitoring well 1SLA-MW02 did not produce enough water to sample using the low-flow method in either May or November 2009 but was sampled during each sampling event via bailer. Only well 1SLA-MW03 produced adequate yield to be sampled using low-flow technique during both sampling events.

Overburden groundwater along the TNTA/WWTP1 sewer line traces was encountered at depths ranging from approximately 3 feet bgs at SL-PZ05 in January 2009 (wet season) to 10 feet bgs at SL-PZ09 in January 2009 (wet season) during soil boring drilling/piezometer installation. During installation of the monitoring wells conducted in March 2009 (wet season), overburden/shale groundwater was encountered at depths of 2 feet bgs (1SLA-BEDGW-003) to 17 feet bgs (WTP1-BEDGW-001). Note that during piezometer and well installation, several locations were

dry with respect to overburden groundwater (Shaw, 2012). Near the eastern half of the TNTA/WWTP1 sewer line traces, the general flow direction in the overburden water-bearing zone is toward the south and southeast. Groundwater flow appears to be toward the west in the vicinity of the western half of the TNTA/WWTP1 sewer line traces.

Based on locations and yields of domestic groundwater wells outside of the PBOW facility boundary, the Ohio Department of Natural Resources divided the bedrock groundwater in the vicinity of PBOW into three zones (D&M, 1997). Zone 1 occurs in the north and northwestern portion of PBOW. It has been characterized as yielding from 100 to 500 gallons per minute (gpm) from karstic limestone approximately 100 feet below grade. Zone 2 is in the northern portion of PBOW and has yields of 15 gpm or less from limestone approximately 300 feet below grade. Zone 3 is located in the eastern and southern portion of the site in predominantly shale bedrock. In addition to being found in the shale, groundwater is located in thin sand and gravel horizons interbedded with silt and clay deposits. Most Zone 3 wells are poor yielding, many of them providing less than 3 gpm (D&M, 1997). The TNTA/WWTP1 sewer line traces are within Zone 1, despite the poor water yield.

Water in the limestone typically occurs in joints and along bedding planes or in solutionally enlarged openings. The conceptual model interprets that bedrock groundwater flow in the Delaware Limestone water-bearing zone is influenced by the frequency, orientation, density, and connectivity of the bedrock fractures. These fractures may result in a localized groundwater flow direction that differs considerably from the regional flow direction.

Three bedrock wells were installed to monitor groundwater in the vicinity of the TNTA/WWTP1 sewer line traces during the RI. These wells were placed north to south in the eastern portion of the sewer lines traces. Bedrock groundwater was encountered in fractures at depths of 51.7 feet bgs at 1SLA-BEDGW-001, 68 feet bgs at 1SLA-BEDGW-002, and 76.6 feet bgs at 1SLA-BEDGW-003 during bedrock monitoring well installation in March 2009. (As mentioned, well 1SLA-BEDGW-001 did not produce sufficient water for sampling during either sampling event.) Bedrock groundwater flow underlying the vicinity of the TNTA/WWTP1 sewer line traces is in a northwest direction in the eastern half of the TNTA/WWTP1 sewer line traces toward a bedrock groundwater trough (Shaw, 2012). It is likely that groundwater flow within the limestone bedrock flows more directly north in the vicinity of the western half of the sewer line traces.

3.1.1.5 Surface Water

Plum Brook, a small stream which flows southwest to northeast, intersects the two TNTA/WWTP1 sewer line traces approximately 800 feet east of WWTP1. Although Plum

Brook typically contains water, the presence of perceptible flow is dependent on the amount of recent precipitation and/or snow melt. However, water has always been observed in this portion of Plum Brook. The average width of Plum Brook in this area is approximately 6 feet and the average depth is roughly 1 foot. Plum Brook was sampled near the two intersections with the former sewer lines as part of the TNTA/WWTP1 sewer line RI. A ditch that has been observed to contain water near the eastern terminus of the sewer lines was previously investigated as part of the TNTA RI effort (IT, 2001a,b,c).

3.1.2 Contaminant Sources, Release Mechanisms, and Migration Pathways

Contaminant sources, release mechanisms, and migration pathways are summarized on Figure 3-1. Briefly, TNT is made by nitrating toluene in a three-step process that uses nitric and sulfuric acids (D&M, 1997). WWTP1 received waste water via the sewer lines from the TNTA operations waste water settling basins. Contamination along the TNTA/WWTP1 sewer lines may have resulted from leaks in the lines or from the release of residual materials within the line during sewer line removal. Any leaks would have been subsurface releases, although materials released by leaks may have diffused upward toward the surface during wet periods. Release of contamination during sewer line removal may have affected either the surface or subsurface soils. Runoff and erosion may have spread contamination over the surrounding surface soil and carried contaminants to nearby streams. Infiltration and leaching may have carried contaminants into the deeper subsurface soil or groundwater. It is possible that surface water and sediment at Plum Brook may have been impacted by contaminants originating from the TNTA/WWTP1 sewer lines through surface drainage.

3.1.3 Receptors and Exposure Pathways

Receptors selected to represent the upper bound on exposure from all plausibly exposed groups of people associated with the TNTA/WWTP1 sewer line traces as well as the pathways by which they may be exposed to chemicals are summarized on Figure 3-1 and in Table 3-1. The exposure variable values used in the contaminant intake models are compiled in Table 3-2. The receptors evaluated in the BHHRA are listed below.

- Current groundskeeper
- Future groundskeeper
- Indoor worker (future)
- Construction worker (current/future)
- On-site resident (future)
- Hunter (future)
- Hunter’s child (future).

Note that the current (Section 3.1.3.1) and future (Section 3.1.3.2) groundskeeper scenarios include different environmental media and are, thus, listed separately. The construction worker may be viable under current or future land use, but the evaluation for this receptor is exactly the same under current and future land use.

Most BHHRAs are based on a reasonable maximum exposure (RME) assumption. The intent of the RME assumption is to estimate the highest exposure level that could reasonably be expected to occur, but not necessarily the worst possible case (EPA, 1989a; 1991a). It is interpreted as reflecting the upper 90 to 95th percentile on exposure. In keeping with EPA (1989a; 1991a) guidance, variables chosen for a baseline RME scenario for ingestion rate, exposure frequency, and exposure duration are generally upper bounds. Other variables, such as body weight and exposed skin surface area, are generally central or average values. In the case of contact rates consisting of multiple components (e.g., dermal contact with soil or water, which consists of a dermal absorption factor [ABS] and soil-to-skin adherence factor [AF] for soil, and permeability coefficient [K_p] and exposure time [ET] for water), only one variable, ABS or K_p, needs to be an upper bound. The conservativeness built into the individual variables ensures that the entire estimate for contact rate is sufficiently conservative.

The averaging time for noncancer evaluation is computed as the product of the exposure duration (years) multiplied by 365 days per year. The resultant noncancer averaging time is used to estimate an average daily dose over the entire exposure period (EPA, 1989a). For cancer evaluation, the averaging time is computed as the product of 70 years, the assumed human lifetime, times 365 days/year. This cancer-based averaging time is used to estimate an average daily dose prorated over a lifetime, regardless of the frequency or duration of exposure. The methodology used in deriving the averaging time for cancer risks assumes that the risk from short-term exposure to a high dose of a given carcinogen is equivalent to long-term exposure to a correspondingly lower dose, provided that the total lifetime doses are equivalent. This approach is generally consistent with the EPA (2005) policy of carcinogen evaluation, although it introduces considerable uncertainty into the BHHRA cancer risk estimates.

A fractional term (FI) is introduced into the chemical intake equations to account for scenarios in which exposure to a potentially contaminated medium associated with the site is less than total daily exposure to that medium. For example, if the site of interest is small or has unusual dimensions so that a groundskeeper would be unlikely to spend all (or nearly all) of his working time at the site, an FI value of less than 1 might be applied to the soil ingestion and dermal intake equations. An FI may also be split between two comparable media. For example, if a resident is exposed to both soil and sediment, FI values are introduced that apportion exposure between the

two media such that the FI value for the two analogous media does not exceed a value of 1 (Section 3.1.3.5).

Receptors and the associated exposure pathways are presented in the following subsections. Please note that some of the pathways considered for the receptors (e.g., surface water exposure; volatile organic compounds [VOC] in soil) could not be quantitatively evaluated because pertinent chemicals associated with these pathways were not identified as COPCs.

3.1.3.1 Current Groundskeeper

The groundskeeper scenario is designed to evaluate the upper bound for long-term site worker exposure to surface soil in the current site-use scenario and total soil in the future site-use scenario. It is noted that other than infrequent mowing (see Section 1.3), no groundskeeper is currently working at the site, but current land use does not prohibit a site worker from performing regular groundskeeping activities at the site.

Exposure to surface soil is evaluated for a (potential) current groundskeeper. Total soil is typically evaluated under the future groundskeeper use scenario because hypothetical future construction may include considerable excavation of subsurface soil. This soil may be spread on the surface and regraded such that some of the soil currently in the subsurface (i.e., 1 to 10 feet bgs) will be spread as surface soil (0 to 1 foot bgs). Groundwater, which could theoretically be developed as a source of drinking water, is also evaluated for the groundskeeper in the future site-use scenario, as discussed in Section 3.1. It is assumed that any contact with surface water or sediment associated with the TNTA/WWTP1 sewer line traces by this receptor would be infrequent and sporadic, because such contact would not be a part of the groundskeeper's regular duties or activities. Therefore, exposure to these media is not quantified.

Direct soil exposure pathways include incidental ingestion and dermal contact. Inhalation of dust raised by lawnmowers or other equipment is also evaluated because relatively high dust concentrations may be produced within the groundskeeper's breathing zone, with little opportunity for dilution by the large volume of ambient air.

Shaw's experience has been that surface soil that is contaminated with VOCs and that has been in place for extended periods is not a significant source of airborne VOCs, because infiltration and dissipation over time reduces residues at the surface (i.e., first few centimeters) from which volatilization would occur. However, as noted previously, the data set for surface soil may include samples taken from up to 1 foot bgs, which would include the soil zone deeper than the top few centimeters, where dissipation has not reduced VOC concentrations. In other words, the

surface soil data set might indicate the presence of VOCs, although volatilization to the air is unlikely to be significant. Therefore, a surface soil-to-air volatilization model is not used in addition to the activity-based dust emissions model to estimate airborne concentrations of VOCs. Instead, the airborne concentrations estimated by the dust emissions model are assumed to sufficiently estimate levels of VOCs that may arise from volatilization, because the dust emissions model treats the VOCs as if they were located at the surface. It is assumed that VOC emissions from subsurface soil (i.e., at depths greater than 1 foot bgs) would be attenuated by the overlying soil so that concentrations in ambient air would not be toxicologically significant.

The groundskeeper is assumed to be a 70-kilogram (kg) adult who works 8 hours per day, approximately 5 days per week year-round on site for a total of 250 days/year for 25 years (EPA, 2004a). The respiratory rate for the groundskeeper is assumed to be 20 cubic meters (m^3) per 8-hour workday or 2.5 cubic meters per hour (m^3/hr) (EPA, 1991a), and the soil incidental ingestion rate is assumed to be 100 milligrams per day (mg/day) (EPA, 2002). The groundskeeper is assumed to be exposed dermally to soil. An exposed skin surface area of 3,300 square centimeters (cm^2) and a soil AF of 0.2 milligrams per square centimeter (mg/cm^2) are assumed (EPA, 2004a).

3.1.3.2 Future Groundskeeper

A future groundskeeper would be exposed to soil via the same exposure pathways as the current groundskeeper described in Section 3.1.3.1. However, the future groundskeeper scenario assumes that construction has taken place and that some of the soil currently in the subsurface has been brought to the surface during earthmoving activities. Therefore, the future groundskeeper is assumed to be exposed to a combination of surface and subsurface soil (total soil) rather than surface soil alone.

In addition, a hypothetical future groundskeeper is assumed to be exposed to groundwater, which could theoretically be developed as a source of drinking water in the future. His drinking water ingestion rate is assumed to be 1 liter per day (L/day) (EPA, 1991a). He may also experience dermal contact with groundwater used to clean equipment and to rinse dust or perspiration from his body. For this evaluation, it is assumed that the head, forearms, and hands, approximately 3,300 cm^2 of his body (EPA, 2004a), would be exposed intermittently for up to 1 hour/day. Because exposure is assumed to be intermittent rather than continuous, organic chemical uptake across the dermis would not reach steady state, which guides the selection of the EPA (2004a) model used to quantify this pathway (Section 3.3).

3.1.3.3 Indoor Worker

This receptor scenario was used to evaluate exposure to indoor airborne VOCs entrapped in a building. VOCs released from subsurface soil may enter a building through joints or cracks in the foundation or slab. The indoor worker is also potentially exposed to surface soil via incidental ingestion. Exposure to COPCs in surface soil via dermal contact and inhalation of airborne dust and VOCs from surface soil, although plausible, are expected to be less significant than incidental ingestion, because this receptor spends his work time indoors. Therefore, dermal contact and inhalation of dust and airborne VOCs from surface soil are not quantified separately from ingestion exposure (EPA, 2002). Under a future use scenario for this receptor, construction of a building would be necessary. This would require excavation and regrading of soil. Normally, when construction is involved (e.g., such as for the future groundskeeper or resident), total soil rather than surface soil would be evaluated for ingestion exposure. However, the chief purpose for this receptor is to evaluate exposure via vapor intrusion of contaminants from subsurface soil into indoor air. Thus, the evaluation of direct contact with subsurface soil as a component of total soil would equate to "double counting" of COPCs in subsurface soil. Also, the groundskeeper reflects a worst-case exposure for a long-term worker with respect to direct contact with both surface soil and total soil. Therefore, direct contact with surface soil for the indoor worker is included to reflect a more complete exposure scenario, but direct contact with subsurface soil is most effectively addressed from an RME perspective by the groundskeeper.

The indoor worker is assumed to be a 70-kg adult who works 8 hours/day, approximately 5 days/week year-round on the site for a total of 250 days/year for 25 years (EPA, 2002). His incidental soil ingestion rate is assumed to be 50 mg/day (EPA, 2002), and his inhalation rate is assumed to be 20 m^3/8-hour workday (EPA, 1991a).

A future indoor worker is assumed to be exposed to groundwater, which could theoretically be developed as a source of drinking water (Section 3.1). His drinking water ingestion rate is assumed to be 1 L/day (EPA, 1991a). Some indoor worker positions may require relatively frequent dermal contact with groundwater as well, e.g., a food preparer/cafeteria worker who would wash his hands, produce, equipment, etc. For this evaluation, it is assumed that the head, forearms, and hands, approximately 3,300 cm^2 of his body (EPA, 2004a), would be exposed intermittently for up to 1 hour per day. Because exposure is assumed to be intermittent rather than continuous, organic chemical uptake across the dermis would not reach steady state, which guides the selection of the EPA (2004a) model used to quantify this pathway (Section 3.3.4).

3.1.3.4 Construction Worker

The construction worker scenario is used to evaluate short-term exposure to surface and subsurface soil (total soil) in either the current or future land-use scenario. Construction projects are expected to be infrequent. It is assumed that the construction worker participates in only one construction project on the site. Note that no construction projects are anticipated specifically along the TNTA/WWTP1 sewer line traces, but the vicinity of the sewer line traces is currently under NASA control and a construction project may be possible under current land use. A wind farm planned for the area may include limited excavation along portions of the sewer line traces. Relevant exposure pathways include incidental ingestion and dermal contact, inhalation of dust raised by operating construction equipment, and inhalation of airborne VOCs released from subsurface soil during excavation and grading. Exposure to groundwater by the construction worker is also possible; however, if on-site groundwater were developed as a tap water source, other potential future groundwater receptors such as the groundskeeper would have longer and/or more frequent groundwater exposure. Therefore, groundwater exposure is not evaluated for the construction worker.

The construction worker may also be exposed to surface water and sediment associated with TNTA/WWTP1 sewer line traces during projects such as installation of underground utilities or rerouting of surface flow. Dermal contact is the most significant pathway for exposure to surface water. Incidental ingestion of surface water is also possible but is not expected to be nearly as significant as dermal contact. Inhalation of VOCs from surface water is also possible, but the large volume of outdoor air and natural air currents are expected to dilute airborne concentrations so that this pathway is expected to be less significant than dermal contact, which is quantified. For these reasons, incidental ingestion and inhalation of VOCs from surface water are not quantified separately from dermal contact. Dermal contact and incidental ingestion may be important pathways for exposure to sediment, and both are evaluated.

The construction worker is assumed to be a 70-kg adult who works 8 hours/day, approximately 5 days/week. This represents an annual exposure frequency rate of about 250 days per year, which is the same as described for the groundskeeper (Section 3.1.3.1) and indoor worker (Section 3.1.3.3). Construction projects involving soil exposure are assumed to last 6 months. The respiratory rate for the construction worker is assumed to be 20 m^3/8-hour workday (2.5 m^3/hr) (EPA, 1991a). A soil ingestion rate of 330 mg/day is assumed for the construction worker (EPA, 2002). A dermal soil AF for the construction worker of 0.3 mg/cm^2 and an exposed body surface area of 3,300 cm^2 are assumed, which represent the head, hands, and forearms (EPA, 2002; 2004a).

The construction worker may be exposed to surface water and sediment during the 6-month construction period. The construction worker dermal exposure parameters for sediment are assumed to be exactly the same as those for soil. Dermal exposure to surface water is assumed to occur for up to 4 hours per day, or one-half the normal work day. It is assumed the exposure to surface water is intermittent during this period. An exposed body surface area of 3,300 cm^2, the same as for sediment and soil, is assumed for exposure of the construction worker to surface water. It is expected that the construction worker would wear appropriate footgear and leg protection to minimize surface water and sediment exposure to the legs.

The construction worker scenario described above provides for several different kinds of construction projects, such as upland excavation and building projects (exposure primarily to soil) as well as stream rerouting (exposure primarily to surface water and sediment). It is unlikely, however, that a single construction worker would participate in all these activities during a given project. Therefore, the evaluation described above is probably overly conservative and may represent some double counting. For example, it is unlikely that the construction worker would be simultaneously ingesting soil, sediment, and surface water. Similarly, the air in his breathing zone is not likely to contain the reasonable maximum concentrations of COPCs estimated for soil while he is exposed to surface water. The potential for double counting is not expected to contribute significantly to total risk estimates summed across chemicals, pathways, and media. Should construction worker risk estimates exceed acceptable limits, risk and hazard estimates may be performed using refined exposure assumptions based on the physical characteristics of the site. For example, an upland excavation and building project may be assumed for one or more areas of the site, and a stream rerouting project may be assumed for another. Effectively, the risks and hazards associated with surface water/sediment exposure and soil exposure could be separated. This approach would more precisely reflect plausible exposure scenarios, reduce the likelihood of double counting, and more accurately identify risk-driving media and chemicals. These refined estimates would be presented in the uncertainty analysis.

3.1.3.5 On-Site Resident

The on-site residential scenario is used to evaluate the upper bound for long-term exposure to site soil, surface water, sediment, and groundwater under the future land-use scenario. Residential land use is plausible because property surrounding the PBOW facility includes rural residential use. This type of land use is also consistent with assumed future land use of other PBOW sites such as TNTA and TNTC (IT, 2001a).

The on-site residential scenario is evaluated assuming a 30-year residential exposure scenario, considering exposure to a resident as a young child (6-year duration, ages 1 through 6 years)

through the adult portion of life spent at this residence (24-year duration) (EPA, 1991a). Noncancer hazard estimates are derived separately for the child and adult life stages. Cancer risk is estimated as the sum of the risks calculated for the adult (24 years) and the child (6 years) (EPA, 2002; 2011c).

The resident is assumed to be exposed directly to total soil, because residential development would involve excavation and regrading, which would mix surface and subsurface soil. Relevant pathways for total soil exposure include incidental ingestion, dermal contact, and inhalation of dust and VOCs. Evaluation of VOCs from total soil is addressed during evaluation of airborne dust, as described for the groundskeeper. For evaluating inhalation of airborne dust, it is assumed that 80 percent of the soil surface is covered with pavement or vegetation. Inhalation of VOCs released from subsurface soil entrapped in indoor air is also evaluated. The resident is also assumed to be exposed to VOCs that have been released from subsurface soil through cracks in the building foundation to indoor air. It is noted that because some of the subsurface soil is expected to be brought to the surface in the future, using only subsurface soil data will conservatively result in some double counting of exposure to any VOC COPCs that may be present in the subsurface soil. This can be addressed in the uncertainty analysis in cases where the subsurface soil-to-indoor air pathway significantly affects risk and hazard estimates. This pathway did not contribute significantly to risk at the TNTA/WWTP1 sewer line traces, as no VOCs were identified as COPCs in subsurface soil.

It is assumed that, under future residential land use, the overburden and limestone bedrock water units will be developed as sources of potable water (Section 3.1). The resident is assumed to use groundwater underlying the site as the sole source of household tap water. Exposure to COPCs in groundwater would occur via ingestion, dermal contact during bathing/washing, and inhalation of VOCs released to the air during household use of tap water associated with multiple household uses.

The resident in the vicinity of the TNTA/WWTP1 sewer line traces could have access to Plum Brook and be exposed to associated contaminants in surface water and sediment. Plausible exposure pathways include dermal contact with surface water and incidental ingestion and dermal contact with sediment. Incidental ingestion of surface water in a wading scenario is considered less significant than dermal contact and is not quantified separately from dermal contact. Inhalation of VOC emissions from surface water is also possible, but the large volume of outdoor air and natural air currents are expected to dilute airborne concentrations, so that this pathway is expected to be less significant than dermal contact, which is quantified. For these

reasons, the inhalation of VOC emissions from surface water is not quantified separately from dermal contact.

The adult resident is assumed to be a 70-kg person with an incidental soil ingestion rate of 100 mg/day and an inhalation rate of 20 cubic meters per day (m^3/day) or 0.83 m^3/hr (EPA, 1991a). A body surface area of 5,700 cm^2, representing the hands, forearms, head, and lower legs, is assumed to be available for dermal exposure to soil (EPA, 2004a). A soil AF of 0.07 mg/cm^2 is used as the default RME value for the adult resident (EPA, 2004a). The adult resident is assumed to be exposed for 350 days/year for 24 years (EPA, 1991a; 2002).

The child resident is assumed to be a 1- through 6-year-old child with an average body weight of 15 kg, a soil ingestion rate of 200 mg/day, and an average inhalation rate of 10 m^3/day or 0.417 m^3/hr (EPA, 2004d). An average body surface area of 2,800 cm^2 throughout the 6-year childhood exposure period, representing the head, hands, forearms, lower legs, and feet, is assumed for dermal contact with soil (EPA, 2004a). A soil AF of 0.2 mg/cm^2 is used as the default RME value for the child resident (EPA, 2004a). The child resident is assumed to be exposed for 350 days/year for 6 years (EPA, 1991a; 2002).

It is assumed that the resident would visit Plum Brook in the vicinity of the sewer line traces for 8 hours/day, 2 days/week during the warmer half of the year. This resident is assumed to wade for 3 hours/day on 52 days of the year. Mechanisms of exposure to soil and sediment are likely to be similar. Therefore, the incidental soil ingestion rate of 100 mg/day, the surface area of 5,700 cm^2, and the AF of 0.07 mg/cm^2 are also applied to sediment exposure in the adult. Similarly, the resident child soil ingestion rate of 200 mg/day, skin surface area of 2,800 cm^2, and soil AF of 0.2 mg/cm^2 are applied to sediment exposure for this receptor. This area of Plum Brook generally contains only about a foot of nonflowing water. It is assumed that an adult body surface area of 7,000 cm^2 is available for exposure to surface water. This represents the same body parts to which soil and sediment would be exposed (i.e., hands, forearms, head, and lower legs) plus the feet (EPA, 1997a; 2004a). The body surface area of 2,800 cm^2, representing the hands, forearms, head, lower legs, and feet, used for soil and sediment exposure in the young child are also used for surface water exposure for this receptor.

EPA (1989a) permits the development of an FI to reflect the proportion of total daily exposure that a receptor obtains from potentially contaminated medium (Section 3.1.3). For this receptor, the FI is used to apportion the resident's time of exposure between site soil and sediment. It is assumed that the resident spends 16 hours/day awake and potentially exposed to soil or sediment. As previously noted, 350 days/year are available for contact with soil; 52 of those days are also

available for contact with sediment. It is assumed that contact with soil and sediment does not occur simultaneously; i.e., on those days when the resident spends time at Plum Brook, 8 hours would be spent in contact with soil and 8 hours would be spent in contact with sediment. Therefore, the fraction of exposure to soil is 16 hours/16 hours = 1 on the 298 days without time spent at the Plum Brook, and the fraction of exposure to soil is estimated as 8 hours/16 hours = 0.5 on the 52 days with some time spent at the streams. A weighted fraction of 0.93 (rounded to 0.9) is estimated for exposure to soil over the entire 350 days/year exposure frequency. A weighted fraction of 0.07 (rounded to 0.1) is estimated for exposure to sediment over the entire 350 days/year exposure frequency.

An adolescent resident may be the most likely individual to have regular exposure to sediment and surface water associated with the TNTA/WWTP1 sewer line traces. It is not expected that adults would regularly visit this area of Plum Brook, as it does not support game fish and would seemingly not provide any attraction. It is unlikely that a young child (i.e., ages 1 through 6) would frequent this area of Plum Brook for substantial portions of time, because such young children (especially at the lower end of this age range) would require continued adult supervision. However, as described previously, it is conservatively assumed that the resident will be regularly exposed to surface water and sediment for 30 years: 6 years assumed as a young child and 24 years assumed as an adult. For cancer effects, the 30-year exposure to surface water and sediment represented by both the young child and adult are combined. This approach is more conservative than evaluating an adolescent and is also consistent with BHHRAs performed for PBOW sites in the past.

With respect to groundwater exposure, it is assumed that an adult resident ingests 2 L/day of tap water (EPA, 1991a) and that the young child drinks 1 L/day (EPA, 2011c). The total body surface areas of the adult and of the young child resident are assumed to be exposed to tap water while bathing/showering. The total surface area for an adult is assumed to be 20,000 cm^2 and the total surface area for the young child is assumed to be 6,600 cm^2 (EPA, 1997a). Both the child and adult resident are assumed to be dermally exposed to COPCs in groundwater while bathing/showering. The child is assumed to bathe for 20 minutes per day (0.33 hour/day) (EPA, 1997a), and the adult is assumed to shower for 12 minutes per day (0.2 hour/day) (EPA, 1997a). Inhalation rates of 0.833 m^3/hr for the adult (EPA, 1991a) and 0.416 m^3/hr for the child (EPA, 2004d) are used. Because EPA (1997a) lists a 90th percentile for time spent in a residence as over 23 hours per day, it is conservatively assumed that the resident spends 24 hours per day in the house.

3.1.3.6 Hunter

This scenario is created to evaluate the potential for contaminants in soil to affect food chain pathways. The TNTA/WWTP1 sewer line traces provides habitat for deer and other wildlife. Even though hunting is not currently permitted at the TNTA/WWTP1 sewer line traces, deer hunting is permitted in other areas within PBOW; therefore, future use of the TNTA/WWTP1 sewer line traces for hunting is evaluated in this BHHRA.

Many kinds of game animals may be hunted and consumed (e.g., squirrel, pheasant and other upland birds, turkey, and deer); however, the deer is the species most likely to contribute meaningfully to the diet. Therefore, this evaluation is limited to a deer hunter. Potential exposure pathways include incidental surface soil ingestion, dermal contact with surface soil, and ingestion of venison from deer that browse plants growing on contaminated surface soil, all of which are evaluated quantitatively. Inhalation of airborne dust from wind currents is a potentially complete exposure pathway; however, vegetation reduces dust emissions to insignificant levels (EPA, 1996), and it is assumed that the deer hunter would spend virtually all of his time on vegetated rather than bare soil. Therefore, it is assumed that inhalation exposure would contribute much less than incidental ingestion, and the inhalation exposure pathway is not quantified separately from ingestion.

Inhalation exposure to airborne VOCs from subsurface soil and surface water is not evaluated for the reasons previously explained for other receptors. Also, ingestion and dermal exposure to surface water and sediment are expected to be negligible for this receptor, as contact with these media would generally be avoided during hunting activities.

The deer hunter is assumed to be a 70-kg adult who harvests deer and consumes venison over a 30-year period. It is assumed that he spends 14 days per year hunting on PBOW. His incidental soil ingestion rate is assumed to be 100 mg/day (EPA, 1991a). Hunting at PBOW occurs in the fall and winter. Given the temperate climate of northern Ohio during hunting season, a hunter would dress appropriately, with typically only the hands and head exposed, at most. The default industrial RME exposed skin surface area of 3,300 cm^2, which represents the hands, forearms, and head (EPA, 2004a), is conservatively assumed for the hunter. The default industrial RME soil AF of 0.2 mg/cm^2 (EPA, 2004a) is also assumed.

Data regarding the rate of venison ingestion were not located; therefore, a hypothetical scenario is adapted from the assumptions applied to a similar site in West Virginia (IT, 2000) and subsequently applied to TNTA and TNTC (IT, 2001a). A highly conservative but plausible scenario consists of a hunter who kills one deer from the vicinity of the TNTA/WWTP1 sewer

line traces property each year. It is assumed that the hunter eats 10 pounds (4.5 kg) of venison per year (Sharp, 1995). This consumption rate corresponds to 0.013 kilograms per day (kg/day) (0.186 grams per kilogram of body weight per day [g/kg-day]) of venison for each of the 350 days per year (EPA, 1991a) that the hunter spends at his residence.

3.1.3.7 Hunter's Child

It is likely that a successful hunter, described in Section 3.1.3.6, would share his venison with the rest of the family, which may include small children. Small children, however, would be unlikely to accompany the hunter afield. Therefore, the direct exposure pathways evaluated for the hunter (i.e., incidental ingestion and dermal contact with soil) are not evaluated for the small child.

Data regarding the rate of venison ingestion by small children were not located. However, if it is assumed that venison may replace beef in the diet, the differences in beef consumption between adults and children can be used to estimate a venison ingestion rate for children. EPA (1997a) provides per capita beef intake data for <1- to 5-year-old children ranging from 0.941 to 1.46 g/kg-day (time-weighted average of 1.296 g/kg-day). EPA (1997a) provides per capita beef intake data for 12- to 70-plus-year-old adults ranging from 0.568 to 0.83 g/kg-day (time-weighted average of 0.727 g/kg-day). From these data, it can be estimated that the rate of beef consumption for small children, expressed on a body weight basis, is approximately 1.8 times that of an adult. Therefore, a venison ingestion rate of 0.335 g/kg-day is estimated for a young child from the venison ingestion rate of 0.186 g/kg-day for the adult. Assuming that the child is 1 through 6 years old with an average body weight of 15 kg (EPA, 1991a; 2002), the child's venison ingestion rate may be expressed as 0.005 kg/day.

3.1.3.8 Other Receptors Not Considered

Another plausible receptor group is delivery personnel. These receptors, however, would be less intensively exposed to soil than the groundskeeper; therefore, their exposures are not evaluated. The vicinity of the TNTA/WWTP1 sewer line traces could become part of the area used for National Guard training activities. National Guard trainees, however, may be less exposed to any of the potentially contaminated media than the receptors identified previously. Because they would likely not represent an upper bound for nonresidential exposure, these receptors are not evaluated. This area of Plum Brook does not support game fish. Therefore, fish ingestion as an indirect pathway for exposure to surface water and sediment is not evaluated. Also, as discussed in Section 3.1, off-site use of groundwater is not evaluated because nearby residents use municipal water from surface water sources as a potable source, and potential on-site users would be exposed to higher concentrations of contaminants in groundwater.

3.2 Quantification of Exposure-Point Concentrations

The EPC is an estimate of the concentration of a COPC in a given medium to which a receptor may be exposed over the duration of the exposure. An EPC may be based on chemical concentrations in media that have been directly measured using laboratory analysis, or it may be derived based on environmental medium-to-medium transport modeling. The EPCs of COPCs in soil, groundwater, surface water, and sediment are derived based on measured analytical data. Note that the EPC for dermal exposure to VOCs in groundwater is based on one-half the EPC concentration derived from the measured concentrations in groundwater (Sections 3.2.1 and 3.2.2.3). This value is used because it is assumed that 50 percent of the groundwater VOC concentration is volatilized during normal household use (Section 3.2.2.2). Concentrations of COPCs in air and venison are not measured (and in some cases cannot reasonably be measured) but are based on models that use the EPCs of COPCs in the appropriate directly measured media (i.e., soil and groundwater) as input values.

Section 3.2.1 describes the approaches used to derive EPCs for direct exposure to soil, groundwater, surface water, and sediment based on analytical measurements from samples of these media. Models to derive EPCs for the air are described in Sections 3.2.2.1 and 3.2.2.2, and the model used to derive venison EPCs is described in Section 3.2.2.4.

3.2.1 Soil, Groundwater, Surface Water, and Sediment Concentrations

Exposure to an environmental medium is generally assumed to be random, and the EPC should be the arithmetic average encountered over the duration of exposure (EPA, 1989a). Therefore, the population mean concentration, if known, would be the ideal value selected as the EPC. The sample mean is an obvious estimate of the population mean. However, uncertainties exist as to how well the sample mean represents the population mean. Therefore, EPA (1989a) has recommended the inclusion of a UCL for RME evaluation as a conservative estimate of the true mean exposure concentration.

The EPA (2011a; 2010a,b) ProUCL (Version 4.01) software was used to estimate UCLs for the data sets of all environmental media represented by at least five samples. If the data set consists of fewer than five data points, the MDC was selected as the EPC. Analytical data from field duplicates are averaged with originals to yield one result for use in the statistical manipulations (Section 2.5). One-half the reporting limit is used as the ProUCL input concentration for nondetects. Nondetect sample results with aberrantly high detection limits due to matrix interferences or other sample-specific causes are included in the initial ProUCL calculations. This is a conservative approach, as EPA (1989a) recommends that nondetect results with aberrantly high detection limits be removed from the data set so that calculation of the UCL is

not unduly skewed by a nondetect. Because the latest version of ProUCL (EPA, 2010a) includes mathematical manipulations under the default "with NDs" mode that are more robust than previous versions, single elevated detection limits are less likely to skew the UCL estimates than in the past. If it is observed during the risk characterization that an elevated nondetect value skews a UCL estimate such that this value substantially affects the result of the risk estimate, the ProUCL model is rerun without the elevated nondetect value and the risks are recalculated. If this recalculation is performed on a data set, data eliminated for the recalculation are identified in the risk characterization and discussed in the uncertainty analysis. The re-evaluation of elevated nondetects was not performed in the TNTA/WWTP1 sewer line BHHRA.

ProUCL generates a variety of UCL estimates for each data set. The ProUCL output for each COPC is included in Appendix B. Generally, the results of one or two (sometimes more) of the UCL estimates are recommended. This recommendation is based on a variety of factors, including the distribution (i.e., normal, lognormal, gamma, or not discernable) that provides the best fit, number of nondetects, size of the data set, and skewness. If the recommended value(s) under the default mode equals or exceeds the MDC, ProUCL is rerun using the full data set mode, under the assumption that the COPC is present in nondetects at one-half the reporting limit. Occasionally, ProUCL recommends the 97.5 or 99 percent upper confidence limit on the arithmetic mean estimated by the Chebyshev method. In these cases, the UCL estimated by the Chebyshev method (95th percent) is selected as the EPC because this is more consistent with the intent of the RME paradigm as defined by EPA (1989a; 1991a).

The UCL generated by the ProUCL protocol described in the preceding paragraphs or the MDC, whichever is smaller, is selected as the EPC and is understood to represent a conservative estimate of average for use in the risk assessment or in various transport models used to estimate EPCs. Note that EPA (1989a) guidance states that an estimate of average rather than the MDC should be used to represent the EPC under chronic exposure and that use of the maximum is typically not reasonable. Therefore, data sets which use the MDC as the EPC are generally biased high. Unusually high detected values are included in the calculation of the UCL concentration. Inclusion of these high values increases the statistical variability and the overall conservativeness of the risk estimate.

ProUCL is a software tool that provides estimates of the UCL using a variety of mathematical approaches. As mentioned, its output includes one or more recommendations. Depending on the data set, some of the estimates generated by the various calculation methods included in ProUCL may vary by an order of magnitude. ProUCL and the decision tree on which its recommendations are based have been developed using multitudes of simulated data sets with a variety of

distributions and other characteristics. There are uncertainties as to how well this decision tree derives a recommended UCL for a given data set. This uncertainty tends to increase with variability and skewness and where a large number of the samples are nondetects. For example, with respect to distribution testing, ProUCL bases the determination of distribution type only on the detected samples. The true concentrations of the nondetected values are unknown, and this lack of information can affect the distribution determination and consequently affect the ProUCL recommendation. The general uncertainties associated with the EPC values and the use of ProUCL are discussed in the uncertainty analysis (Chapter 6.0). Specific uncertainties associated with the EPC values of specific data sets may be discussed in the uncertainty analysis as appropriate.

3.2.2 Exposure-Point Concentrations in Air

The models shown in the following subsections for estimating COPC concentrations in air include only those relevant and used specifically for TNTA/WWTP1 sewer line COPCs and media.

3.2.2.1 COPC Concentrations from Dust

Inhalation exposure to particulate (dust) emissions from soils for the groundskeeper and construction worker evaluations arises from activities that raise dust. Therefore, the most appropriate approach for estimating chemical concentrations in ambient air is the use an activity-based dust loading equation (U.S. Department of Energy [DOE], 1989):

$$C_a = (D)(C_s)(CF_1) \qquad \text{Eq. 3.1}$$

where:

- C_a = contaminant concentration in air (milligrams per cubic meter [mg/m^3], calculated)
- D = dust loading factor (grams [g] of soil/m^3 of air)
- C_s = contaminant concentration in soil (mg/kg)
- CF_1 = conversion factor (1E-3 kg per g).

Plausible values for D include 2E-4 grams per cubic meter (g/m^3) for agricultural activity (DOE, 1989), 6E-4 g/m^3 for construction work (DOE, 1983), and 1E-4 g/m^3 for other activity (National Council on Radiation Protection and Measurements, 1984). The value for D of 1E-4 g/m^3 for other activity is used for the groundskeeper. It is assumed that construction activities requiring intensive contact with soil, for which D = 6E-4 g/m^3 is appropriate, may last for one-half of a construction period. The remaining one-half of the time is more realistically characterized by

D = 1E-4 g/m^3. Therefore, a time-weighted average dust loading factor for construction work of 3.5E-4 g/m^3 is estimated for the construction worker.

Airborne concentrations of VOCs estimated by the dust loading model are assumed to sufficiently estimate levels of VOCs that may arise from volatilization, because the dust loading model treats the VOCs as if they were located at the ground surface.

The resident is more likely to be exposed to dust arising from wind erosion than from dust-raising activities on the site. EPA (1996) derived a model for estimating a dust particulate emission factor (PEF) based on an "unlimited reservoir" model and the assumption that the source area is square:

Eq. 3.2

$$PEF = Q/C \times \frac{3600}{0.036 \times (1 - V) \times (U_m / U_t)^3 \times F(x)}$$

where:

PEF	=	particulate emission factor (cubic meters per kilogram [m^3/kg], calculated)
Q/C	=	inverse of the mean concentration at center of square source (55.99 grams per square meter-second per kg/m^3, site-specific value from Table 3 in EPA [1996] [Zone 7, Cleveland, 5-acre site])
3600	=	seconds/hour
V	=	fraction of surface covered with vegetation (0.8, unitless, assumed)
U_m	=	mean annual wind speed (default, 4.60 meters per second [m/second] equals mean annual wind speed of 10.3 miles per hour [Section 3.1.1])
U_t	=	equivalent threshold value of wind speed at 7 meters (default, 11.32 m/second)
F(x)	=	function dependent on U_m/U_t (default, 0.194).

The concentration of a COPC in air is calculated as follows:

Eq. 3.3

$$C_a = \frac{C_s}{PEF}$$

where:

C_a	=	contaminant concentration in air (mg/m^3, calculated)
C_s	=	contaminant concentration in soil (mg/kg)
PEF	=	particulate emission factor (m^3/kg).

Airborne concentrations of VOCs estimated by the wind erosion model are assumed to sufficiently estimate levels of VOCs that may arise from volatilization, because the wind erosion model treats the VOCs as if they were located at the ground surface.

3.2.2.2 Concentrations in Household Air from Groundwater Use

The inhalation of VOCs released from groundwater, which is assumed to be used as tap water, is evaluated for the on-site residential scenario. Chemicals that have a Henry's Law value exceeding 1E-5 atmospheres/m^3-mole and a molecular weight less than 200 g/mole are considered to be VOCs and are subject to evaluation via this pathway; Henry's Law values and molecular weights are presented in Table 3-3. Other groundwater contaminants are considered on a case-by-case basis for their potential contribution to risk via the inhalation pathway based on the degree of departure from the Henry's Law and molecular weight criteria, groundwater concentration, and toxicity.

The simple whole-house tap water-to-air model described in Part B of the EPA (1991b) Human Health Evaluation Manual (HHEM) was used to evaluate the tap water-to-air pathway. This model was selected based on correspondence between OEPA (2004b) and USACE. Part B of the HHEM recommends a volatilization constant of 0.0005 for the total concentrations of all VOCs detected in groundwater; the conversion is characterized by the following equation:

Eq. 3.4

$$C_a = C_{gw} \times K_{wa} \times 1{,}000 \, {}^{L}\!/_{m^3}$$

where:

C_a = modeled concentration in air (mg/m^3)
C_{gw} = groundwater EPC (mg/L)
K_{wa} = tap water-to-air volatilization constant (0.0005 [unitless] [EPA, 1991b])

Implicit in the HHEM Part B application of this model are the following assumptions: 1) A family of four uses the groundwater as the sole source of household tap water, 2) the volume of the house is 150 m^3, 3) the daily groundwater use is 720 L/day, 4) 50 percent of VOCs in tap water volatilize to household air, and 5) the air exchange rate of the house is 0.25 volumes per hour (EPA, 1991b).

3.2.2.3 Concentrations of VOCs in Groundwater: Resident Dermal Uptake

Volatilization of VOCs from household water reduces the remaining concentration available for dermal contact. As mentioned in Section 3.2.2.2, the HHEM Part B whole-house tap water-to-air model assumes that 50 percent of the VOC concentrations are released to household air. Thus, the concentrations of VOCs remaining in the water after volatilization occurs are calculated by difference as follows:

Eq. 3.5

$$C_d = C_{gw} \times (1 - F_v)$$

where:

C_d = concentration of VOC in household water available for dermal exposure (mg/L, calculated)
C_{gw} = concentration of VOC in groundwater (mg/L)
F_v = fraction of VOCs volatilized to air, (0.5 unitless).

Only the concentration remaining in tap water after volatilization (C_d), as applicable, is assumed to be available for contact with the skin during bathing/showering.

3.2.2.4 Exposure-Point Concentrations of COPCs in Venison

The hunter is assumed to harvest and consume game and share it with family members, including small children. The game is assumed to be venison, because the white-tailed deer is the species hunted most widely and most likely to provide a regular contribution to the diet. Data to reliably estimate contaminant concentrations in venison do not exist, but the following simplifying assumptions permit estimates sufficient for a BHHRA.

- Deer are small ruminants and, as such, are not unlike cattle; thus, it is reasonable to assume they may have similar physiological processes that could yield similar biotransfer factors. Unlike beef, however, deer meat does not undergo marbling with fat, and deer fat is quite unpalatable and is likely to be trimmed rather than consumed. Therefore, the biotransfer factors for edible venison are derived by adjusting biotransfer factors for beef to account for differences in the fat content of table-ready beef (cooked choice retail cuts trimmed to 0 inches of fat: average 14.4 percent fat) and venison (cooked boneless muscle meats: average 2.9 percent fat) (Nutrient Database, 1997).

- Deer are expected to browse a much larger area than that encompassed in the TNTA/WWTP1 sewer line traces; therefore, the fraction of total browse consumed from the TNTA/WWTP1 sewer line traces is expected to be relatively small.

- Indirect food chain pathways may be significant for some metals and for those semivolatile organic compounds that persist in the environment and have the tendency to bioaccumulate. VOCs are generally mobile in the environment and labile in biological systems and do not tend to bioaccumulate.

To reflect the assumptions previously noted, venison biotransfer factors are estimated by multiplying beef biotransfer factors by 2.9/14.4 (or 0.20), and by a fraction, FI_r. This fraction reflects the areal portion of the site compared to a deer's home range area. These assumptions are captured in the following equation:

Eq. 3.6

$$B_v = 0.20(B_b)(FI_r)$$

where:

B_v	=	biotransfer factor for venison (unitless, calculated)
0.20	=	factor to reflect differences in fat content between beef and venison (0.20, unitless, see above)
FI_r	=	areal portion of site compared to a deer's home range (0.03, unitless, see below)
B_b	=	biotransfer factor for beef.

Values for B_b for metals are provided in the toxicity profiles (Appendix C). Toxicity profiles are prepared for each of the COPCs. The toxicity profiles briefly describe the uses of the chemical, its physical properties, behavior in environmental media, biotransfer capability, and toxicity values.

The TNTA/WWTP1 sewer line traces areas are relatively small in comparison to the home range of a white-tailed deer. The total acreage of the TNTA/WWTP1 sewer line traces is approximately 2 acres. The home range of the white-tailed deer is between 150 and 1,280 acres (Sample and Suter, 1994). Even if the low end of this range (150 acres) is assumed for deer in northern Ohio, the area represented by the TNTA/WWTP1 sewer line traces is approximately 1.5 percent of this land area. Although the use of FI_r equal to 0.015 or lower is justified, an FI_r value of 0.03 is used in the BHHRA to be consistent with other small sites evaluated at PBOW.

Deer are assumed to be exposed to contaminants by ingesting browse growing on contaminated soil. It is estimated that deer consume approximately 1.74 kg of browse per day (Sample, et al., 1996), which is approximately 50 percent dry matter (DM), or 0.87 kg browse DM per day (Mautz, et al., 1976). The contaminant concentration in browse is estimated from the following equation, which was originally developed for estimating the contaminant concentration in forage to which cattle may be exposed (EPA, 1994):

Eq. 3.7

$$C_p = (CF)(C_s)(B_p)$$

where:

C_p	=	concentration of contaminant in (plant) forage DM (mg/kg, calculated)
CF	=	conversion factor to adjust for soil containing 20 percent moisture (1.25, unitless).

C_s = concentration of contaminant in soil (mg/kg)
B_p = soil-to-forage biotransfer factor (mg of chemical per kg of dry plant/mg of chemical per kg of dry soil).

Values for B_p are taken from the toxicity profiles in Appendix C. B_p values for the vegetative parts of plants, rather than the reproductive parts of plants, are selected, as possible, because deer browse year-round, and the vegetative parts are more available for the greater part of the year.

The concentration of a COPC in venison can be estimated from the following equation (adapted from EPA [1994]):

Eq. 3.8

$$C_v = (Q_p)(C_p)(B_v)$$

where:

C_v = contaminant concentration in venison (mg/kg, calculated)
Q_p = browse ingestion rate (0.87 kg DM/day)
C_p = contaminant concentration in browse DM (mg/kg)
B_v = biotransfer factor for venison (days/kg).

3.3 Quantification of Chemical Intake

This section describes the models used to quantify doses or intakes of the COPCs by the exposure pathways identified above. Models were taken or modified from EPA (1989a) unless otherwise indicated.

3.3.1 Inhalation of COPCs in Air

The inhaled dose of a COPC in air (for the groundskeeper, construction worker, on-site resident: inhalation of dust and VOCs in ambient air from surface or total soil; for the construction worker: inhalation of VOCs in ambient air from subsurface soil; for the indoor worker and on-site resident: inhalation of VOCs in indoor air from subsurface soil) is estimated as follows:

Eq. 3.9

$$I_a = \frac{(C_a)(FI_a)(IR_a)(EF)(ED)}{(BW)(AT)}$$

where:

I_a = inhaled dose of COPC (milligrams per kilograms per day [mg/kg-day], calculated)
C_a = concentration of COPC in air (mg/m^3)
FI_a = fraction of exposure attributed to site media (unitless)
IR_a = inhalation rate (m^3/day)
EF = exposure frequency (days/year)

ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days).

3.3.2 Incidental Ingestion of COPCs in Soil or Sediment

The ingested dose of a COPC in soil (groundskeeper, construction worker, resident, indoor worker, hunter) or sediment (construction worker, resident) is estimated from the following equation:

Eq. 3.10

$$I = \frac{(C)(FI)(IR)(EF)(ED)(CF)}{(BW)(AT)}$$

where:

I = I_s for soil, I_{sd} for sediment, = ingested dose of COPC (mg/kg-day, calculated)
C = C_s for soil; C_{sd} for sediment; = concentration of COPC (mg/kg)
FI = FI_s for soil; FI_{sd} for sediment; = fraction of exposure attributed to site medium (unitless)
IR = IR_s for soil; IR_{sd} for sediment; = ingestion rate of medium (mg/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
CF = conversion factor (1E-6 kg/mg)
BW = body weight (kg)
AT = averaging time (days).

3.3.3 Incidental Ingestion of COPCs in Water

The ingested dose of a COPC in groundwater (future groundskeeper, resident) is estimated from the following equation:

$$I_w = \frac{(C_w)(IR_w)(FI_w)(EF_w)(ED_w)}{(BW)(AT)} \qquad \text{Eq. 3.11}$$

where:

I_w = ingested dose of COPC in water (mg/kg-day, calculated)
C_w = concentration of COPC in water (mg/L)
IR_w = water ingestion rate (L/day)
FI_w = fraction of exposure attributed to site water (unitless)
EF_w = fraction of exposure attributed to site water exposure frequency (days/year)
ED_w = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days).

3.3.4 Dermal Contact with COPCs in Soil, Sediment, or Water

Unlike the methodologies for estimating inhaled or ingested doses of a COPC, which quantify the dose presented to the barrier membrane (the pulmonary or gastrointestinal mucosa, respectively), dermal dose is estimated as the dose that crosses the skin and is systemically absorbed. For this reason, dermal toxicity values are also based on absorbed dose. The absorbed dose of a COPC is estimated from the following equation (EPA, 2004a):

Eq. 3.12

$$DAD = \frac{(DA)(SA)(EF)(ED)}{(BW)(AT)}$$

where:

DAD = average dermally absorbed dose of COPC (mg/kg-day, calculated)
DA = dose absorbed per unit body surface area per day (milligrams per square centimeter per day [mg/cm^2-day])
SA = SA_s for soil, SA_{sd} for sediment, S_{gw} for groundwater, SA_{sw} for surface water, = surface area of the skin exposed (cm^2)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days).

Dose absorbed per unit body surface area per day (DA) is calculated differently for dermal uptake from soil/sediment and from water. Dermal uptake of constituents from soil (groundskeeper, construction worker, on-site resident, hunter) or sediment (construction worker, on-site resident) assumes that absorption is a function of the fraction of a dermally applied dose that is absorbed. DA is calculated from the following equation (EPA, 2004a):

Eq. 3.13

$$DA = (C_s)(FI_s)(CF)(AF)(ABS)$$

where:

DA = dose absorbed per unit body surface area per day (mg/cm^2-day, calculated)
C = C_s for soil, C_{sd} for sediment, = concentration of COPC in medium (mg/kg)
FI = FI_s for soil, FI_{sd} for sediment, = fraction of exposure attributed to site medium (unitless)
CF = conversion factor (1E-6 kg/mg)
AF = AF_s for soil, AF_{sd} for sediment, = soil- or sediment-to-skin adherence factor (mg/cm^2-day)
ABS = absorption fraction (unitless, chemical-specific).

ABS values are provided in the toxicity profiles for each COPC (Appendix C).

Quantification of dermal uptake of constituents from groundwater (future groundskeeper, resident) or surface water (construction worker, resident) depends on a K_p, which describes the rate of movement of a constituent from water across the dermal barrier to the systemic circulation (EPA, 2004a). The equation for dermal uptake of chemicals from water is the same as the equation for dermal uptake of chemicals from soil (Eq. 3.12). DA is calculated differently for inorganic and organic chemicals in water. For inorganic chemicals, DA is calculated from the following equation:

Eq. 3.14

$$DA = (C_w)(FI)(K_p)(ET_w)(CF)$$

where:

DA	=	dose absorbed per unit body surface area per day (mg/cm^2-day, calculated)
C_w	=	concentration of COPC in water (mg/L)
K_p	=	permeability coefficient (centimeters per hour [cm/hour])
ET_w	=	time of exposure (hours/day)
CF	=	conversion factor (1E-3 liters per cubic centimeter [L/cm^3]).

K_p for organic chemicals varies by several orders of magnitude and is highly dependent on lipophilicity, expressed as a function of the octanol/water partition coefficient (EPA, 2004a). Because the stratum corneum (the outer skin layer) is rich in lipid content, it may act as a sink, initially reducing the transport of chemical to the systemic circulation. With continued exposure and the attainment of steady-state conditions, the rate of dermal uptake increases. Therefore, different equations are used to estimate DA, depending on whether the ET is less than or greater than the estimated time to reach steady state. Non-steady-state exposures occur either when the ET is relatively brief (e.g., showering, for most chemicals) or when intermittent exposure occurs throughout the day (e.g., wading exposure to surface water or washing of hands). For exposure scenarios under which steady state is not reached for a given organic chemical (τ> ET, see below), the following equation is used to calculate DA (EPA, 2004a):

Eq. 3.15

$$DA = 2(FA)(K_p)(C_w)(CF)\sqrt{\left(\frac{6\tau(ET_w)}{\pi}\right)}$$

where:

DA	=	dose absorbed per unit body surface area per day (mg/cm^2-day, calculated)
C_w	=	C_{sw} for surface water, C_{gw} for groundwater, = concentration of COPC in water (mg/L)
FA	=	fraction absorbed from the water (unitless)
K_p	=	permeability coefficient (cm/hour)

CF = conversion factor (1E-3 L/cm^3)
τ = time for concentration of contaminant in stratum corneum to reach steady state per event (hours)
ET_w = time of contact (hour(s)/day).

In cases where steady state is reached (τ<ET), such as where the duration of a bath exceeds the time to reach steady state for a given organic compound, the following equation is used to calculate DA (EPA, 2004a):

Eq. 3.16

$$DA = (FA)(K_p)(C_w)(CF)\left[\frac{ET_w}{1+B} + 2\tau\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]$$

where:

DA = dose absorbed per unit body surface area per day (mg/cm^2-day, calculated)
C_w = concentration of COPC in water (mg/L)
FA = fraction absorbed from the water (unitless)
K_p = permeability coefficient (cm/hour)
CF = conversion factor (1E-3 L/cm^3)
τ = time for concentration of contaminant in stratum corneum to reach steady state per event (hours)
ET_w = time of contact (hour[s]/day)
B = Ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis (unitless).

Assuming one exposure event/day allows expressing ET as hour(s)/day, which preserves the dimensional integrity of the equation.

When available, values for K_p and τ are taken from EPA (2004a). For organics that have no K_p values listed, the values are calculated using the following equation (EPA, 2004a):

Eq. 3.17

$$\text{Log}(K_p) = -2.80 + 0.66(\log K_{ow}) - 0.0056(MW)$$

where:

K_p = permeability coefficient (cm/hour, calculated)
log K_{ow} = log of the octanol/water partition coefficient (unitless)
MW = molecular weight.

Where values for τ are not available, they were calculated using the following equation (EPA, 2004a).

Eq. 3.18

$$\tau = 0.105 \times 10^{(0.0056 \times MW)}$$

where:

τ = time for concentration of contaminant in stratum corneum to reach steady state (hours, calculated)
MW = molecular weight.

Values of K_p and τ used in the BHHRA are summarized in Table 3-3 and documented in Appendix C.

3.3.5 Consumption of Venison

Consumption of venison by the hunter or the hunter's child is evaluated by the following equation:

Eq. 3.19

$$I_v = \frac{(C_v)(IR_v)(EF)(ED)}{(BW)(AT)}$$

where:

I_v = ingested dose of COPC in venison (mg/kg-day, calculated)
Cv = concentration of COPC in venison (mg/kg)
IRv = venison ingestion rate (kg/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days).

4.0 Toxicity Evaluation

Toxicity is defined as the ability of a chemical to induce adverse effects in biological systems. The purpose of the toxicity assessment is two-fold:

- Identify the cancer and noncancer effects that may arise from exposure of humans to the COPC (hazard assessment).
- Provide an estimate of the quantitative relationship between the magnitude and duration of exposure and the probability or severity of adverse effects (dose-response assessment).

The latter is accomplished by the derivation of cancer and noncancer toxicity values, as described in the following sections.

4.1 Evaluation of Carcinogenicity

A few chemicals are known, and many more are suspected, to be human carcinogens. The evaluation of the potential carcinogenicity of a chemical includes both a qualitative and a quantitative aspect (EPA, 2005). The qualitative aspect is a weight-of-evidence evaluation of the likelihood that a chemical might induce cancer in humans. EPA (2005) recognizes five weight-of-evidence group classifications for carcinogenicity. Formerly, EPA (1986) used a letter-based system to describe the weight of evidence for carcinogenicity. Reference to this former system is included because many of the carcinogenicity assessments listed on the Integrated Risk Information System (IRIS) use the former letter-based system (EPA, 2012). The five EPA weight-of-evidence classifications are as follows:

- ***Carcinogenic to Humans*** (corresponds to the former Group A - Human Carcinogen)
- ***Likely to be Carcinogenic to Humans*** (includes both the former Group B1 and Group B2-Probable Human Carcinogens)
- ***Suggestive Evidence of Carcinogenic Potential*** (corresponds to the former Group C - Possible Human Carcinogen)
- ***Inadequate Information to Assess Carcinogenic Potential*** (corresponds to the former Group D - Not Classifiable as to Human Carcinogenicity)
- ***Not Likely to be Carcinogenic to Humans*** (corresponds to the former Group E - Evidence of Noncarcinogenicity to Humans).

The toxicity value for carcinogenicity, called a cancer slope factor (SF), is an estimate of potency. SFs are developed only for chemicals in the first three groups and only if the data are sufficient. The SFs are statistically derived from the dose-response curve from the best human or animal study or studies of the chemical. Although human data are often considered to be more reliable than animal data because there is no need to extrapolate the results obtained in one species to another, most human studies have one or more of the following limitations:

- The duration of exposure is usually considerably less than lifetime.
- The concentration or dose of chemical to which the humans were exposed can be approximated only crudely, usually from historical data.
- Concurrent exposure to other chemicals frequently confounds interpretation.
- Data regarding other factors (tobacco, alcohol, illicit or medicinal drug use, nutritional factors and dietary habits, heredity) are usually insufficient to eliminate or quantify confounding effects on the results.
- Most epidemiologic studies are occupational investigations of workers, which may not accurately reflect the range of sensitivities of the general population.
- Most epidemiologic studies lack the statistical power (i.e., sample size) to detect a low, but chemical-related increased incidence of tumors.

Most potency estimates are derived from animal data, which present different limitations:

- It is necessary to extrapolate from results in animals to predict results in humans, usually by estimating an equivalent human dose from the animal dose.
- The range of sensitivities arising from genotypic and phenotypic diversity in the human population is not reflected in the animal models ordinarily used in cancer studies.
- Usually, very high doses of chemical are used, which may alter normal biology, creating a physiologically artificial state and introducing substantial uncertainty regarding the extrapolation to the low-dose range expected with environmental exposure.
- Individual studies vary in quality (e.g., duration of exposure, group size, scope of evaluation, adequacy of control groups, appropriateness of dose range, absence of concurrent disease, sufficient long-term survival to detect tumors with long induction or latency periods).

The SF is expressed as risk per mg/kg-day, shown mathematically as $(mg/kg\text{-}day)^{-1}$. To be appropriately conservative, the SF is usually the 95 percent upper bound on the slope of the

dose-response curve extrapolated from high (experimental) doses to the low-dose range expected in environmental exposure scenarios. EPA (2005) assumes that there are no thresholds for carcinogenic expression; therefore, any exposure represents some quantifiable risk, however miniscule it may be.

The oral SF is usually derived directly from the experimental dose data, because oral dose is usually expressed as mg/kg-day. When the test chemical was administered in the diet or drinking water, oral dose first must be estimated from data for the concentration of the test chemical in the food or water, food or water intake data, and body weight data.

IRIS (EPA, 2012) expresses inhalation cancer potency as a unit risk based on concentration, or risk per microgram of chemical per m^3 of ambient air, shown mathematically as (micrograms per cubic meter [$\mu g/m^3$])$^{-1}$. Because cancer risk characterization requires an SF expressed as risk per mg/kg-day, the unit risk must be converted to the mathematical equivalent of an inhalation cancer SF, or risk per unit dose as (mg/kg-day)$^{-1}$. Because the inhalation unit risk is based on continuous lifetime exposure of an adult human (assumed to inhale 20 m^3 of air per day and to weigh 70 kg), the mathematical conversion consists of multiplying the unit risk (per $\mu g/m^3$) by 70 kg and by 1,000 µg/mg, and dividing the result by 20 m^3 per day.

4.2 Evaluation of Noncarcinogenic Effects

Many chemicals, whether or not associated with carcinogenicity, are associated with adverse noncarcinogenic effects. The evaluation of noncancer effects (EPA, 1989b) involves the following:

- Qualitative identification of the adverse effect(s) associated with the chemical; these may differ depending on the duration (acute or chronic) or route (oral or inhalation) of exposure.
- Identification of the critical effect for each duration of exposure (i.e., the first adverse effect that occurs as dose is increased).
- Estimation of the threshold dose for the critical effect for each duration of exposure.
- Development of an uncertainty factor (UF); i.e., quantification of the uncertainty associated with interspecies extrapolation, intraspecies variation in sensitivity, severity of the critical effect, slope of the dose-response curve, and deficiencies in the database, in regard to developing a reference dose (RfD) for human exposure.
- Identification of the target organ(s) for the critical effect for each route of exposure.

These information points are used to derive an exposure route- and duration-specific toxicity value called an RfD, expressed as mg/kg-day, which is considered to be the dose for humans, with uncertainty of an order of magnitude or greater, at which adverse effects are not expected to occur. Mathematically, it is estimated as the ratio of the threshold dose to the UF. For purposes of risk assessment, chronic exposure is typically defined as equal to or greater than 7 years, i.e., at least 10 percent of expected life span; subchronic exposure is typically defined as 2 weeks to 7 years. However, professional judgment may be used where exposure durations approach 10 percent of the expected life span. Also, exposure during a critical stage of development, such as a portion of early childhood, may be treated as chronic even if the anticipated exposure duration is considerably less than 10 percent of the expected life span.

IRIS (EPA, 2012) expresses the inhalation noncancer reference value as a reference concentration (RfC) in units of mg/m^3. Because noncancer hazard characterization requires a reference value expressed as mg/kg-day, the RfC must be converted to an inhalation RfD. Because the inhalation RfC is based on continuous exposure of an adult human (assumed to inhale 20 m^3 of air per day and to weigh 70 kg), the mathematical conversion consists of multiplying the RfC (mg/m^3) by 20 m^3/day and dividing the result by 70 kg.

RfD and RfC values are derived for both chronic and subchronic exposure. Under the assumption of monotonicity (incidence, intensity, or severity of effects can increase, but cannot decrease, with increasing magnitude or duration of exposure), a chronic RfD may be considered sufficiently protective for subchronic exposure, but a subchronic RfD may not be protective for chronic exposure. Currently, subchronic RfD values exist for few chemicals. Subchronic RfD values can be derived from chronic RfD values as follows:

- If the UF applied in the derivation of the chronic RfD (or RfC) does not provide for expansion from subchronic to chronic exposure (e.g., if the chronic RfD was derived from a chronic study), the chronic RfD is adopted as being sufficiently protective for subchronic exposure.

- If the UF applied in the derivation of the chronic RfD (or RfC) contains a component to expand from subchronic to chronic exposure, the subchronic RfD is derived by multiplying the chronic RfD by the factor used to expand from subchronic to chronic exposure (e.g., if a factor of 10 was used to expand from subchronic to chronic exposure, the subchronic RfD would be 10 times larger than the chronic RfD).

Only chronic RfDs and RfCs are used in the risk characterization of this BHHRA.

4.3 Dermal Toxicity Values

Dermal RfDs and SFs are derived from the corresponding oral values, provided there is no evidence to suggest that dermal exposure induces exposure route-specific effects that are not appropriately modeled by oral exposure data. In the derivation of a dermal RfD, the oral RfD is multiplied by the gastrointestinal absorption factor (GAF), expressed as a decimal fraction. The resulting dermal RfD, therefore, is based on absorbed dose. The RfD based on absorbed dose is the appropriate value with which to compare a dermal dose, because dermal doses are expressed as absorbed doses rather than exposure doses. The dermal SF is derived by dividing the oral SF by the GAF. The oral SF is divided, rather than multiplied, by the GAF because the SF is expressed as a reciprocal dose.

4.4 Target Organ Toxicity

As a matter of science policy, EPA assumes dose and effect to be additive for noncarcinogenic effects (EPA, 1989a). This assumption provides the justification for adding the HQ or hazard index (HI) values in the risk characterization for noncancer effects (Section 5.2) resulting from exposure to multiple chemicals, pathways, or media. However, EPA (1989a) acknowledges that adding all HQ or HI values may overestimate hazard, because the assumption of additivity is probably appropriate only for those chemicals that exert their toxicity by the same mechanism.

Mechanisms of toxicity data sufficient for predicting additivity with a high level of confidence are available for very few chemicals. In the absence of such data, EPA (1989a) assumes that chemicals that act on the same target organ may do so by the same mechanism of toxicity; that is, the target organ serves as a surrogate for mechanism of toxicity. When total HI for all media for a receptor exceeds 1 due to the contributions of several chemicals, it is appropriate to segregate the chemicals by route of exposure and mechanism of toxicity (i.e., target organ) and estimate separate HI values for each target organ.

As a practical matter, because human environmental exposures are likely to involve near- or sub-threshold doses, the target organ chosen for a given chemical is the one associated with the critical effect. If more than one organ is affected by a given chemical at the threshold, then all affected target organs are selected for this chemical. The target organ is also selected on the basis of duration of exposure (i.e., the target organ for chronic or subchronic exposure to low or moderate doses is selected rather than the target organ for acute exposure to high doses) and route of exposure. Because dermal RfD values are derived from oral RfD values, the oral target organ is adopted as the dermal target organ. For some chemicals, no target organ is identified. This occurs when no adverse effects are observed or when adverse effects such as reduced

longevity or growth rate are not accompanied by recognized organ- or system-specific functional or morphologic alteration.

4.5 Sources of Toxicity Information Used in the Risk Assessment

Toxicity values were selected for use in the BHHRA based on EPA Office of Solid Waste and Emergency Response Directive 9285.7-53 (EPA, 2003), which prescribes the following hierarchy:

- **Tier 1** values: IRIS (EPA, 2012) database.
- **Tier 2** values: These are EPA's provisional peer-reviewed toxicity values. The provisional peer-reviewed toxicity values are developed by the Office of Research and Development, the National Center for Environmental Assessment, and the Superfund Health Risk Technical Support Center on a chemical-specific basis when requested by the Superfund program.
- **Tier 3** values: These are other toxicity values from additional EPA and non-EPA sources of toxicity information. As stated in the EPA Office of Solid Waste and Emergency Response directive, "priority should be given to those sources of information that are the most current, the basis for which is transparent and publicly available, and which have been peer reviewed." Two common examples of Tier 3 values are EPA's Health Effects Assessment Summary Tables (EPA, 1997b) and the California Environmental Protection Agency (2012) Office of Environmental Health Hazard Assessment Toxicity Criteria Database.

The Environmental Council of the States-U.S. Department of Defense (2007) has issued a toxicity value hierarchy that basically supports the EPA (2003) hierarchy presented previously but places higher emphasis on the necessity for external peer review.

GAFs used to derive dermal RfD values and SFs from the corresponding oral toxicity values are obtained from the following sources, in order of hierarchy:

- Oral absorption efficiency data compiled by the National Center for Environmental Assessment for the Superfund Health Risk Technical Support Center of EPA, such as listed in EPA (2004a).
- Federal agency reviews of the empirical data, such as Agency for Toxic Substances and Disease Registry toxicological profiles and various EPA criteria documents
- Other published reviews of the empirical data
- The primary literature.

GAFs obtained from reviews are compared to empirical (especially more recent) data, when possible, and are evaluated for suitability for use in deriving dermal toxicity values from oral toxicity values. Some of the GAF values are also listed on the RSL Web site support tables (EPA, 2011e). The suitability of the GAF increases when the following similarities are present in the oral pharmacokinetic study from which the GAF is derived and in the key toxicity study from which the oral toxicity value is derived:

- The same strain, sex, age, and species of test animal were used.
- The same chemical form (e.g., the same salt or complex of an inorganic element or organic compound) was used.
- The same mode of administration (e.g., diet, drinking water, or gavage vehicle) was used.
- Similar dose rates were used.

Individual COPC-specific toxicity profiles, including sources of the toxicity and GAF values, are included in Appendix C for all of the COPCs evaluated in the BHHRA. Summary toxicity information sufficient to support the risk calculations, including toxicity values, GAFs, and target organs are provided in Table 4-1.

5.0 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 the presence of site-specific contaminants. This is done by combining the intake rates estimated during the exposure assessment with the appropriate toxicity information identified during the toxicity assessment. Noncancer hazards and cancer risks are characterized separately, including COPCs that induce both types of effects.

Quantitative expressions are calculated during risk characterization that describe the probability of developing cancer (i.e., ILCRs), or the nonprobabilistic comparison of estimated dose with an RfD for noncancer effects (i.e., HQs and HIs). Quantitative estimates are developed for individual chemicals, exposure pathways, and exposure media for each receptor. These quantitative risk characterization expressions, in combination with qualitative information, are used to guide risk management decisions. Risk characterization, as described in this section, is applied only to COPCs.

Generally, the risk characterization follows the methodology prescribed by EPA (1989a), as modified by more recent information and guidance. EPA methods are appropriately designed to be health protective and tend to overestimate rather than underestimate risk. The risk results, however, may be overly conservative, because risk characterization involves multiplication of the conservative assumptions built into the estimation of the EPCs, exposure (intake) estimates, and toxicity dose-response assessments.

5.1 Cancer Risk

The risk from exposure to potential chemical carcinogens is estimated as the probability of an individual developing cancer over a lifetime and is called the ILCR. In the low-dose range, which would be expected for most environmental exposures, cancer risk is estimated from the following linear equation (EPA, 1989a):

Eq. 5.1

$$ILCR = (CDI)(SF)$$

where:

ILCR = incremental lifetime cancer risk, a unitless expression of the probability of developing cancer, adjusted for background incidence, calculated

CDI = chronic daily intake, averaged over 70 years (mg/kg-day)
SF = cancer slope factor (risk per mg/kg-day).

The chronic daily intake (CDI) term in Equation 5.1 is equivalent to the "I" or "DAD" terms (intake or dose) in Equations 3.9 through 3.12 and 3.19 when these equations are evaluated for cancer intakes.

The use of Equation 5.1 assumes that chemical carcinogenesis does not exhibit a threshold and that the dose-response relationship is linear in the low-dose range. Because this equation could generate theoretical cancer risks greater than 1 for high-dose levels, it is considered to be inaccurate at cancer risks greater than 1E-2. In these cases, cancer risk is estimated by the following one-hit model (EPA, 1989a):

Eq. 5.2

$$ILCR = 1 - e^{-(CDI)(SF)}$$

where:

ILCR = incremental lifetime cancer risk, a unitless expression of the probability of developing cancer, adjusted for background incidence, calculated
$e^{-(CDI)(SF)}$ = the exponential of the negative of the risk calculated using Equation 5.1.

Because none of the COPCs had an ILCR greater than 1E-2 using Equation 5.1, it was not necessary to use Equation 5.2 for any of the TNTA/WWTP1 sewer line COPCs. As a matter of policy, EPA (1986) considers the carcinogenic potency of simultaneous exposure to low doses of carcinogenic chemicals to be additive, regardless of the chemicals' mechanisms of toxicity or sites of action (organs of the body). Cancer risk arising from exposure to multiple chemicals in a given exposure medium and pathway is estimated from the following equation (EPA, 1989a):

Eq. 5.3

$$ILCR_p = ILCR_{(chem1)} + ILCR_{(chem2)} + \cdots ILCR_{(chem\,i)}$$

where:

$ILCR_p$ = total pathway risk of cancer incidence, calculated
$ILCR_{(chem\ i)}$ = individual chemical cancer risk for the pathway.

The sum of the ILCRs summed across pathways is the total ILCR as shown in the following equation:

Eq. 5.4

$$Total\ ILCR = ILCR_{(p\,1)} + ILCR_{(p\,2)} + \cdots ILCR_{(p\,i)}$$

where:

Total ILCR = total incremental lifetime cancer risk across all pathways
$ILCR_{pi}$ = incremental lifetime cancer risks associate with pathway "*i*."

The total ILCR represents all additional cancer risks posed to a given receptor by contact with contaminants in site environmental media.

Total ILCRs in the range of 1E-6 to 1E-4 are regarded as acceptable (EPA, 1990); as mentioned in Section 2.4.1, this range is referred to as the "NCP risk management range." Risks less than this range are regarded as negligible. A target cancer risk goal of 1E-5 is used by OEPA and was selected by the PBOW Project Delivery Team as a basis to consider remedial action. Use of this 1E-5 goal represents a departure from the Army's practice of generally using a cancer risk exceeding a value of 1E-4 (the upper end of the NCP risk management range) to trigger remedial action considerations.

5.2 Noncancer Effects of Chemicals

The hazards associated with noncancer effects of chemicals are evaluated by comparing an exposure level or intake with an RfD. The HQ, defined as the ratio of intake to RfD, is estimated as follows (EPA, 1989a):

Eq. 5.5

$$HQ = I \ / \ RfD$$

where:

HQ = hazard quotient (unitless, calculated)
I = intake of chemical averaged over subchronic or chronic exposure period (mg/kg-day)
RfD = reference dose (mg/kg-day).

The "I" term in Equation 5.5 is equivalent to the "I" or "DAD" terms (intake or dose) in Equations 3.9 through 3.12 and 3.19 when these equations are evaluated for noncancer intakes.

Chemical noncancer hazards are evaluated using chronic RfD values. This approach is different from the probabilistic approach used to evaluate cancer risks. An HQ of 0.01 does not imply a 1-in-100 chance of an adverse effect, but indicates only that the estimated intake is 100 times lower than the RfD. An HQ of unity indicates that the estimated intake equals the RfD. If the HQ is greater than unity, there may be concern for potential adverse health effects.

In the case of simultaneous exposure of a receptor to multiple chemicals, or to a given chemical by multiple pathways, an HI is calculated as the sum of the HQs by the following equation:

Eq. 5.6

$$HI = HQ_1 + HQ_2 + \ldots HQ_i$$

where:

HI = hazard index (unitless, calculated)
HQ_i = hazard quotient for the ith chemical, or for the ith pathway.

A total HI is calculated as the sum of all HI values, including all media and all COPCs, for a given receptor. Calculating a total HI as the sum of HQ values is based on the assumption that the potential for noncancer effects is additive. EPA (1989a), however, acknowledges that the assumption of additivity is probably appropriate only for chemicals that induce adverse effects by the same mechanism (Section 4.4). Therefore, if the total HI for a receptor exceeds 1, individual HI values may be calculated for each target organ. When exposure to a given COPC in a medium exceeds a value of 1, the target organ associated with that COPC will also exceed a value of 1, indicating that adverse health effects associated with that COPC cannot be regarded as unlikely.

A total target organ HI is calculated by summing the HI values (associated by target organ[s]), across exposure pathways as follows:

Eq. 5.7

$$Total\ Target\ Organ\ HI_a = HI_{p1-a} + HI_{p2-a} + \ldots HI_{pi-a}$$

where:

Total target organ HI_a = total hazard index for target organ "*a*" (unitless, calculated)
HI_{pi-a} = hazard index for target organ "*a*" via pathway "*i*."

HI values of 1 or less indicate that adverse noncancer health effects associated with that target organ of any individual under the exposure assumptions for that receptor are unlikely. If the total target organ HI exceeds a value of 1, then adverse noncancer health effects concerning that target organ and receptor cannot be regarded as unlikely.

5.3 Risk Characterization Results

Cancer and noncancer risk characterization results were evaluated for each receptor and each environmental medium using the methods described in Sections 5.1 and 5.2. The following subsections describe the risk characterization results for each receptor evaluated for exposure at the TNTA/WWTP1 sewer line traces. Risk summary tables are shown for each receptor as

referenced. The detailed quantitative evaluation tables that include the exposure equations presented in Chapter 3.0, and the risk characterization equations presented in Chapter 5.0 are provided in Appendix D. Analytical results used as input for the BHHRA are included in Appendix E. As described in Section 2.2, the risk characterization for soil in the following subsections do not include the samples that are offset 10 feet from the sewer line trace. These offset samples are evaluated as described in Section 5.4 for the TP-27 and TP-33 potential hot spot areas.

5.3.1 Current Groundkeeper

The ILCR for the current groundskeeper (Table 5-1) exposed to surface soil both through direct contact and via inhalation of suspended particulates is estimated as 1E-5. This is within the 1E-6 to 1E-4 NCP risk management range and equals the PBOW cancer risk goal of 1E-5.

The total HI for the current groundskeeper (Table 5-1) is 0.8. This is less than the target HI value of 1, indicating that noncancer health effects are unlikely to occur.

5.3.2 Future Groundskeeper

The exposure assumptions for the future groundskeeper differ from those of the current groundskeeper (Section 5.3.1) in that the future groundskeeper is assumed to be exposed to total soil rather than surface soil, and the future groundkeeper is also assumed to be exposed to groundwater via direct contact (ingestion and dermal exposure). The risk characterization was run separately for bedrock groundwater exposure and overburden (well) groundwater exposure.

Bedrock Groundwater Use. The total ILCR for the future groundskeeper, assuming hypothetical bedrock groundwater use, is 4E-4 (Table 5-1). This value exceeds both the NCP risk management range and the PBOW target cancer risk goal of 1E-5. The predominant contributor to the total ILCR is associated with arsenic in groundwater, with an ILCR of 3.7E-4, (approximately 89 percent of total ILCR for receptor), and benzene in groundwater contributed an ILCR of 3.0E-5 (approximately 7 percent of total ICLR). The cancer risks associated with the remaining chemicals evaluated in bedrock groundwater (1.0E-6) and soil (6.5E-6) are collectively below the PBOW target cancer risk goal of 1E-5.

Benzene is a petroleum hydrocarbon constituent that is known to be naturally occurring in the limestone groundwater at PBOW (Shaw, 2006) and was found to be prevalent in bedrock groundwater underlying nearby PBOW sites (Shaw, 2011b). As described in Section 3.1.1.2, petroleum hydrocarbon staining and/or odor were observed at depth during the drilling of all three TNTA/WWTP1 sewer line wells. Also, hydrogen sulfide odor was observed in 1SLA-

BEDGW-002 (greater than 200 ppm) during well purging. Hydrogen sulfide has also been observed at high concentrations in bedrock wells at nearby PBOW sites, notably in AP1 well AP1-BEDGW-002 (Shaw, 2011b), WWTP1 well WTP1-BEDGW-001 (Shaw, 2012), and LBA monitoring well MNTA-BEDGW-001 (more than 200 ppm) (Shaw, 2011a). Approximately 14 feet of petroleum product was observed in upgradient well TNTA-BEDGW-001 (Shaw, 2008), and over 1 foot of petroleum product was also observed on the surface of the water during sampling AP1 well AP1-BEDGW-001 (located to the southwest) (Shaw, 2011b). Petroleum hydrocarbons were also found at depth in four of the six bedrock wells in the LBA (Shaw, 2011a), and petroleum hydrocarbons were observed seeping from fractures at WWTP1 wells WTP1-BEDGW-001 to the west (Shaw, 2011c), indicating the prevalence of petroleum hydrocarbons in the bedrock zone within this general area of PBOW. These observations provide evidence that petroleum hydrocarbons and elevated levels of hydrogen sulfide are naturally occurring constituents in limestone bedrock within this general area of PBOW.

Of the three wells installed along the TNTA/WWTP1 sewer line traces, one (1SLA-BEDGW-001) of the three could not be sampled during either sampling event. The lack of water at this well suggests the potential for limited groundwater in the vicinity of the sewer line traces, which is consistent with the limited bedrock groundwater yield at nearby PBOW sites WWTP1, LBA, and AP1 bedrock monitoring wells. Also, the presence of naturally occurring petroleum hydrocarbons indicates that potable use by a site worker is not a plausible exposure pathway.

In addition, the arsenic present in the TNTA/WWTP1 sewer line bedrock groundwater appears to be unrelated to PBOW activities based on the following observations:

- Arsenic was detected at background concentrations in the overlying TNTA/WWTP1 sewer line soil samples. The MDC (20.3 mg/kg) of arsenic in total soil is less than that of the background data set (36.5 mg/kg), and the TNTA/WWTP1 sewer line mean concentration (11.2 mg/kg) of arsenic in total soil is essentially equal to that of the PBOW background data set (10.8 mg/kg).

- Arsenic was not detected in any of the samples from the overlying overburden groundwater wells.

- Arsenic is not a component of any waste stream related to TNT manufacturing.

Because arsenic and benzene are naturally occurring and not products of PBOW operations, the risk and hazard estimates are also background-related and not associated risks evaluated PBOW process chemicals. The ILCR for the future groundskeeper without the contributions of

groundwater is 7E-6 (Table 5-2), which is within the NCP cancer risk management range and less than the 1E-5 PBOW cancer risk goal.

The total HI for the future groundskeeper (Table 5-1) is 4. This exceeds the target HI value of 1, which would seem to indicate that noncancer health effects cannot be regarded as unlikely to occur. Over 90 percent of this HI is associated with the hypothetical use of bedrock groundwater, which alone represents an HI of 4. As discussed previously for cancer risk to this receptor, TNTA/WWTP1 sewer line groundwater is unlikely to be present in sufficient quantity for use. Also, note that over 60 percent of this HI value is associated with benzene (HQ=0.4) and arsenic (HQ=2.3) in groundwater. As stated previously, benzene is not associated with former PBOW operations but is associated with naturally occurring petroleum. As discussed previously for cancer effects, arsenic in bedrock groundwater is unlikely to be associated with former site operations because it was not detected in overlying TNTA/WWTP1 sewer line overburden groundwater, the TNTA/WWTP1 sewer line soil concentrations were within PBOW background levels, and arsenic is not a component of any waste stream related to the manufacture of TNT.

If the contributions of groundwater pathways are appropriately excluded for this receptor based on low water yield and naturally poor groundwater quality, the resulting HI for this receptor is 0.4 (Table 5-2). This is less than the target HI criterion of 1, indicating that this receptor is unlikely to encounter adverse noncancer health effects.

Overburden Groundwater Use. The total ILCR for the future groundskeeper, assuming hypothetical use of overburden groundwater, is 7E-6 (Table 5-1). This value is within the NCP risk management range and is less than the PBOW target cancer risk goal of 1E-5. Because none of the overburden groundwater COPCs are carcinogenic, this ILCR is attributable solely to exposure to total soil COPCs.

The total HI for the future groundskeeper, assuming hypothetical use of overburden groundwater, is 5 (Table 5-1). This exceeds the target HI criterion of 1, indicating that noncancer health effects cannot be regarded as unlikely to occur under this scenario. Approximately 92 percent of this HI is associated with thallium (HQ=4.0) and cobalt (HQ=0.5) in groundwater. Neither of these exceeds the BSC in total soil (Table 2-6), nor is either of these a component of any waste stream associated with the manufacture of TNT. Therefore, these COPCs do not appear to be related to former PBOW activities. The HI value excluding exposure to non-site-related thallium and cobalt in groundwater is less than the target value of 1.

Overburden groundwater along the TNTA/WWTP1 sewer line traces appears to be of limited yield. Of the 10 piezometers installed along or near the sewer line traces, only 4 produced enough water to sample. As described in Section 3.1.1.4, groundwater could not be sampled from well 1SLA-MW01 due to insufficient yield, and two of the remaining five groundwater samples could not be collected using low-flow technique. This is similar to the results of nearby sites WWTP1 (Shaw, 2011c), AP1 (Shaw, 2011b), and the LBA (Shaw, 2011a), where most of the overburden wells produced insufficient water for low-flow sampling. TNTA/WWTP1 sewer line overburden groundwater is thus interpreted as having insufficient production for use as tap water. Therefore, inclusion of the groundwater use pathway may exaggerate overall exposure to this receptor.

If groundwater exposure pathways are appropriately excluded for this receptor because of low groundwater yield and non-site relatedness as described in the previous paragraphs, the HI is 0.4 (Table 5-2). This is less than the target HI criterion of 1, indicating that adverse noncancer human health effects are unlikely for this receptor.

5.3.3 Indoor Worker

The exposure assumptions for the future indoor worker include direct contact with surface soil, inhalation of volatiles from subsurface soil, and direct exposure to groundwater via direct contact (ingestion and dermal exposure). The risk characterization was run separately for bedrock groundwater exposure and overburden (well) groundwater exposure.

Bedrock Groundwater Use. The total ILCR for the future indoor worker, assuming hypothetical bedrock groundwater use, is 4E-4 (Table 5-1). This value exceeds both the NCP risk management range and the PBOW target cancer risk goal of 1E-5. Approximately 99 percent of this ILCR is associated with benzene (3.0E-5) and arsenic (3.7E-4) in groundwater. The cancer risks associated with the remaining chemicals evaluated in bedrock groundwater (1.0E-6) and soil (4.3E-6) are collectively below the PBOW target cancer risk goal of 1E-5.

As described in Section 5.3.2, benzene is a petroleum constituent that is known to be naturally occurring in the limestone groundwater at PBOW (Shaw, 2006), and petroleum staining and/or odor were reported at depth in all three of the TNTA/WWTP1 sewer line bedrock wells. Evidence of petroleum hydrocarbons was likewise found in a number of the nearby bedrock wells (see Section 3.1.1.2). Additionally, as discussed in Section 5.3.2, the presence of elevated arsenic in TNTA/WWTP1 sewer line bedrock groundwater appears to be unrelated to former site activities, and the bedrock groundwater underlying the vicinity of the former TNTA/WWTP1 sewer lines would not likely yield sufficient volume for tap water use.

The ILCR for the future indoor worker is 4E-6 if the contribution of bedrock groundwater is appropriately excluded (Table 5-2). This value is within the NCP risk management range and is less than the PBOW 1E-5 cancer risk goal.

The total HI for the future indoor worker (Table 5-1) is 4. This exceeds the target HI value of 1, which would seem to indicate that noncancer health effects cannot be regarded as unlikely to occur. Approximately 93 percent of this HI is associated with the hypothetical use of bedrock groundwater. As discussed in Section 5.3.2 for the future groundskeeper, TNTA/WWTP1 sewer line bedrock groundwater is unlikely to be present in quantities sufficient for use. Also, over 60 percent of this HI value is associated with benzene (HQ=0.4) and arsenic (HQ=2.3) in bedrock groundwater. As explained in Section 5.3.2, the presence of benzene and arsenic appear to be unrelated to former site operations.

If the contributions of hypothetical bedrock groundwater are excluded because of low yield and naturally poor quality, the resulting HI for the indoor worker is 0.3 (Table 5-2). This is less than the target criterion of 1 and suggests that adverse noncancer health effects are unlikely.

Overburden Groundwater Use. The total ILCR for the future indoor worker, assuming hypothetical use of overburden groundwater, is 4E-6 (Table 5-1). This value is within the NCP risk management range and is less than the PBOW target cancer risk goal of 1E-5. Because none of the overburden groundwater COPCs are carcinogenic, this ILCR is attributable solely to exposure to total soil COPCs.

The total HI for the indoor worker is 5, assuming hypothetical use of overburden groundwater (Table 5-1). This value exceeds the target HI criterion of 1, indicating that noncancer health effects cannot be regarded as unlikely to occur under this scenario. Over 90 percent of this HI is associated with thallium (HQ=4.0) and cobalt (HQ=0.5) in overburden groundwater. Neither of these exceeds the BSC in total soil (Table 2-6), nor is either a component of any waste stream associated with the manufacture of TNT. Therefore, these COPCs appear to be unrelated to former PBOW activities. The HI value excluding exposure to non-site-related thallium and cobalt in groundwater is less than the target value of 1.

Overburden groundwater along the TNTA/WWTP1 sewer line traces also appears to be of limited yield, as described in Sections 3.1.1.4 and 5.3.2. This is similar to the results of nearby PBOW sites WWTP1 (Shaw, 2011c), AP1 (Shaw, 2011b), and the LBA (Shaw, 2011a), where most of the overburden wells produced insufficient water for low-flow sampling. TNTA/

WWTP1 sewer line overburden groundwater is thus interpreted as having insufficient production for use as tap water, and inclusion of the groundwater use pathway may exaggerate overall exposure to this receptor.

If groundwater exposure pathways are appropriately excluded for this receptor because of low groundwater yield and non-site relatedness as described in the previous paragraphs, the HI is 0.3 (Table 5-2). This is less than the target HI criterion of 1, indicating that adverse noncancer human health effects are unlikely for this receptor.

5.3.4 Construction Worker

The construction worker is assumed to be exposed to total soil through direct contact and via inhalation of suspended particulates and to sediment and surface water via direct contact. The ILCR for the TNTA/WWTP1 sewer line construction worker (Table 5-1) is estimated as 4E-7. This is less than both the 1E-6 to 1E-4 NCP risk management range and the PBOW cancer risk goal of 1E-5.

The total HI for the construction worker (Table 5-1) is 1. This equals the target HI value of 1. Therefore, noncancer health effects are regarded as unlikely to occur.

5.3.5 Resident

The exposure assumptions for the resident include direct contact with total soil, inhalation of particulates from total soil, inhalation of volatiles from subsurface soil, direct exposure to sediment and surface water (ingestion and dermal exposure), and direct exposure to groundwater via direct contact (ingestion and dermal exposure). The risk characterization was run separately for bedrock groundwater exposure and overburden (well) groundwater exposure. The ILCR was calculated assuming exposure during a combined 30-year child/adult exposure duration, whereas separate noncancer HI values were calculated for the young child and adult life stages (Section 3.1.3.5). The results of each are described below.

Bedrock Groundwater Use. The total ILCR for the resident, assuming bedrock groundwater exposure, is 2E-3 (Table 5-1). This value exceeds both the NCP risk management range and the PBOW target cancer risk goal. Over 99 percent of this ILCR is associated with arsenic (1.6E-3), benzene (1.4E-4), and naphthalene (1.2E-5) in groundwater. As discussed in Section 5.3.2, the presence of elevated arsenic in TNTA/WWTP1 sewer line bedrock groundwater does not appear to be related to former site activities. As described in Section 5.3.2, benzene is a petroleum constituent that is known to be naturally occurring in the limestone groundwater at PBOW (Shaw, 2006), and during well installation, petroleum was observed at all three TNTA/WWTP1

sewer line wells and is present in nearby WWTP1, AP1, and LBA bedrock wells. Naphthalene is also a naturally occurring constituent in petroleum. Evidence that the naphthalene found in TNTA/WWTP1 sewer line bedrock groundwater is not related to PBOW activities includes the following observations: 1) Naphthalene and other petroleum-related compounds were not detected in the overlying overburden groundwater, and 2) naphthalene was not detected in soil. Additionally, as discussed in Section 5.3.2, bedrock groundwater underlying the vicinity of the TNTA/WWTP1 sewer line traces does not appear to provide adequate yield for tap water use, regardless of quality.

The cancer risk associated with exposure to analytes other than background-related arsenic, benzene, and naphthalene in groundwater is 5E-6. This value is less than the PBOW cancer risk goal of 1E-5 and is within the NCP risk management range.

If the use of the bedrock groundwater is excluded from this receptor in recognition of low yield and the observation that virtually all cancer risks associated with this medium result from naturally occurring constituents, the ILCR for the resident is 2E-5 (Table 5-2). This value is within the NCP risk management range but exceeds the PBOW 1E-5 cancer risk goal. With respect to the total soil ILCR, approximately 48 percent (1.0E-5) is associated with nitroaromatics and approximately 52 percent (1.1E-5) is associated with PAHs. The PAHs are not part of the TNT manufacturing waste stream and likely originate from burning practices that have been used by NASA for years to control weeds and other vegetative growth along and in the vicinity of the sewer line traces. If the contribution of the non-U.S. Department of Defense (DoD)-related PAHs are duly excluded, the ILCR associated with this receptor equals the PBOW cancer risk goal of 1E-5, which is the logarithmic midpoint of the NCP risk management range.

The total HI for the child resident, assuming bedrock groundwater exposure, is 32 (Table 5-1). This exceeds the target HI value of 1, indicating that noncancer health effects cannot be regarded as unlikely to occur. Approximately 86 percent of this HI value is associated with exposure to bedrock groundwater, and over 75 percent of the groundwater HI value is associated with arsenic (HQ=15), benzene (HQ=2.8), naphthalene (HQ=0.6), 2-methylnapthalene (HQ=1.0), toluene (HQ=0.6), and xylenes (HQ=0.7). The non-site relatedness of arsenic, benzene, and naphthalene are discussed above with respect to cancer risks. 2-Methylnaphthalene, toluene, and xylenes, similar to benzene and naphthalene, are components of naturally occurring petroleum. All of the petroleum-related compounds, including naphthalene, 2-methylnapthalene, and the BTEX compounds, appear to be unrelated to former PBOW activities based on the observation that none of these compounds were detected in the overlying overburden groundwater or TNTA/WWTP1 sewer line soil.

As discussed in Section 5.3.2, bedrock groundwater underlying the TNTA/WWTP1 sewer line traces is unlikely to provide adequate yield for potable use. Therefore, if the contribution of bedrock groundwater is appropriately excluded because of low water yield and naturally low quality, the resultant HI for the child resident is 4 (Table 5-2). Virtually all of this HI is associated with total soil, and 97 percent of this HI is associated with TNT. Accordingly, this HI value exceeds the target HI, indicating that adverse noncancer health effects cannot be regarded as unlikely to result from exposure by the child resident receptor to TNTA/WWTP1 sewer line total soil. Moreover, because TNT is the sole risk driver, this HI is related to former PBOW operations. Please note that as discussed in Section 5.4, elevated TNT concentrations are not representative of the entire length of the sewer line traces, but instead are limited to reported concentrations in samples collected near test pits TP-27 and TP-33.

The total HI for the adult resident, assuming bedrock groundwater exposure, is 12 (Table 5-1). This exceeds the target HI value of 1, indicating that noncancer health effects cannot be regarded as unlikely to occur. Approximately 96 percent of this HI is associated with exposure to bedrock groundwater, and over 75 percent of the groundwater HI value is associated with arsenic (HQ=6.5), benzene (HQ=1.2), naphthalene (HQ=0.3), 2-methylnaphthalene (HQ=0.4), toluene (0.3), and xylenes (HQ=0.3). The non-site relatedness of these COPCs is discussed for the child resident in the preceding paragraphs. Also, as discussed above, bedrock groundwater underlying the TNTA/WWTP1 sewer line traces likely provides insufficient yield to consider as a source of residential groundwater. Therefore, the contribution of bedrock groundwater may be appropriately excluded.

If the use of the bedrock groundwater is excluded from this receptor in recognition of low yield and naturally poor water quality,, the resultant HI for the adult resident is 0.5 (Table 5-2). This is less than the target HI, indicating that adverse noncancer health effects are unlikely to result from exposure by the adult resident receptor to TNTA/WWTP1 sewer line total soil, sediment, and surface water.

Overburden Groundwater Use. None of the TNTA/WWTP1 sewer line overburden groundwater COPCs are carcinogenic. Therefore, the assumption of exposure to overburden groundwater does not contribute to cancer risks for this receptor. The total ILCR for the future resident is 2E-5 (2.4E-5, prior to rounding) (Table 5-1). This value is within the NCP risk management range but exceeds the PBOW target cancer risk goal. Over 90 percent of this value is associated with exposure to total soil. With respect to the total soil ILCR, approximately 48 percent (1.0E-5) is associated with nitroaromatics and approximately 52 percent (1.1E-5) is

associated with PAHs. The PAHs are not part of the TNT manufacturing waste stream and likely originate from burning practices that have been used by NASA for years to control weeds and other vegetative growth along and in the vicinity of the sewer line traces. If the contribution of the non-DoD-related PAHs are duly excluded, the ILCR associated with this receptor equals the PBOW cancer risk goal.

The total HI for the child resident, assuming overburden groundwater exposure, is 34 (Table 5-1). This exceeds the target HI value of 1, which indicates that noncancer health effects cannot be regarded as unlikely to occur. Approximately 87 percent of this HI is associated with exposure to overburden groundwater. As described in Section 5.3.2, the entire overburden groundwater noncancer hazard is associated with inorganic chemicals, especially thallium (HQ=26) and cobalt (HQ=4), that are not related to former PBOW activities. Further, overburden groundwater would not provide adequate yield for tap water use.

If the groundwater pathway is appropriately excluded based on non-site relatedness and insufficient groundwater yield, then the total HI for the child resident exposed to TNTA/WWTP1 sewer line total soil, sediment, and surface water is 4 (Table 5-2). This value exceeds the target HI criterion of 1, indicating that adverse noncancer health effects cannot be regarded as unlikely. Virtually all of this HI is associated with total soil, and 97 percent of this HI is associated with TNT. Moreover, because TNT is the sole risk driver, this HI is related to former PBOW operations. Please note that as discussed in Section 5.4, elevated TNT concentrations are not representative of the entire length of the sewer line traces, but instead are limited to reported concentrations near test pits TP-27 and TP-33.

The total HI for the adult resident, assuming overburden groundwater exposure, is 13 (Table 5-1). This exceeds the target HI value of 1, which indicates that noncancer health effects cannot be regarded as unlikely to occur. As discussed for the child resident, the contribution of the groundwater exposure may be appropriately excluded. The resultant total HI for the adult resident exposed to TNTA/WWTP1 sewer line total soil, sediment, and surface water is 0.5 (Table 5-2), which is less than the target HI criterion of 1.

5.3.6 Adult Hunter

The ILCR for the adult hunter (Table 5-1) exposed to surface soil both through direct contact and via the ingestion of venison is estimated as 9E-7. This is less than the 1E-6 to 1E-4 NCP risk management range and less than the PBOW cancer risk goal of 1E-5.

The total HI for the adult hunter is (Table 5-1) is 0.04. This is far less than the target HI value of 1, indicating that noncancer health effects are unlikely to occur.

5.3.7 Hunter's Child

The ILCR for the hunter's child (Table 5-1) exposed to surface soil via the ingestion of venison from deer which grazed on site is estimated as 2E-12. This is less than both the 1E-6 to 1E-4 NCP risk management range and the PBOW cancer risk goal of 1E-5.

The total HI for the hunter's child (Table 5-1) is estimated at 0.00001. This value is far less than the target HI criterion of 1 and indicates that noncancer health effects are unlikely to occur.

5.4 Evaluation of Potential Hot Spot Areas

As discussed in Section 2.2, additional delineation samples were collected near test pits TP-27 and TP-33 based on elevated concentrations of TNT, which were regarded as potential hot spot areas prior to this additional delineation and evaluation. Section 5.4.1 evaluates the vicinity of test pit TP-33, Section 5.4.2 evaluates the vicinity of test pit TP-27, and Section 5.4.3 discusses the evaluation and presents the risk characterization results of the TNTA/WWTP1 sewer lines excluding the potential hot spot areas.

5.4.1 Evaluation of Potential Hot Spot TP-33

TNT was found at an elevated concentration (1,380 mg/kg) in test pit TP-33 soil sample TNTA-SL-TP33, collected in December 2008 from a depth of 5 to 5.5 feet bgs. Soil boring samples were collected from this sample location, identified as SB02 (Figure 2-1), in January 2009 at depths of 0 to 1 and 8 to 10 feet bgs, prior to receiving the analytical results from the test pit sample. The 0 to 1 foot sample and both field duplicate samples collected at 8 to 10 feet are nondetect with respect to TNT and all other nitroaromatics.

Eight additional subsurface soil boring samples were collected from within 20 feet surrounding sample location SB02, and a ninth sample was collected at the previously sampled SB02 location in August 2011. A sample list of all TP-33 samples is provided in Table F-1 (Appendix F). Each of these nine soil samples was collected at a depth of 5 to 7 feet bgs, to intercept the contamination indicated by the test pit sample TP-33. The sample collected at SB02 had a very low TNT concentration of only 0.0793 mg/kg. Of the other eight samples collected in 2011 near the TP-33 location, TNT was detected in only four of these and at a very low MDC of 0.549 mg/kg.

Because TNT was present only at very low concentrations in the nine 2011 delineation soil samples and was not detected in the 0 to 1 foot or 8 to 10 foot bgs soil boring samples collected in 2009, the single elevated TNT concentration detected in the December 2008 test pit TP-33 sample is regarded as nonrepresentative of TNT concentrations in the vicinity of test pit TP-33. Therefore, the TP-33 area is not regarded as a hot spot.

5.4.2 Evaluation of Potential Hot Spot TP-27

A test pit sample from location TP-27 was initially collected at a depth of 3 to 3.5 feet bgs in December 2008. The TNT concentration found in this sample (3.35 mg/kg) was relatively low, slightly less than the RBSC (3.6 mg/kg). However, when the 0 to 1 foot and 8 to 10 feet bgs soil boring samples were collected from this same location, identified as SB-05 (Figure 2-1), TNT was detected in the 0 to 1 foot surface soil sample at an elevated concentration of 138 mg/kg. TNT was detected in the SB05 sample collected at 8 to 10 feet bgs, but at only a very low concentration (0.371 mg/kg). This information suggested the presence of a potential hot spot area, especially with respect to surface or near-surface soil.

Four additional surface soil samples were collected from within 10 feet of sample location SB05, and a fifth sample was collected at SB05 in August 2011 to delineate the contamination in the vicinity of TP-27. These included two samples that were offset 10 feet perpendicular, roughly north (SB-13) and south (SB11) of the former sewer line location. These also included two samples roughly east (SB12) and west along the sewer line (SB14), approximately 10 feet from SB05 (Figure 2-1). The analytical results yielded an even higher TNT concentration at SB12 of 1,200 mg/kg and a lower concentration west of SB05 at SB14 (18 mg/kg). TNT was also detected in both August 2011 offset samples, but at very low concentrations (0.11 at SB13 and 0.27 at SB11).

To further delineate the TNT contamination, especially that found in the August 2011 sample SB12, additional delineation samples were collected in the vicinity of TP-27 in September 2011. These include locations SB23 to the west, SB24 and SB25 offset from sewer line location SB12, and a total of seven samples east of SB12, designated as SB26 through SB32. All TP-27 samples are shown on the Figure 2-1 inset. Only a very low TNT concentration (0.64 mg/kg) was reported for offset sample SB24 (north of SB12), and TNT was not detected in SB25, which is located south of location SB12. The contamination was bounded to the west by sample SB23, which is located approximately 30 feet west of location SB05, and the contamination is bounded to the east by sample SB27, which is located approximately 20 feet east of SB12. Both SB23 and SB27 are nondetect for TNT. Samples SB29 through SB32 are all located east of nondetect sample SB27.

Based on the presence of elevated TNT concentrations that were confirmed by the delineation samples, the vicinity of the TP-27 test pit is identified as a hot spot with respect to TNT. This TP-27 hot spot is delineated as an area of approximately 60 feet by 20 feet (1,200 square feet or 0.03 acre), as described above and depicted on Figure 2-1.

5.4.3 Evaluation of the TNTA/WWTP1 Sewer Lines Minus the Potential Hot Spot Areas

This section presents a re-evaluation of the human health risks and hazards associated with the length of the former TNTA/WWTP1 sewer lines, excluding the TP-33 and TP-27 areas. Sections 5.4.1 and 5.4.2 present evaluations of what had been regarded as the potential hot spot areas with respect to TNT. It is concluded in Section 5.4.1 that the single elevated TNT concentration at TP-33 in nonrepresentative of conditions in that area. Section 5.4.2 concludes that the TP-27 area is a TNT hot spot that may need to be addressed separately. The purpose of this re-evaluation is to calculate the risks and hazards associated with the TNTA/WWTP1 sewer line traces without inappropriately skewing the EPC values by the inclusion of a nonrepresentative TNT concentration contributed by the TP-33 area and the hot spot concentrations that may be addressed separately at the TP-27 area.

The TNTA/WWTP1 sewer lines minus potential hot spots (MPHS) risk evaluation was conducted in the same way as the general risk assessment conducted for the entire length of the TNTA/WWTP1 sewer lines, which is discussed in Chapters 2.0 through 5.2 of this BHHRA and presented in Section 5.3. Therefore, this MPHS sewer line risk evaluation includes the COPC identification, exposure calculations, and risk calculations. Tables showing the results for these steps are provided in Appendix F (Tables F-1 through F-13). Note that the ProUCL input and output are provided in Appendix B and that the data used in this risk evaluation are provided in Appendix E.

Because nitroaromatics were detected at only very low concentrations in surface soil (outside of the TP-27 hot spot), benzo(a)pyrene is the only COPC identified in MPHS sewer line surface soil (Table F-2). The total soil COPCs for the MPHS sewer line risk evaluation are TNT, 2,4-DNT, and benzo(a)pyrene (Table F-4). These COPCs were evaluated for each of the receptors discussed in Chapter 3.0 and presented for the general sewer line trace evaluation in Section 5.3. These include the current groundskeeper, future groundskeeper, indoor worker, construction worker, resident (child and adult for noncancer), hunter, and hunter's child. The risk characterization results for each receptor are summarized in Table 5-3 and briefly discussed below.

5.4.3.1 Current Groundkeeper

The ILCR of the current MPHS sewer line groundskeeper is 2E-7, which is less than both the NCP risk management range and the PBOW cancer risk goal. No non-cancer-based COPCs were identified for surface soil, so the likelihood of adverse noncancer health effects is regarded as negligible.

5.4.3.2 Future Groundkeeper

The ILCR of the future MPHS sewer line groundskeeper is 5E-7, which is less than both the NCP risk management range and the PBOW cancer risk goal. The HI for this receptor is 0.03. Because this value is less than the target HI of 1, adverse noncancer health effects are regarded as unlikely for this receptor.

5.4.3.3 Indoor Worker

The ILCR of the MPHS sewer line indoor worker is 5E-8, which is less than both the NCP risk management range and the PBOW cancer risk goal. No non-cancer-based COPCs were identified for surface soil, so the likelihood of adverse noncancer health effects is regarded as negligible.

5.4.3.4 Construction Worker

The ILCR of a MPHS sewer line construction worker is 4E-8, which is less than both the NCP risk management range and the PBOW cancer risk goal. The HI for this receptor is 0.1. Because this value is less than the target HI of 1, adverse noncancer health effects are regarded as unlikely for this receptor.

5.4.3.5 Resident

The ILCR of a MPHS sewer line resident is estimated as 2E-6. The ILCR for the resident is within the NCP risk management range and is less than the PBOW cancer risk goal.

The total HI for the MPHS child resident is 0.3. Because this value is less than the target HI of 1, adverse noncancer health effects are regarded as unlikely for this receptor.

The total HI for the MPHS adult resident is 0.03. Because this value is less than 1, adverse noncancer health effects are regarded as unlikely for this receptor.

5.4.3.6 Adult Hunter

The ILCR for the MPHS adult hunter exposed to surface soil both through direct contact and via the ingestion of venison is estimated as 1E-8. This is less than the 1E-6 to 1E-4 NCP risk management range and less than the PBOW cancer risk goal of 1E-5.

There are no noncancer health effects associated with the lone MPHS surface soil COPC, benzo(a)pyrene. Therefore, the noncancer hazard is regarded as negligible.

5.4.3.7 Hunter's Child

The lone MPHS COPC, benzo(a)pyrene, is not regarded as bioaccumulative. Therefore, the cancer risk and noncancer hazard are regarded as negligible for this receptor.

5.5 Risk-Based Remediation Criteria

Risk-based remedial concentrations (RBRC) are derived to provide support for risk management decisions. Thus, they are developed only for the chemicals of concern (COC) in media that are associated with unacceptable risk or hazard and that may potentially warrant remedial action.

COCs are preliminarily identified in the BHHRA as site-related chemicals that either exceed a medium-specific applicable or relevant and appropriate requirement or contribute significantly to an unacceptable risk or hazard. Significant contribution to cancer risk is defined as that associated with a COPC (all exposure pathways for a given receptor and medium) which is estimated as having an ILCR of 1E-6 or greater. Significant contribution to noncancer hazard is defined as that associated with a COPC (all exposure pathways for a given receptor and medium) which is estimated as having a target organ-specific HQ of 0.1 or greater. The list of preliminary COCs identified in the BHHRA may be revised by the project delivery team during the feasibility study (FS) process based on other site-specific considerations.

RBRCs are developed in the TNTA/WWTP1 sewer line BHHRA because the HI for the child resident (HI=4) exceeds the target HI goal of 1. Based on an HQ of 4.2 associated with childhood residential exposure, TNT is identified as a preliminary COC in total soil.

No COCs are identified for TNTA/WWTP1 sewer line bedrock groundwater or overburden groundwater because the risk drivers in these media are naturally occurring and are not related to former PBOW activities, and use of groundwater underlying the sewer line traces is regarded as implausible.

RBRCs are back-calculated from the risk characterization results, which reflect the site-specific concentrations, exposure assumptions, and toxicity assumptions applied in the BHHRA. Consequently, the RBRCs are specific to site, source medium, receptor, and chemical. RBRCs are values based on specific risk (i.e., ILCR=1E-6, 1E-5) or hazard levels (i.e., HQ=0.1, 1). They are intended to indicate a range within which cleanup values may be developed during the FS process should the medium in question require a remedial action. RBRCs are not intended to serve as final cleanup criteria. Further information such as site-specific conditions, spatial orientation of the contamination, other COCs, other contaminated media, and remedial action objectives should be considered in the development of the final cleanup levels during the FS process.

As stated above, the RBRCs are back-calculated using the risk characterization results. An RBRC for a COC that is based on cancer effects is derived for a given medium from the following equation:

Eq. 5.8

$$RBRC_{coc-R} = \frac{EPC_{coc}\ TR}{ILCR_{coc-R}}$$

where:

$RBRC_{coc\text{-}R}$	=	risk-based remedial concentration for a given COC, receptor, and source medium (calculated)
EPC_{coc}	=	exposure-point concentration of the COC in the given medium
TR	=	target risk level (1E-6, 1E-5)
$ILCR_{coc\text{-}R}$	=	total incremental lifetime cancer risk for a given COC, receptor, and source medium combination.

An RBRC for the noncancer effects of a COC in a given medium is derived as follows:

Eq. 5.9

$$RBRC_{coc-R} = \frac{EPC_{coc}\ THI}{HQ_{coc-R}}$$

where:

$RBRC_{coc\text{-}R}$	=	risk-based remedial concentration for a given COC, receptor and source medium (calculated)
EPC_{coc}	=	exposure-point concentration of the COC in the given medium
THI	=	target hazard index (0.1, 1)
$HQ_{coc\text{-}R}$	=	hazard quotient for a given COC, receptor and source medium combination.

Concentration units are not provided in Equations 5.8 and 5.9; the soil RBRC and EPC units are both mg/kg. Both cancer-based and non-cancer-based RBRCs are derived for COCs, such as TNT, for which both cancer and noncancer-based toxicity values are available.

Table 5-4 presents the RBRCs for future residential land use COCs (child resident is used for noncancer hazard). All input values for the calculations presented in Equations 5.8 and 5.9 (i.e., EPCs, HQs, and ILCRs) are also provided in Table 5-4. Note that for PBOW sites where remediation has been conducted or is ongoing, residential land use has been used as the basis of developing cleanup goals rather than any worker or recreational scenarios.

6.0 Uncertainty Analysis

The primary objective of the BHHRA is to characterize and quantify potential human health risks. However, these risks are estimated using incomplete and imperfect information that introduces uncertainties at various stages of the risk assessment process. Uncertainties associated with earlier stages of the risk assessment become magnified when they are linked with other uncertainties in the latter stages. Reliance on a simplified numerical presentation of dose rate and risk without consideration of uncertainties, limitations, and assumptions inherent in their derivation can be misleading. For example, the calculated ILCR for a given scenario "A" may be 1E-5 (meets the PBOW risk goal) and that of scenario "B" may be 5E-5 (exceeds the PBOW risk goal). However, if the uncertainties associated with scenario "B," for instance, span orders of magnitude and the ILCR is regarded as biased high, it is not unlikely that scenario "A" actually presents a higher risk of developing cancer.

The chief goal of this analysis is to evaluate uncertainties and present them in context of their potential impact on the interpretation of the risk assessment results and the types of environmental management decisions that may be based on these results. The uncertainty analysis does not exhaustively describe all potential uncertainties but presents those that have the largest implications for the interpretation of the risk assessment results. This analysis also summarizes the types and, as applicable, the magnitude of the uncertainties at each stage of the risk assessment. Although the discussion in the following sections includes generic uncertainties that are common to the state of human health risk assessment practice overall (e.g., additivity of health effects in the risk characterization), the uncertainty analysis focuses on the sets of uncertainties that are specific to the vicinity of the former TNTA/WWTP1 sewer lines.

6.1 Types of Uncertainty

Uncertainties in risk assessment are categorized into two general types: 1) variability inherent in the (true) heterogeneity of the data set, measurement precision, and measurement accuracy and 2) uncertainty that arises from data gaps. Estimates of the degree of variability tend to decrease as the sample size increases. This is because larger data sets are less impacted by individual samples/measurements and typically allow for greater accuracy. Uncertainty that arises from data gaps is addressed by applying models and assumptions. Models are applied because they represent a level of understanding to address certain exposure parameters that are impractical or impossible to measure (e.g., COPC concentrations in air that would result from groundwater use that has not yet occurred–or may never occur–at the site). Assumptions represent an educated estimate to address information that is not available (e.g., additivity of carcinogens).

6.2 Sources of Uncertainty

The discussion in the following subsections provides an overview of uncertainty, with a focus on those sources that are most likely to affect interpretation of the risk assessment results.

6.2.1 Sample Selection

Soil samples were collected from within the traces of the former TNTA/WWTP1 sewer lines which had previously carried TNT manufacturing wastes for TNTA to WWTP1. Field screening was performed along the length of the former sewer lines to identify any areas with elevated concentrations of nitroaromatics that may have resulted from leakage or removal of the sewer lines. Delineation sampling was conducted to verify and delineate potential hot spot areas in the vicinity of test pit locations TP-27 and TP-33. Groundwater well locations were selected from upgradient and along each of the two sewer line traces in an upgradient-to-downgradient direction. Because of a lack of yield, no groundwater samples could be collected from upgradient bedrock well 1SLA-BEDGW-001. This paucity of water at particular locations is consistent with the findings at other nearby PBOW sites. Selection of the nested bedrock and overburden well locations was based partly on observations made during overburden piezometer installation, where only 4 of the 10 piezometers yielded an adequate volume of water for sampling. Six collocated surface water and sediment samples were collected at the locations where the sewer lines formerly crossed Plum Brook. At each of the two former crossings, sediment/surface water samples were collected upstream, at the crossing point, and downstream.

The soil samples adequately characterize the sewer line traces. The groundwater samples appear to provide adequate coverage given the conditions of low water yield in the bedrock and overburden water zones. Although an inability to collect some of the planned samples might otherwise indicate a potential uncertainty, such concerns are obviated by the observation that the low groundwater yields that are characteristic of the TNTA/WWTP1 sewer line wells were also observed at the wells of adjacent PBOW sites. Thus, the low water yields found in the TNTA/WWTP1 sewer line wells are to be expected. The surface water/sediment samples provide appropriate coverage at the locations where the sewer line would have been most likely to impact the stream. In summary, the sampling protocol was appropriately biased toward those areas most likely to have been impacted by the sewer lines. Thus, the sample data are appropriate and may introduce a high bias.

6.2.2 Exposure-Point Concentration Estimates

Uncertainty is introduced in the statistical approach used to calculate the EPCs. As stated in the HHEM (EPA, 1989a), the average concentration of the site should be used as the concentration term. Generally, a UCL is used to account for the uncertainty of using a sample data set to

estimate the true population mean concentration for the site. ProUCL Version 4.01 software (EPA, 2011a) was used to calculate the EPCs for those media with five or more samples. However, as is readily observed by reviewing the ProUCL output (Appendix B), the calculation of the UCL can vary with methodology. It is unclear as to whether the UCL value of a specific EPC would result in an underestimate or overestimate of the true population mean. However, the general use of a UCL on all the data sets, even given the uncertainty as to whether a given method provides full coverage at 95 percent confidence, would result in general overestimation of the population mean and associated risks. Therefore, as intended by human health risk assessment guidance (EPA, 1989a), this practice of using the UCL as the EPC (note that the MDC is used as the EPC if the UCL exceeds the MDC) introduces bias that tends to overestimate the population mean and the resultant risk values. Also, as discussed in Section 5.4.3, the inclusion of the test pit TP-27 hot spot area or the nonrepresentative sample at TP-33 may artificially skew the EPC values high, resulting in a substantially conservative bias for the TNTA/WWTP1 sewer line risk characterization presented in Section 5.3.

The TNTA/WWTP1 sewer line bedrock groundwater data set has fewer than five samples. Thus, the MDC was used as the EPC for these data sets. Use of the MDC likely introduces a high bias to the risk values.

6.2.3 Land-Use Assumptions/Receptor Selection

The current groundskeeper is intended to represent an on-site worker under the current land use as NASA-controlled property. Because there is currently no identified NASA activity other than occasional mowing in the eastern portion of the site and along Maintenance Road, the use of this receptor likely overestimates risks and hazards to a current site worker. The assumed future use of the hunter and the hunter's child are reasonable, as other areas within PBOW may currently be legally hunted by permit.

Unrestricted land use, including residential use, is a reasonable assumption for the future TNTA/WWTP1 sewer line traces, given the rural residential use of property adjacent to the PBOW facility. The assumption that either the overburden or bedrock groundwater will be used as a potable water source in the future is regarded as implausible for reasons described in Section 6.2.4.

6.2.4 Groundwater Use

The use of bedrock groundwater along the TNTA/WWTP1 sewer line traces is regarded as unlikely because it contains natural petroleum and hydrogen sulfide, which can be commonly observed in area quarries (Shaw, 2005). As described in Section 3.1.1.2, petroleum hydrocarbon

staining and/or odor were observed at depth during the drilling of all three TNTA/WWTP1 sewer line wells. Note that 1SLA-BEDGW-001 was dry and no samples could be collected from this well. Also, hydrogen sulfide odor was observed in 1SLA-BEDGW-002 (greater than 200 ppm) during well purging. Hydrogen sulfide has also been observed at high concentrations in bedrock wells at nearby PBOW sites, notably in AP1 well AP1-BEDGW-002, WWTP1 well WTP1-BEDGW-001 (Shaw, 2011c), and LBA monitoring well MNTA-BEDGW-001 (more than 200 ppm) (Shaw, 2011b). Also, in upgradient well TNTA-BEDGW-001, approximately 14 feet of free product has been found on the surface of the water during sampling (Shaw, 2008). Petroleum hydrocarbons were also found at depth in four of the six bedrock wells in the LBA (Shaw, 2011a) to the west, indicating the prevalence of petroleum contamination in the bedrock zone within this general area of PBOW. These observations provide evidence that petroleum hydrocarbons and elevated levels of hydrogen sulfide are naturally occurring in this general area of PBOW.

The TNTA/WWTP1 sewer line overburden groundwater has been found to be of low yield. The overburden groundwater is regionally and seasonally discontinuous throughout much of PBOW (Shaw, 2006). This discontinuity also appears to be true of overburden groundwater underlying the vicinity of the TNTA/WWTP1 sewer line traces, as only 4 of the 10 piezometers yielded an adequate volume of water to sample. Also, of the three TNTA/WWTP1 sewer line overburden groundwater monitoring wells, only 1SLA-MW03 could be sampled using low-flow sampling during each sampling event, and well 1SLA-MW01 could not be sampled at all in March 2009 because of insufficient water. Note that potable wells need to provide a flow rate that is orders of magnitude greater than that needed for low-flow sampling.

In summary, use of the bedrock groundwater and overburden groundwater as a potable source along the TNTA/WWTP1 sewer line traces is regarded as implausible for the following reasons: 1) Overburden groundwater yields water volumes that are inadequate; 2) bedrock groundwater has naturally occurring petroleum and hydrogen sulfide constituents that make the water unsuitable for potable or industrial use, regardless of yield; 3) this poor bedrock quality is associated with the presence of hydrogen sulfide off-gassing, a concern with respect to nuisance odors and potential health issues; 4) no residential wells in the area have been identified as potable; and 5) municipal water is available in the area.

6.2.5 Exposure Assumption Values

The exposure assumption values used in the exposure assessment (Table 3-1) are selected to represent either an upper bound (e.g., 95th percentile) or midrange value, depending on the particular parameter. Mathematically combining these terms in exposure equations is generally

thought to result in decidedly conservative exposure estimations (Cogliano, 1997; Burmaster and Harris, 1993). In general, this conservativeness is associated with the state of risk assessment practice, which attempts to focus on the upper end of exposure possibilities rather than more realistic levels of exposure and not on assumptions made specifically for the TNTA/WWTP1 sewer line traces. An exception to this statement with respect to TNTA/WWTP1 sewer lines is the FI term.

The use of the default FI term of 1 for soil, as was used in the BHHRA, is decidedly conservative for a linear feature such as a sewer line trace where the width of the affected area is 20 feet or less. Although an FI value of less than 1 would be appropriate, it is speculative as what the FI term value should be. Certainly a value of much less than 1 would be defensible for a groundskeeper or indoor worker. However, the soil risks/hazards for receptors other than the future resident did not exceed the PBOW HI or ILCR criteria. It is conceivable, if unlikely, that a foundation for a small, hypothetical house could bisect a sewer line trace. In this case, an FI term approaching a value of 1 may be defensible. Thus, in summary, use of the default FI term of 1 contributes a high bias, especially for receptors other than the resident. Its use also contributes a high bias to the resident, but this bias may be difficult to quantify if a house were placed such that it bisected a portion of a sewer line trace.

6.2.6 Groundwater-to-Air Household Model

The groundwater-to-air household model (EPA, 1991b) has considerable associated uncertainties. Some parameters that affect the model include the air exchange rate of the house (which can vary with the season) level of groundwater usage, and size of the house. EPA (1991b) states that the model assumes a four-member household that uses 720 L/day of water, a home with a volume of 150 m^3, and 0.25 household air exchanges per hour. The *Exposure Factors Handbook* (EPA, 1997a) lists the following information for the average four-person home: household use of 892 L/day (4 × 223 L/day), volume of 431 m^3, and air exchange rate of 0.63 volumes per hour. If the values from the *Exposure Factors Handbook* were used instead of the default values from EPA (1991b), the resultant estimated household air concentrations would be less than those estimated in the BHHRA by a factor of nearly 5. In summary, the selection of the groundwater-to-air model parameter values used by EPA (1991b) may contribute a conservative bias to the resultant risk estimates.

6.2.7 Toxicity Assessment

Uncertainties associated with the toxicity assessment include those regarding development of the health effects criteria values, the classification of potential carcinogenicity, the extrapolation of exposure route-specific toxicity values to other routes of exposure, and the extrapolation of toxic

effects observed in animal studies to potential adverse effects in humans. A general summary of these uncertainties is provided in the following paragraphs.

The development of health effects criteria for noncancer effects involves considerable professional judgment. An uncertainty factor of up to 10 may be applied to a toxicologically identified benchmark dose or concentration to address the unknown regarding each of the following (EPA, 1989b): lowest-observed-adverse-effects level to no-observed-adverse-effects level, subchronic-to-chronic extrapolation, route-to-route extrapolation, and species-to-species extrapolation. A "modifying factor" of 10 or less is likewise applied in the development of RfDs and RfCs, using professional judgment. This modifying factor is intended to address gaps in the database and the steepness of the dose-response curve. In practice, the overall UF, derived by multiplying the individual uncertainty factors by the modifying factor, associated with RfD and RfC values may span up to four orders of magnitude.

The EPA weight-of-evidence classification system for carcinogens is used to examine and classify chemical agents with respect to their carcinogenic potential. Most EPA potential carcinogens are classified based on animal data, without sufficient human data to support a causal association (i.e., former Group B2; refer to Section 4.1). Also, the linearized multistage (LMS) mathematical model was used to extrapolate values from relatively high-dose rodent studies to relatively low-dose human exposures in the development of SFs for these compounds. This application of the LMS model is the subject of much controversy. Thus, the LMS approach used to develop SFs, combined with other assumptions, tends to overestimate potential risks.

Overall, the toxicity values, assuming similar effects between humans and test species, tend to result in overestimates of noncancer hazards or cancer risks. However, it is possible that a given chemical can elicit a toxic response in humans that is not observed in the laboratory species studied or that humans may be more sensitive to a given chemical. In this instance, it is possible for the use of the toxicity values to result in underestimates of risks/hazards.

6.2.8 Risk Characterization

It is assumed that the effects of simultaneous exposures to multiple carcinogens at a site are additive. Likewise, it is assumed that noncancer effects of contaminants are additive if they have a similar mechanism of toxicity. In risk assessment practice, it is assumed that the effects of chemicals that affect the same target organ are additive unless chemical-specific information would dictate otherwise. However, chemicals in combination may act additively, synergistically, or antagonistically or may not influence one another at all. Therefore, depending on the

interactive effects (if any), the risk characterization approach to multiple contaminants may lead to either underestimates or overestimates of potential risk/hazard.

6.2.9 Evaluation of Selected COPCs for Site Relatedness

As described in Section 2.4.3, a comparison of naturally occurring metals is performed in two steps. The first is a comparison to BSCs; a chemical whose MDC does not exceed the BSC is assumed to be related to background and thus eliminated from further evaluation. The second step is performed for selected metals and organic compounds during the risk characterization step, after exposure calculations are performed which include the potential background-related contributions as part of the overall ILCR and HI results.

For inorganics in soil or bedrock groundwater, the risk characterization background evaluation step typically may include a statistical comparison of the site data set to the background data set using the WRS statistical test as appropriate (Section 2.4.3.2). For TNTA/WWTP1 sewer lines, no inorganics were identified for soil and the bedrock groundwater data set was too small (four samples) to perform meaningful statistical analysis. Therefore, the WRS statistical approach was not used in this BHHRA.

A qualitative background evaluation was performed for petroleum-related organic compounds observed in TNTA/WWTP1 sewer line bedrock groundwater, most notably for benzene and other petroleum-related compounds. During the drilling of the TNTA/WWTP1 sewer line bedrock wells, petroleum hydrocarbon staining (on the cores) and/or odor were observed at depth for all three wells. Also, hydrogen sulfide odor was observed in 1SLA-BEDGW-002 (greater than 200 ppm) during well purging (Shaw, 2012). Hydrogen sulfide has also been observed at high concentrations in bedrock wells at nearby PBOW sites, notably in AP1 well AP1-BEDGW-002 (Shaw, 2011b), WWTP1 well WTP1-BEDGW-001 (Shaw, 2011c), and LBA monitoring well MNTA-BEDGW-001 (more than 200 ppm) (Shaw, 2011a). Approximately 14 feet of petroleum product was removed from upgradient well TNTA-BEDGW-001 (Shaw, 2008), and petroleum was also observed on the surface during the sampling of other nearby wells (e.g., AP1-BEDGW-001) (Shaw, 2011b). Petroleum hydrocarbons were also found at depth in four of the six bedrock wells in the LBA (Shaw, 2011a), and petroleum hydrocarbons were observed seeping from fractures at WWTP1 well WTP1-BEDGW-001 to the west (Shaw, 2011c). These observations provide evidence that petroleum hydrocarbons and elevated levels of hydrogen sulfide are naturally occurring in this general area of PBOW.

Of the three wells installed along the TNTA/WWTP1 sewer line traces, one (1SLA-BEDGW-001) of the three could not be sampled during either sampling event, suggesting the potential for

limited groundwater in the vicinity of the sewer line trace (Shaw, 2012). This is consistent with the limited bedrock groundwater yield in the nearby WWTP1, LBA, and AP1 bedrock monitoring wells. Also, the presence of naturally occurring petroleum indicates that potable use by a site worker is not a plausible exposure pathway.

The arsenic present in the TNTA/WWTP1 sewer line bedrock groundwater appears to be unrelated to PBOW activities based on the following observations:

- Arsenic was detected at background concentrations in the overlying TNTA/WWTP1 sewer line soil samples. The MDC (20.3 mg/kg) of arsenic in total soil is less than that of the background data set (36.5 mg/kg), and the TNTA/WWTP1 sewer line mean concentration (11.2 mg/kg) of arsenic in total soil is essentially equal to that of the PBOW background data set (10.8 mg/kg).

- Arsenic was not detected in any of the samples from the overlying overburden groundwater wells.

- Arsenic is not a component of any waste stream related to TNT manufacturing.

7.0 Summary and Conclusions

7.1 Summary

The BHHRA was conducted to evaluate cancer risk and noncancer hazards associated with the TNTA/WWTP1 sewer line surface soil, subsurface soil, surface water, sediment, bedrock groundwater, and overburden groundwater. A risk-based screening approach was used to identify COPCs and focus the risk assessment on those chemicals detected at the TNTA/WWTP1 sewer line traces that may contribute appreciably to risk or hazard. The sampled media were screened against the respective RBSCs, and inorganics in bedrock groundwater and soil were also screened against BSCs. Only complete exposure pathways are typically quantitatively evaluated in a BHHRA (EPA, 1989a). Because of poor natural quality, the groundwater underlying the vicinity of the TNTA/WWTP1 sewer lines is regarded as nonpotable, and potable use is accordingly an incomplete pathway. Therefore, the evaluation of groundwater based on potable use represents a deviation from standard risk assessment practice.

COPCs for the various media were identified based on this screening. Exposure and risk/hazard associated with the COPCs were evaluated using the following receptors (media evaluated in parentheses):

- Current groundskeeper (surface soil)
- Future groundskeeper (total soil, groundwater)
- Future indoor worker (surface soil, subsurface soil [inhalation pathway only], groundwater)
- Current/future construction worker (total soil, surface water, sediment)
- Future resident (total soil, surface water, sediment, overburden groundwater, bedrock groundwater)
- Future adult hunter (surface soil, including venison pathway)
- Future hunter's child (surface soil [venison pathway only]).

Each receptor scenario that includes groundwater was run separately for overburden groundwater and bedrock groundwater. Because groundwater yield was found to be insufficient for potable use in the overburden and bedrock units underlying the TNTA/WWTP1 sewer line traces and the TNTA/WWTP1 sewer line traces bedrock groundwater was observed to be of naturally poor quality due to the presence of petroleum and hydrogen sulfide, the receptors evaluated for

potable groundwater use were also evaluated assuming no groundwater use. Thus, use of bedrock or overburden groundwater is regarded as implausible. The resident was evaluated for noncancer hazards separately for the young child (ages 1 through 6 years) and adult life stages.

Risk Characterization Results from Full Soil Data Sets. The overall HI and ILCR values of the receptors evaluated for the full soil data sets evaluated in Section 5.3 are summarized in the following bullets; exceedances of the PBOW cancer risk goal (ILCR>1E-5) are shown as bolded and exceedances of the noncancer hazard criterion (HI>1) or the NCP risk management range (1E-6 to 1E-4) are shown as bold italics:

- Current groundskeeper: ILCR = 1E-5; HI = 0.8
- Future groundskeeper – all pathways, including bedrock groundwater use: ***ILCR = 4E-4; HI = 4***
- Future groundskeeper – all pathways, including overburden groundwater use: ILCR = 7E-6; ***HI = 5***
- Future groundskeeper – all pathways, excluding groundwater use: ILCR = 7E-6; HI = 0.4
- Indoor worker – all pathways, including bedrock groundwater use: ***ILCR = 4E-4; HI = 4***
- Indoor worker – all pathways, including overburden groundwater use: ILCR = 4E-6; ***HI = 5***
- Future indoor worker – all pathways, excluding groundwater use: ILCR = 4E-6; HI = 0.3
- Construction worker: ILCR = 4E-7; HI = 1
- Resident – all pathways, including bedrock groundwater use: ***ILCR = 2E-3; child HI = 32; adult HI = 12***
- Resident – all pathways, including overburden groundwater use: ILCR =1E-5 (**2E-5**); ***child HI = 34; adult HI = 13***
- Resident – all pathways, excluding groundwater use: ILCR = 1E-5 (**2E-5**); ***child HI = 4;*** adult HI = 0.5
- Hunter: ILCR = 9E-7; HI = 0.4
- Hunter's child: ILCR = 2E-12; HI = 0.00001.

For the resident exposed to overburden groundwater and excluding exposure to groundwater, the ILCR is reported as 1E-5 and parenthetically as 2E-5. The value of 2E-5 is the total ILCR regardless of contaminant source. However, over 50 percent of the soil-related ILCR for this receptor is associated with PAHs in surface soil. The PAHs are not part of any TNT manufacturing waste and are not found in subsurface soil as would be expected, had they been associated with the sewer line contents. A likely source of the PAHs is the controlled burning that has been used by NASA for years to control vegetation within the area occupied by the sewer line traces. If the apparently non-DoD-related contributions of the PAHs are excluded, the ILCR for the resident is 1E-5, which equals the PBOW cancer risk goal.

Potential Hot Spots Evaluation and Risk Characterization. The above HI and ILCR results include those associated with soil samples that were collected from along the entire length of the sewer lines traces. This includes two areas that were initially regarded as potential hot spot areas with respect to TNT, one at test pit TP-27 and one at test pit TP-33. Additional samples were collected in these areas to delineate the contamination. The results of the nine delineation samples collected near TP-33 indicate that the elevated detection of TNT (1,300 mg/kg) in sample SB02 at TP-33 does not represent a hot spot area, as the highest concentration of TNT detected in the delineation samples was only 0.549 mg/kg. A subsequent sample collected from the same location as SB02 yielded a TNT concentration of only 0.0793 mg/kg, and TNT was not detected in four of the nine samples. Instead, the elevated TNT concentration reported at location SB02 is not confirmed and the TP-33 area is not regarded as a hot spot (Section 5.4.1).

Based on delineation soil samples, the test pit TP-27 location was found to represent a hot spot with a delineated area of approximately 1,200 square feet (Section 5.4.2). This is one of only two locations revealed by the field test kit samples to have a total nitroaromatics concentration greater than the field screening value (10 mg/kg). Although this location is a hot spot, the HI of the sewer line in its entirety was found to be a value of 4 for the resident child. Virtually all of this value is associated with TNT in soil at this hot spot. As such, this location may be considered for remediation using cleanup levels derived based on RBRC values which were developed as described in Section 5.5.

7.2 Conclusions

The ILCR and HI values for the two current exposure scenarios (current groundskeeper and construction worker) each meet the PBOW cancer risk goal (ILCR$\leq$1E-5) and the noncancer hazard criterion (HI$\leq$1). Note that no groundskeeping appears to have occurred along the TNTA/WWTP1 sewer line traces in recent years, except occasional mowing or burning. Thus, the current groundskeeper scenario, which assumes a full-time, 25-year employee who works

exclusively along the TNTA/WWTP1 sewer line traces for 8 hours per day, 250 days per year, appears to greatly overestimate the exposure levels of any current on-site worker or other current receptor.

The cancer risks associated with the following future receptors assumed to use bedrock groundwater as a hypothetical source of tap water exceed the NCP risk management range and PBOW cancer risk goal: future groundskeeper, future indoor worker, and future resident. Each of these also exceeds the target HI criterion of 1. The HI value for each of these three receptors under the assumption of overburden groundwater use also exceeds the HI target goal.

The cancer risks and noncancer hazards associated with bedrock groundwater are almost entirely attributable to naturally occurring petroleum-related compounds and arsenic, which also does not appear to be related to former site activities. The noncancer hazards associated with overburden groundwater are entirely due to inorganics, especially thallium and cobalt, which do not appear to be associated with former site activities. Use of either the overburden or bedrock groundwater is regarded as implausible because of insufficient yield. Additionally, the naturally poor quality of the groundwater and associated hydrogen sulfide off-gassing of the bedrock unit make the underlying groundwater unsuitable as a potable source. The readily available municipal water supply obviates the need for use of groundwater as a potential source of tap water in the general vicinity of PBOW.

If the use of groundwater is excluded, only the HI value of 4 for the child resident exceeds the target HI of 1. This HI is almost entirely associated with TNT. Elevated TNT concentrations are not representative of the entire length of the sewer line traces, but instead are limited to reported concentrations near test pits TP-27 and TP-33. Therefore, these two test pit areas were further investigated and evaluated as potential hot spots. This evaluation concluded that the TP-33 was not a hot spot and that the elevated TNT concentration detected in a single sample was not representative of the vicinity of TP-33. The TP-27 area was identified as a hot spot based on additional contamination revealed by the delineation soil samples.

Because the TP-27 area is regarded as a hot spot, the TP-27 area analytical results may be excluded from the general TNTA/WWTP1 sewer line data sets and addressed separately. Likewise, the TP-33 data may be excluded from the data set, because the single elevated concentration is clearly not characteristic of this site. If both the TP-27 and the TP-33 data sets are removed from the risk characterization (and groundwater is excluded), none of the TNTA/WWTP1 sewer line receptors have an ILCR value that exceeds the PBOW cancer risk goal and none of these receptors have an HI that exceeds the target HI of 1.

TNT was identified as a preliminary COC because exposure associated with TNT in soil at the TP-27 hot spot may result in an HI for the TNTA/WWTP1 sewer lines that exceeds the target HI for the resident child. Therefore, RBRCs were developed for TNT to aid in site management decisions.

8.0 References

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TABLES

Table 2-1

Summary of Samples Evaluated in the Baseline Human Health Risk Assessment
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Sample Location	Sample Number	Sample Purpose	Sample Date	Depth of Sample (ft bgs)			Analysis
Surface Soil							
SL-SB01	SL0061	REG	1/13/2009	0	-	1	Exp, Metals, PCB, SVOC, TOC
SL-SB02	SL0063	REG	1/12/2009	0	-	1	Exp, Metals, PCB, SVOC
SL-SB03	SL0067	REG	1/13/2009	0	-	1	Exp, Metals, PCB, SVOC
SL-SB04	SL0069	REG	1/13/2009	0	-	1	Exp, Metals, PCB, SVOC
SL-SB05	SL0071	REG	1/13/2009	0	-	1	Exp [a], Metals, PCB, SVOC
SL-SB05	SL0233	REG	8/23/2011	0	-	1	Exp [a]
SL-SB06	SL0073	REG	1/13/2009	0	-	1	Exp, Metals, PCB, SVOC
SL-SB07	SL0075	REG	1/14/2009	0	-	1	Exp, Metals, PCB, SVOC
SL-SB07	SL0076	FD	1/14/2009	0	-	1	Exp, Metals, PCB, SVOC
SL-SB08	SL0079	REG	1/14/2009	0	-	1	Exp, Metals, PCB, SVOC
SL-SB12	SL0237	REG	8/23/2011	0	-	1	Exp
SL-SB14	SL0239	REG	8/23/2011	0	-	1	Exp
SL-SB23	SL0248	REG	9/22/2011	0	-	1	Exp
SL-SB27	SL0252	REG	9/22/2011	0	-	1	Exp
Subsurface Soil							
SL-SB02	SL0232	REG	8/22/2011	5	-	7	Exp [a]
TNTA-SL-TP33	SL0041	REG	12/4/2008	5	-	5.5	Exp [a]
45A CL-1	45A CL-1	REG	11/4/2010	8	-	10	Exp
45A CL-2	45A CL-2	REG	11/4/2010	8	-	10	Exp
45A CL-3	45A CL-3	REG	11/4/2010	8	-	10	Exp
53B CL-1	53B CL-1	REG	11/5/2010	8	-	10	Exp
53B CL-2	53B CL-2	REG	11/5/2010	8	-	10	Exp
53B CL-3	53B CL-3	REG	11/5/2010	8	-	10	Exp
SL-SB01	SL0062	REG	1/13/2009	4	-	6	Exp, Metals, PCB, SVOC
SL-SB02	SL0064	REG	1/12/2009	8	-	10	Exp, Metals, PCB, SVOC
SL-SB02	SL0065	FD	1/12/2009	8	-	10	Exp, Metals, PCB, SVOC
SL-SB03	SL0068	REG	1/13/2009	5	-	6	Exp, Metals, PCB, SVOC
SL-SB04	SL0070	REG	1/13/2009	3.4	-	5.4	Exp, Metals, PCB, SVOC
SL-SB05	SL0072	REG	1/13/2009	8	-	10	Exp, Metals, PCB, SVOC
SL-SB06	SL0074	REG	1/13/2009	5	-	6	Exp, Metals, PCB, SVOC
SL-SB07	SL0078	REG	1/14/2009	5	-	6	Exp, Metals, PCB, SVOC
SL-SB08	SL0080	REG	1/14/2009	7.1	-	9.1	Exp, Metals, PCB, SVOC
SL-SB09	SL0081	REG	1/12/2009	5	-	6	Exp, Metals, PCB, SVOC
SL-SB09	SL0082	REG	1/12/2009	8	-	10	Exp, Metals, PCB, SVOC
SL-SB10	SL0083	REG	1/12/2009	5	-	6	Exp, Metals, PCB, SVOC

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TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Sample Location	Sample Number	Sample Purpose	Sample Date	Depth of Sample (ft bgs)			Analysis
SL-SB10	SL0084	REG	1/12/2009	8	-	10	Exp, Metals, PCB, SVOC
SL-SB15	SL0240	REG	8/22/2011	5	-	7	Exp
SL-SB22	SL0247	REG	8/22/2011	5	-	7	Exp
TNTA-SL-TP03	SL0003	REG	12/4/2008	5	-	5.5	Exp
TNTA-SL-TP04	SL0004	REG	12/4/2008	4	-	4.5	Exp
TNTA-SL-TP21	SL0025	REG	12/5/2008	4	-	4.5	Exp
TNTA-SL-TP22	SL0026	REG	12/5/2008	4	-	4.5	Exp
TNTA-SL-TP22	SL0027	FD	12/5/2008	4	-	4.5	Exp
TNTA-SL-TP23	SL0029	REG	12/5/2008	4	-	4.5	Exp
TNTA-SL-TP24	SL0030	REG	12/5/2008	4	-	4.25	Exp
TNTA-SL-TP25	SL0031	REG	12/5/2008	4	-	4.25	Exp
TNTA-SL-TP26	SL0032	REG	12/4/2008	4	-	4.3	Exp
TNTA-SL-TP27	SL0033	REG	12/4/2008	3	-	3.5	Exp
TNTA-SL-TP28	SL0034	REG	12/4/2008	3	-	3.25	Exp
TNTA-SL-TP28	SL0035	FD	12/4/2008	3	-	3.25	Exp
TNTA-SL-TP29	SL0037	REG	12/4/2008	5	-	5.5	Exp
TNTA-SL-TP30	SL0038	REG	12/4/2008	5	-	5.25	Exp
TNTA-SL-TP32	SL0040	REG	12/4/2008	5	-	5.5	Exp
TNTA-SL-TP34	SL0042	REG	12/4/2008	5	-	5.5	Exp
TNTA-SL-TP35	SL0043	REG	12/4/2008	5	-	5.25	Exp
TNTA-SL-TP36	SL0044	REG	12/4/2008	5	-	5.5	Exp
TNTA-SL-TP37	SL0045	REG	12/4/2008	4	-	4.25	Exp
Bedrock Groundwater							
1SLA-BEDGW-002	SL3084	REG	7-May-09	NA			Gen Chem, Exp, Field Tests, Metals (f & uf), SVOC, VOC
1SLA-BEDGW-002	SL3094	REG	11-Nov-09	NA			Gen Chem, Exp, Field Tests, Metals (f & uf), SVOC, VOC
1SLA-BEDGW-003	SL3085	REG	6-May-09	NA			Gen Chem, Exp, Field Tests, Metals (f & uf), SVOC, VOC
1SLA-BEDGW-003	SL3095	REG	10-Nov-09	NA			Gen Chem, Exp, Field Tests, Metals (f & uf), SVOC, VOC
1SLA-BEDGW-003	SL3096	FD	10-Nov-09	NA			Gen Chem, Exp, Field Tests, Metals (f & uf), SVOC, VOC
Overburden Groundwater							
1SLA-MW01	SL3090	REG	11/9/2009	NA			Exp, Gen Chem, Metals (f & uf), SVOC, VOC
1SLA-MW02	SL3081	REG	5/8/2009	NA			Exp, Gen Chem, Metals (f & uf), SVOC, VOC
1SLA-MW02	SL3091	REG	11/10/2009	NA			Exp, Gen Chem, Metals (f & uf), SVOC, VOC
1SLA-MW03	SL3082	REG	5/6/2009	NA			Exp, Gen Chem, Metals (f & uf), SVOC, VOC
1SLA-MW03	SL3092	REG	11/10/2009	NA			Exp, Gen Chem, Metals (f & uf), SVOC, VOC

Table 2-1

Summary of Samples Evaluated in the Baseline Human Health Risk Assessment
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Sample Location	Sample Number	Sample Purpose	Sample Date	Depth of Sample (ft bgs)	Analysis
Piezometer Groundwater [b]					
SL-PZ02	SL3001	FD	27-Jan-09	NA	Cyanide, Exp, Gen Chem
SL-PZ02	SL3003	REG	27-Jan-09	NA	Cyanide, Exp, Gen Chem
SL-PZ05	SL3006	REG	30-Jan-09	NA	Cyanide, Exp, Gen Chem
SL-PZ08	SL3009	REG	26-Jan-09	NA	Cyanide, Exp, Gen Chem
SL-PZ09	SL3010	REG	26-Jan-09	NA	Cyanide, Exp, Gen Chem
Sediment Samples					
1SLA-SD01	SL1000	REG	30-Oct-09	0 - 0	Exp, PCBs, Solids
1SLA-SD02	SL1001	REG	30-Oct-09	0 - 0	Exp, PCBs, Solids
1SLA-SD03	SL1002	REG	30-Oct-09	0 - 0	Exp, PCBs, Solids
1SLA-SD04	SL1003	REG	30-Oct-09	0 - 0	Exp, PCBs, Solids
1SLA-SD05	SL1004	REG	30-Oct-09	0 - 0	Exp, PCBs, Solids
1SLA-SD06	SL1005	REG	30-Oct-09	0 - 0	Exp, PCBs, Solids
1SLA-SD06	SL1006	FD	30-Oct-09	0 0	Exp, PCBs, Solids
Surface Water					
1SLA-SW01	SL2000	REG	30-Oct-09	0 - 0	Exp
1SLA-SW02	SL2001	REG	30-Oct-09	0 - 0	Exp
1SLA-SW03	SL2002	REG	30-Oct-09	0 - 0	Exp
1SLA-SW04	SL2003	REG	30-Oct-09	0 - 0	Exp
1SLA-SW05	SL2004	REG	30-Oct-09	0 - 0	Exp
1SLA-SW06	SL2005	REG	30-Oct-09	0 - 0	Exp
1SLA-SW06	SL2006	FD	30-Oct-09	0 - 0	Exp

[a] The explosive results in these regular samples were averaged to provide one result as follows:
SL0071 and SL0233 were averaged and LS0232 and SL0041 were averaged
[b] These samples are summarized and screened, but no exposure calculations are presented.

Exp - Explosives.
f & uf - Metals analysis performed on filtered and unfiltered samples, respectively.
FD - Field duplicate; averaged with regular sample.
ft bgs - Feet below ground surface.
Gen Chem - General chemistry.
Metals - Metals analysis performed on unfiltered samples unless otherwise noted.
PCB - Polychlorinated biphenyls.
REG - Regular sample.
SVOC - Semivolatile organic compounds.
TOC - Total organic carbon.

Table 2-2

Background Screening Concentrations of Inorganics in Soil
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical Name (mg/kg)	Frequency of Detection	Range of Detected Concentrations	Range of Reporting Limits [a]	Statistical Distribution	Arithmetic Mean	95% UTL [b]	Background Screening Criterion [c]
Aluminum	12 / 12	3520 - 15500	22.6 - 26.5	L	8.43E+03	2.69E+04	15500
Antimony	9 / 25	5.9 - 9.3	5.4 - 8.0	NP	4.68E+00	NA	9.30
Arsenic	23 / 26	2.1 - 36.5	1.1 - 24.7	L	1.08E+01	7.10E+01	36.5
Barium	9 / 12	35.6 - 826	22.6 - 26.5	L	1.16E+02	1.30E+03	826
Beryllium	6 / 25	0.57 - 1	0.57 - 1.2	L	5.65E-01	1.17E+00	1.00
Cadmium	0 / 25	NA	0.57 1.2	L	4.49E-01	NA	NA
Calcium	12 / 12	735 - 52300	566 - 663	L	1.13E+04	2.18E+05	52300
Chromium	25 / 26	4.4 - 29	1.1 - 12.3	NP	1.34E+01	NA	29.0
Cobalt	9 / 12	9.6 - 116	5.7 - 61.7	L	2.26E+01	2.48E+02	116
Copper	23 / 26	2.3 - 56.2	2.2 - 3.3	L	1.70E+01	1.47E+02	56.2
Iron	12 / 12	5880 - 234000	11.3 - 123	L	4.01E+04	3.58E+05	234000
Lead	26 / 26	1.9 - 48.6	0.34 - 7.4	L	1.28E+01	5.13E+01	48.6
Magnesium	12 / 12	629 - 10400	566 - 663	L	3.26E+03	3.08E+04	10400
Manganese	26 / 26	21 - 13300	1.7 - 18.5	L	7.29E+02	3.51E+03	3506
Mercury	2 / 26	0.085 - 0.085	0.037 - 0.3	L	9.06E-02	5.60E-01	0.085
Nickel	26 / 26	5.4 - 55.1	4.5 - 5.3	L	2.28E+01	7.79E+01	55.1
Potassium	11 / 12	579 - 3390	566 - 663	L	1.24E+03	6.08E+03	3390
Selenium	5 / 25	0.61 - 2	0.57 - 4.9	NP	1.55E+00	NA	2.00
Silver	2 / 26	1.1 - 11.1	1.1 - 1.3	NP	1.00E+00	NA	11.1
Sodium	0 / 12	NA	566 - 663	L	3.03E+02	NA	NA
Thallium	2 / 25	1.2 - 1.3	1.1 - 6.1	NP	1.91E+00	NA	1.30
Vanadium	11 / 12	9 - 40.9	5.7 - 61.7	L	2.48E+01	8.31E+01	40.9
Zinc	26 / 26	6.6 - 655	0.57 - 12.3	L	7.30E+01	3.22E+02	322

L - Lognormal; mg/kg - milligrams per kilogram; NP - nonparametric; NA - not applicable; not available.

[a] A single background sample had to be diluted such that the reporting limits of this sample (BCG-SB01, 6990) were elevated 10 or 20 times higher than they would have been if not diluted. This affects the maximum reporting limit shown for arsenic, chromium, cobalt, iron, lead, manganese, and vanadium. Reporting limits for these analytes in all other samples were much lower, approximately by an order of magnitude or more in each case.

[b] 95% UTL - 95% upper tolerance limit calculated as described in Shaw (2005).

[c] The maximum detected concentration is used as the background screening criterion for nonparametric data sets; for normal or lognormal data sets, the 95% UTL or the maximum detected concentration, whichever is less, is used.

Note: Detection limits from sample 6990 were deleted when calculating results for antimony, beryllium, cadmium, selenium, and thallium. The detection limits were elevated by dilution factors which greatly exceed any detected concentration and would bias results unrealistically high.

Source: IT Corporation, 2000, *TNT Area B Remedial Investigation, Volume II Baseline Human Health Risk Assessment* , Final, Former Plum Brook Ordnance Works, Sandusky, Ohio, August, and reports referenced therein.

Table 2-3

Background Screening Concentrations of Inorganics in Groundwater TNTA/WWTP1 Sewer Lines Former Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of Values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Mean µg/L	Standard Deviation	UTL [a] µg/L	BSC [b] µg/L
Metals - Unfiltered										
Aluminum	11 / 13	85	3.15E+01	3.09E+02	2.00E+02	2.00E+02	1.05E+02	6.98E+01	4.17E+02	309
Arsenic	4 / 26	15	3.30E+00	7.40E+00	1.00E+01	1.00E+01	4.99E+00	6.56E-01	7.92E+00	7.4
Barium	28 / 28	100	2.58E+01	1.18E+04	2.00E+02	2.00E+03	1.73E+03	3.77E+03	1.86E+04	11800
Calcium	28 / 28	100	1.74E+04	3.16E+05	5.00E+03	5.00E+03	1.38E+05	8.31E+04	5.09E+05	316000
Cobalt	6 / 27	22	1.00E+00	1.21E+01	5.00E+01	5.00E+01	2.05E+01	8.75E+00	5.96E+01	12.1
Copper	2 / 28	7	3.30E+00	1.98E+01	2.50E+01	2.50E+01	1.24E+01	2.26E+00	2.25E+01	19.8
Iron	24 / 27	89	3.82E+01	1.55E+03	1.00E+02	1.00E+02	4.15E+02	4.87E+02	2.59E+03	1550
Magnesium	28 / 28	100	7.28E+03	2.17E+05	5.00E+03	5.00E+03	7.17E+04	5.85E+04	3.33E+05	217000
Manganese	28 / 28	100	3.60E+00	6.88E+02	1.50E+01	1.50E+01	8.12E+01	1.24E+02	6.36E+02	636
Nickel	4 / 27	15	4.80E+00	8.60E+00	4.00E+01	4.00E+01	1.81E+01	4.67E+00	3.90E+01	8.6
Potassium	28 / 28	100	2.53E+03	1.16E+05	5.00E+03	5.00E+04	2.70E+04	3.06E+04	1.64E+05	116000
Sodium	28 / 28	100	1.33E+04	1.39E+06	5.00E+03	5.00E+04	3.55E+05	4.36E+05	2.30E+06	1390000
Zinc	14 / 19	74	8.30E-01	5.07E+02	2.00E+01	2.00E+01	5.55E+01	1.23E+02	6.06E+02	507

[a] The upper tolerance limit (UTL) is calculated as described in Shaw (2005).

[b] The BSC (background screening criterion) is the calculated UTL or the maximum detected concentration, whichever is less.

µg/L - Micrograms per liter.

BTEX - Benzene, toluene, ethylbenzene, and xylenes.

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

Table 2-4

Statistical Summary and Selection of Chemicals of Potential Concern in Surface Soil (0 to 1 Foot)
TNTA/WWTP1 Sewer Line
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Detection Frequency	Percent Detection	Range of Values (mg/kg) Detected Concentrations Minimum	VQ	Maximum	VQ	Method Detection Limits Minimum	Maximum	Mean mg/kg	BSC [a] mg/kg	RBSC [b] mg/kg	COPC? [c,d]	95% UCL [e] mg/kg	EPC [f] mg/kg
Inorganics														
Aluminum	8 / 8	100	7.50E+03	J/J	1.24E+04		1.01E+00	2.19E+00	9.09E+03	1.55E+04	7.70E+03	N (b)		---
Antimony	3 / 8	38	3.30E-01	J	5.29E-01	J/J	2.31E-01	2.74E-01	3.14E-01	9.30E+00	3.10E+00	N (a)		---
Arsenic	8 / 8	100	4.80E+00	J	1.22E+01	J	4.62E-01	5.48E-01	6.87E+00	3.65E+01	3.90E-01	N (b)		---
Barium	8 / 8	100	4.60E+01		8.40E+01		9.23E-02	1.10E-01	5.49E+01	8.26E+02	1.50E+03	N (a)		---
Beryllium	8 / 8	100	5.22E+00	J	7.87E+00	J	9.23E-02	1.10E-01	6.28E+00	1.00E+00	1.60E+01	N (a)		---
Cadmium	2 / 8	25	2.85E-01	J/J	3.87E-01	J	2.31E-01	2.74E-01	2.79E-01	NA	7.00E+00	N (a)		---
Calcium	8 / 8	100	3.99E+03		7.33E+03		2.52E+00	5.48E+00	5.02E+03	5.23E+04	Nutrient	N (c)		---
Chromium	8 / 8	100	1.70E+00		1.65E+01		2.31E-01	2.74E-01	1.18E+01	2.90E+01	2.90E-01	N (b)		---
Cobalt	8 / 8	100	4.19E+00		8.65E+00		9.20E-02	2.03E-01	6.12E+00	1.16E+02	2.30E+00	N (b)		---
Copper	8 / 8	100	1.54E+01		2.78E+01		2.31E-01	2.74E-01	2.06E+01	5.62E+01	3.10E+02	N (a)		---
Iron	8 / 8	100	1.46E+04		2.52E+04		9.23E-01	2.03E+00	1.83E+04	2.34E+05	5.50E+03	N (b)		---
Lead	8 / 8	100	1.03E+01		2.83E+01		2.31E-01	2.74E-01	1.63E+01	4.86E+01	4.00E+02	N (a)		---
Magnesium	8 / 8	100	1.61E+03	J	3.50E+03	J	9.23E-01	1.10E+00	2.35E+03	1.04E+04	Nutrient	N (c)		---
Manganese	8 / 8	100	1.37E+02		3.06E+02		9.23E-02	1.10E-01	2.05E+02	3.51E+03	1.80E+02	N (b)		---
Mercury	8 / 8	100	3.14E-02		4.43E-01		1.16E-02	1.29E-02	9.10E-02	8.50E-02	2.30E+00	N (a)		---
Nickel	8 / 8	100	2.68E+00	J	1.96E+01		1.39E-01	1.64E-01	1.05E+01	5.51E+01	1.50E+02	N (a)		---
Potassium	8 / 8	100	4.61E+02		9.00E+02		1.15E+01	1.37E+01	6.22E+02	3.39E+03	Nutrient	N (c)		---
Selenium	3 / 8	38	5.10E-01	J	6.08E-01	J	4.62E-01	5.48E-01	5.30E-01	2.00E+00	3.90E+01	N (a)		---
Sodium	8 / 8	100	3.11E+01		7.67E+01		5.05E+00	1.10E+01	5.27E+01	NA	Nutrient	N (c)		---
Thallium	1 / 8	13	3.66E-01	J	3.66E-01	J	2.31E-01	2.74E-01	2.71E-01	1.30E+00	7.80E-02	N (b)		---
Vanadium	8 / 8	100	1.98E+01		2.63E+01		9.23E-02	1.10E-01	2.18E+01	4.09E+01	3.90E+01	N (a)		---
Zinc	8 / 8	100	3.40E+01	J	7.23E+01		1.15E+00	1.37E+00	5.22E+01	3.22E+02	2.30E+03	N (a)		---
Polychlorinated biphenyls (PCB)														
Aroclor 1016	6 / 8	75	1.91E-02	J	1.16E+00	J	8.21E-03	9.24E-03	1.92E-01		3.90E-01	Y	8.14E-01	8.14E-01
Aroclor 1260	1 / 8	13	1.47E-01	J/J	1.47E-01	J/J	8.21E-03	9.24E-03	2.60E-02		2.20E-01	N (a)		---
Explosives														
Amino-2,6-dinitrotoluene, 4-	5 / 12	42	1.63E-01	J/U	3.13E+01		7.40E-02	8.00E+00	4.34E+00		1.50E+01	Y	1.10E+01	1.10E+01
Amino-4,6-dinitrotoluene, 2-	4 / 12	33	6.05E-01		5.01E+01		7.40E-02	8.00E+00	5.78E+00		1.50E+01	Y	2.17E+01	2.17E+01
Dinitrotoluene, 2,4- [g]	1 / 12	8	1.93E+00	/U	1.93E+00	/U	9.00E-02	9.70E+00	1.08E+00		7.20E-01	Y	4.56E+00	1.93E+00
Dinitrotoluene, 2,6- [g]	1 / 12	8	1.48E+00	/U	1.48E+00	/U	8.10E-02	8.70E+00	9.56E-01		7.20E-01	Y	4.06E+00	1.48E+00
Trinitrobenzene, 1,3,5-	1 / 12	8	1.96E-01	J	1.96E-01	J	7.40E-02	8.00E+00	8.72E-01		2.20E+02	N (a)		---
Trinitrotoluene, 2,4,6-	5 / 12	42	2.71E-01	J	1.20E+03		7.40E-02	8.00E+00	1.19E+02		3.60E+00	Y	3.11E+02	3.11E+02
Semivolatile Organic Compounds														
Acenaphthylene	1 / 8	13	1.11E-01	J	1.11E-01	J	4.97E-03	2.58E-02	2.10E-02		3.40E+02 [h]	N (a)		---
Anthracene	1 / 8	13	2.99E-01	J	2.99E-01	J	8.95E-03	4.65E-02	5.02E-02		1.70E+03	N (a)		---
Benzo(a)anthracene	3 / 8	38	4.70E-02	J	1.54E+00		2.72E-02	1.41E-01	2.37E-01		1.50E-01	Y	1.17E+00	1.17E+00
Benzo(a)pyrene	2 / 8	25	5.30E-02	J	1.18E+00		2.72E-02	1.41E-01	1.89E-01		1.50E-02	Y	1.01E+00	1.01E+00
Benzo(b)fluoranthene	3 / 8	38	7.13E-02	J	2.00E+00		6.90E-02	3.58E-01	3.51E-01		1.50E-01	Y	1.52E+00	1.52E+00
Benzo(ghi)perylene	1 / 8	13	6.90E-01		6.90E-01		1.01E-01	5.24E-01	2.31E-01		1.70E+02 [i]	N (a)		---
Benzo(k)fluoranthene	1 / 8	13	5.40E-01		5.40E-01		1.25E-01	6.52E-01	2.48E-01		1.50E+00	N (a)		---
Benzoic acid	2 / 8	25	5.37E-01		6.39E-01	QJ	1.01E-01	5.24E-01	2.79E-01		2.40E+04	N (a)		---
Bis(2-ethylhexyl)phthalate	1 / 8	13	8.69E-02	J	8.69E-02	J	3.83E-02	1.99E-01	6.58E-02		3.50E+01	N (a)		---

Table 2-4

Statistical Summary and Selection of Chemicals of Potential Concern in Surface Soil (0 to 1 Foot)
TNTA/WWTP1 Sewer Line
Plum Brook Ordnance Works, Sandusky, Ohio

			Range of Values (mg/kg)											
	Detection	Percent	Detected Concentrations				Method Detection Limits		Mean	BSC [a]	RBSC [b]		95% UCL [e]	EPC [f]
Chemical	Frequency	Detection	Minimum	VQ	Maximum	VQ	Minimum	Maximum	mg/kg	mg/kg	mg/kg	COPC? [c,d]	mg/kg	mg/kg
Chrysene	3 / 8	38	6.32E-02	J	1.36E+00		1.64E-02	8.53E-02	2.07E-01		1.50E+01	N (a)		---
Dibenz(a,h)anthracene	1 / 8	13	1.96E-01	J	1.96E-01	J	9.36E-02	4.86E-01	1.59E-01		1.50E-02	Y	3.69E-01	1.96E-01
Dinitrotoluene, 2,4-	3 / 8	38	5.63E-02	J	4.42E+00		1.45E-02	7.56E-02	5.77E-01		7.20E-01	Y	3.33E+00	3.33E+00
Dinitrotoluene, 2,6-	1 / 8	13	2.18E+00		2.18E+00		9.94E-03	5.17E-02	2.82E-01		7.20E-01	Y	3.60E+02	2.18E+00
Fluoranthene	4 / 8	50	2.61E-02	J/U	3.05E+00		8.95E-03	4.65E-02	4.28E-01		2.30E+02	N (a)		---
Indeno(1,2,3-cd)pyrene	1 / 8	13	1.06E+00		1.06E+00		1.34E-01	6.98E-01	3.25E-01		1.50E-01	Y	8.73E-01	8.73E-01
Nitroaniline, 3-	1 / 8	13	2.99E-01	J	2.99E-01	J	1.40E-02	7.30E-02	5.03E-02		6.10E+01 [j]	N (a)		---
Phenanthrene	3 / 8	38	4.27E-02	J	3.92E-01	J	1.01E-02	5.23E-02	7.88E-02		1.70E+02 [i]	N (a)		---
Pyrene	3 / 8	38	7.26E-02	J	2.22E+00		1.65E-02	8.59E-02	3.21E-01		1.70E+02	N (a)		---

COPC - Chemical of potential concern.
BSC - Background screening criterion.
RBSC - Risk-based screening concentration.
VQ - Validation qualifier.
J - The compound/analyte was positively identified; the reported result is the estimated concentration of the compound/analyte detected in the sample analyzed
Q - estimated due to instrument response below method criteria.
/U - The compound/analyte was positively identified in one sample averaged with a field duplicate that was nondetect (U qualified)
mg/kg - Milligrams per kilogram.

[a] IT Corporation (IT), 1998, *Site Investigation of Acid Areas* , Plum Brook Ordnance Works, Sandusky, Ohio, August.
[b] Risk-Based Screening Concentrations based on USEPA Regional Screening Level Table (November 2011) residential soil values and are based on a risk level of 1.0E-06 and a hazard index of 0.1.
[c] N - Chemical is not chosen as a COPC:
(a) - Maximum detected concentration is less than the RBSC.
(b) - Maximum detected concentration is less than the BSC.
(c) - Essential nutrient.
[d] Y - Chemical is chosen as COPC.
[e] 95% UCL (Upper confidence limit) determined using ProUCL Version 4.1 (U.S. Environmental Protection Agency (EPA), 2011, ProUCL Version 4.1, Office of Research and Development, Las Vegas, Nevada, and Technology Support Center, Atlanta, GA, May, on line at http://www.epa.gov/esd/tsc/TSC_form.htm.
[f] Concentration used in risk assessment equal to 95% UCL or maximum detected concentration, whichever is lower. The EPC used to evaluate lead using the Lead Model (see text for details) is equal to the arithmetic mean.
[g] Results from the semivolatiles analysis, rather than the explosives analysis, were used in the risk assessment. See Section 2.3 of the text for details
[h] RBSC based on acenaphthene.
[i] RBSC based on pyrene.
[j] RBSC based on 2-nitroaniline.

Table 2-5

Statistical Summary and Selection of Chemicals of Potential Concern in Subsurface Soil
TNTA/WWTP1 Sewer Line
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Detection Frequency	Percent Detection	Range of Values (mg/kg) Detected Concentrations Minimum	VQ	Maximum	VQ	Method Detection Limits Minimum	Maximum	Mean mg/kg	BSC [a] mg/kg	RBSC [b] mg/kg	COPC? [c,d]	95% UCL [e] mg/kg	EPC [f] mg/kg
Inorganics														
Aluminum	12 / 12	100	7.04E+03		1.03E+04		8.77E-01	1.99E+00	8.77E+03	1.55E+04	7.70E+03	N (b)		---
Antimony	12 / 12	100	2.52E-01	J	5.72E-01		2.05E-01	2.49E-01	3.98E-01	9.30E+00	3.10E+00	N (a)		---
Arsenic	12 / 12	100	1.12E+01	J	2.03E+01	J	4.10E-01	4.98E-01	1.41E+01	3.65E+01	3.90E-01	N (b)		---
Barium	12 / 12	100	1.62E+01		1.16E+02		8.20E-02	9.96E-02	4.65E+01	8.26E+02	1.50E+03	N (a)		---
Beryllium	12 / 12	100	6.56E+00	J	1.03E+01	J	8.20E-02	9.96E-02	7.84E+00	1.00E+00	1.60E+01	N (a)		---
Cadmium	6 / 12	50	2.34E-01	J	5.59E-01		2.05E-01	2.49E-01	2.76E-01	NA	7.00E+00	N (a)		---
Calcium	12 / 12	100	2.79E+03		4.58E+04		2.19E+00	4.98E+00	3.18E+04	5.23E+04	Nutrient	N (c)		---
Chromium	12 / 12	100	1.08E+01		1.59E+01		2.05E-01	2.49E-01	1.34E+01	2.90E+01	2.90E-01	N (b)		---
Cobalt	12 / 12	100	8.57E+00		1.73E+01		8.20E-02	1.78E-01	1.16E+01	1.16E+02	2.30E+00	N (b)		---
Copper	12 / 12	100	2.77E+01	J	3.70E+01		2.05E-01	2.49E-01	3.36E+01	5.62E+01	3.10E+02	N (a)		---
Iron	12 / 12	100	2.26E+04		6.56E+04		8.73E-01	4.52E+00	3.13E+04	2.34E+05	5.50E+03	N (b)		---
Lead	12 / 12	100	1.19E+01		1.64E+01		2.05E-01	2.49E-01	1.39E+01	4.86E+01	4.00E+02	N (a)		---
Magnesium	12 / 12	100	3.60E+03	J	1.08E+04	J/J	8.20E-01	9.96E-01	7.84E+03	1.04E+04	Nutrient	N (c)		---
Manganese	12 / 12	100	2.85E+02		8.33E+02		8.20E-02	9.96E-02	4.29E+02	3.51E+03	1.80E+02	N (b)		---
Mercury	10 / 12	83	1.27E-02	J	2.00E-02	J	9.52E-03	1.23E-02	1.55E-02	8.50E-02	2.30E+00	N (a)		---
Nickel	11 / 12	92	1.41E+01	J	3.97E+01		1.23E-01	1.49E-01	1.92E+01	5.51E+01	1.50E+02	N (a)		---
Potassium	12 / 12	100	7.75E+02		1.67E+03		1.02E+01	1.24E+01	1.15E+03	3.39E+03	Nutrient	N (c)		---
Selenium	4 / 12	33	4.53E-01	J	1.32E+00	J	4.10E-01	4.98E-01	5.60E-01	2.00E+00	3.90E+01	N (a)		---
Sodium	12 / 12	100	6.83E+01		1.88E+02		4.38E+00	9.96E+00	1.17E+02	NA	Nutrient	N (c)		---
Thallium	11 / 12	92	2.65E-01	J	6.97E-01		2.05E-01	2.49E-01	3.71E-01	1.30E+00	7.80E-02	N (b)		---
Vanadium	12 / 12	100	1.55E+01		2.70E+01		8.20E-02	9.96E-02	1.87E+01	4.09E+01	3.90E+01	N (a)		---
Zinc	12 / 12	100	5.30E+01	J	2.61E+02	J	1.02E+00	1.24E+00	8.99E+01	3.22E+02	2.30E+03	N (a)		---
Polychlorinated biphenyls (PCB)														
Aroclor 1016	1 / 12	8	5.53E-02	J	5.53E-02	J	7.27E-03	8.06E-03	1.17E-02		3.90E-01	N (a)		---
Aroclor 1221	4 / 12	33	1.75E-02	QJ	1.34E-01		7.27E-03	8.06E-03	3.19E-02		1.40E-01	N (a)		---
Explosives														
Amino-2,6-dinitrotoluene, 4-	5 / 38	13	2.09E-01	J	3.78E+00		5.60E-02	1.55E-01	2.73E-01		1.50E+01	N (a)		---
Amino-4,6-dinitrotoluene, 2-	5 / 38	13	1.49E-01	J	9.98E+00		5.60E-02	7.18E-01	4.83E-01		1.50E+01	N (a)		---
Dinitrotoluene, 2,4-	6 / 38	16	2.01E-01	J	3.25E+00		6.80E-02	1.55E-01	2.75E-01		7.20E-01	Y		3.25E+00
Dinitrotoluene, 2,6-	4 / 38	11	2.17E-01	J	5.29E-01		6.10E-02	1.60E-01	1.60E-01		7.20E-01	N (a)		---
Trinitrobenzene, 1,3,5-	7 / 38	18	9.11E-02	J	1.75E+00		5.60E-02	1.55E-01	2.82E-01		2.20E+02	N (a)		---
Trinitrotoluene, 2,4,6-	12 / 38	32	8.95E-02	J	6.90E+02	J	5.60E-02	3.89E+01	2.05E+01		3.60E+00	Y		6.90E+02
Semivolatile Organic Compounds														
Dinitrotoluene, 2,4-	3 / 12	25	8.18E-02	J	4.34E-01		1.29E-02	1.41E-02	6.18E-02		7.20E-01	N (a)		---
Dinitrotoluene, 2,6-	2 / 12	17	4.11E-02	J	1.28E-01	J	8.81E-03	9.64E-03	2.18E-02		7.20E-01	N (a)		---
Phenanthrene	5 / 12	42	5.04E-02	J	8.98E-02	J	8.92E-03	9.76E-03	3.31E-02		1.70E+02 h	N (a)		---

COPC - Chemical of potential concern.
BSC - Background screening criterion.
RBSC - Risk-based screening concentration.
VQ - Validation qualifier.

Table 2-5

Statistical Summary and Selection of Chemicals of Potential Concern in Subsurface Soil
TNTA/WWTP1 Sewer Line
Plum Brook Ordnance Works, Sandusky, Ohio

J - The compound/analyte was positively identified; the reported result is the estimated concentration of the compound/analyte detected in the sample analyzed
Q - Estimated due to instrument response below method criteria.
/ - Averaged samples; shwoing both qualifiers.
mg/kg - Milligrams per kilogram.

[a] IT Corporation (IT), 1998, *Site Investigation of Acid Areas*, Plum Brook Ordnance Works, Sandusky, Ohio, August.
[b] Risk-Based Screening Concentrations based on USEPA Regional Screening Level Table (November 2011) residential soil values and are based on a risk level of 1.0E-06 and a hazard index of 0.1.
[c] N - Chemical is not chosen as a COPC:
(a) - Maximum detected concentration is less than the RBSC.
(b) - Maximum detected concentration is less than the BSC.
(c) - Essential nutrient.
[d] Y - Chemical is chosen as COPC.
[e] 95% UCL (Upper confidence limit) determined using ProUCL Version 4.1 (U.S. Environmental Protection Agency [EPA], 2011, ProUCL Version 4.1, Office of Research and Development, Las Vegas, Nevada, and Technology Support Center, Atlanta, GA, May, on line at http://www.epa.gov/esd/tsc/TSC_form.htm).
[f] Concentration used in risk assessment equal to 95% UCL or maximum detected concentration, whichever is lower. The EPC used to evaluate lead using the Lead Model (see text for details) is equal to the arithmetic mean.
[g] RBSC based on acenaphthene.
[h] RBSC based on pyrene.
[i] RBSC based on 2-nitroaniline.

Table 2-6

Statistical Summary and Selection of Chemicals of Potential Concern in Total Soil
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Detection Frequency	Percent Detection	Range of Values (mg/kg) Detected Concentrations Minimum	VQ	Maximum	VQ	Method Detection Limits Minimum	Maximum	Mean mg/kg	BSC [a] mg/kg	RBSC [b] mg/kg	COPC? [c,d]	95% UCL [e] mg/kg	EPC [f] mg/kg
Inorganics														
Aluminum	20 / 20	100	7.04E+03		1.24E+04		8.77E-01	2.19E+00	8.90E+03	1.55E+04	7.70E+03	N (b)		---
Antimony	15 / 20	75	2.52E-01	J	5.72E-01		2.05E-01	2.74E-01	3.64E-01	9.30E+00	3.10E+00	N (a)		---
Arsenic	20 / 20	100	4.80E+00	J	2.03E+01	J	4.10E-01	5.48E-01	1.12E+01	3.65E+01	3.90E-01	N (b)		---
Barium	20 / 20	100	1.62E+01		1.16E+02		8.20E-02	1.10E-01	4.99E+01	8.26E+02	1.50E+03	N (a)		---
Beryllium	20 / 20	100	5.22E+00	J	1.03E+01	J	8.20E-02	1.10E-01	7.22E+00	1.00E+00	1.60E+01	N (a)		---
Cadmium	8 / 20	40	2.34E-01	J	5.59E-01		2.05E-01	2.74E-01	2.77E-01	NA	7.00E+00	N (a)		---
Calcium	20 / 20	100	2.79E+03		4.58E+04		2.19E+00	5.48E+00	2.11E+04	5.23E+04	Nutrient	N (c)		---
Chromium	20 / 20	100	1.70E+00		1.65E+01		2.05E-01	2.74E-01	1.28E+01	2.90E+01	2.90E-01	N (b)		---
Cobalt	20 / 20	100	4.19E+00		1.73E+01		8.20E-02	2.03E-01	9.41E+00	1.16E+02	2.30E+00	N (b)		---
Copper	20 / 20	100	1.54E+01		3.70E+01		2.05E-01	2.74E-01	2.84E+01	5.62E+01	3.10E+02	N (a)		---
Iron	20 / 20	100	1.46E+04		6.56E+04		8.73E-01	4.52E+00	2.61E+04	2.34E+05	5.50E+03	N (b)		---
Lead	20 / 20	100	1.03E+01		2.83E+01		2.05E-01	2.74E-01	1.49E+01	4.86E+01	4.00E+02	N (a)		---
Magnesium	20 / 20	100	1.61E+03	J	1.08E+04	JJ	8.20E-01	1.10E+00	5.64E+03	1.04E+04	Nutrient	N (c)		---
Manganese	20 / 20	100	1.37E+02		8.33E+02		8.20E-02	1.10E-01	3.39E+02	3.51E+03	1.80E+02	N (b)		---
Mercury	18 / 20	90	1.27E-02	J	4.43E-01		9.52E-03	1.29E-02	4.57E-02	8.50E-02	2.30E+00	N (a)		---
Nickel	19 / 20	95	2.68E+00	J	3.97E+01		1.23E-01	1.64E-01	1.57E+01	5.51E+01	1.50E+02	N (a)		---
Potassium	20 / 20	100	4.61E+02		1.67E+03		1.02E+01	1.37E+01	9.38E+02	3.39E+03	Nutrient	N (c)		---
Selenium	7 / 20	35	4.53E-01	J	1.32E+00	J	4.10E-01	5.48E-01	5.48E-01	2.00E+00	3.90E+01	N (a)		---
Sodium	20 / 20	100	3.11E+01		1.88E+02		4.38E+00	1.10E+01	9.13E+01	NA	Nutrient	N (c)		---
Thallium	12 / 20	60	2.65E-01	J	6.97E-01		2.05E-01	2.74E-01	3.31E-01	1.30E+00	7.80E-02	N (b)		---
Vanadium	20 / 20	100	1.55E+01		2.70E+01		8.20E-02	1.10E-01	1.99E+01	4.09E+01	3.90E+01	N (a)		---
Zinc	20 / 20	100	3.40E+01	J	2.61E+02	J	1.02E+00	1.37E+00	7.49E+01	3.22E+02	2.30E+03	N (a)		---
Polychlorinated biphenyls (PCB)														
Aroclor 1016	7 / 20	35	1.91E-02	J	1.16E+00	J	7.27E-03	9.24E-03	8.37E-02		3.90E-01	Y	2.31E-01	2.31E-01
Aroclor 1221	4 / 20	20	1.75E-02	QJ	1.34E-01		7.27E-03	9.24E-03	2.26E-02		1.40E-01	N (a)		---
Aroclor 1260	1 / 20	5	1.47E-01	JJ	1.47E-01	JJ	7.27E-03	9.24E-03	1.51E-02		2.20E-01	N (a)		---
Explosives														
Amino-2,6-dinitrotoluene, 4-	10 / 50	20	1.63E-01	J/U	3.13E+01		5.60E-02	8.00E+00	1.25E+00		1.50E+01	Y	2.51E+00	2.51E+00
Amino-4,6-dinitrotoluene, 2-	9 / 50	18	1.49E-01	J	5.01E+01		5.60E-02	8.00E+00	1.75E+00		1.50E+01	Y	3.63E+00	3.63E+00
Dinitrotoluene, 2,4- [g]	7 / 50	14	2.01E-01	J	3.25E+00		6.80E-02	9.70E+00	4.68E-01		7.20E-01	Y	7.91E-01	7.91E-01
Dinitrotoluene, 2,6-	5 / 50	10	2.17E-01	J	1.48E+00	/U	6.10E-02	8.70E+00	3.51E-01		7.20E-01	Y	5.48E-01	5.48E-01
Trinitrobenzene, 1,3,5-	8 / 50	16	9.11E-02	J	1.75E+00		5.60E-02	8.00E+00	4.23E-01		2.20E+02	N (a)		---
Trinitrotoluene, 2,4,6-	17 / 50	34	8.95E-02	J	1.20E+03		5.60E-02	3.89E+01	4.42E+01		3.60E+00	Y	1.67E+02	1.67E+02
Semivolatile Organic Compounds														
Acenaphthylene	1 / 20	5	1.11E-01	J	1.11E-01	J	4.40E-03	2.58E-02	1.12E-02		3.40E+02 [h]	N (a)		---
Anthracene	1 / 20	5	2.99E-01	J	2.99E-01	J	7.93E-03	4.65E-02	2.51E-02		1.70E+03	N (a)		---
Benzo(a)anthracene	3 / 20	15	4.70E-02	J	1.54E+00		2.41E-02	1.41E-01	1.10E-01		1.50E-01	Y	5.11E-01	5.11E-01
Benzo(a)pyrene	2 / 20	10	5.30E-02	J	1.18E+00		2.41E-02	1.41E-01	9.10E-02		1.50E-02	Y	4.48E-01	4.48E-01
Benzo(b)fluoranthene	3 / 20	15	7.13E-02	J	2.00E+00		6.11E-02	3.58E-01	1.79E-01		1.50E-01	Y	6.71E-01	6.71E-01
Benzo(ghi)perylene	1 / 20	5	6.90E-01		6.90E-01		8.94E-02	5.24E-01	1.49E-01		1.70E+02 [i]	N (a)		---
Benzo(k)fluoranthene	1 / 20	5	5.40E-01		5.40E-01		1.11E-01	6.52E-01	1.69E-01		1.50E+00	N (a)		---
Benzoic acid	2 / 20	10	5.37E-01		6.39E-01	QJ	8.94E-02	5.24E-01	1.68E-01		2.40E+04	N (a)		---

Table 2-6

Statistical Summary and Selection of Chemicals of Potential Concern in Total Soil
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Detection Frequency	Percent Detection	Range of Values (mg/kg) Detected Concentrations Minimum	VQ	Maximum	VQ	Method Detection Limits Minimum	Maximum	Mean mg/kg	BSC [a] mg/kg	RBSC [b] mg/kg		COPC? [c,d]	95% UCL [e] mg/kg	EPC [f] mg/kg
Bis(2-ethylhexyl)phthalate	1 / 20	5	8.69E-02	J	8.69E-02	J	3.39E-02	1.99E-01	4.77E-02		3.50E+01		N (a)		---
Chrysene	3 / 20	15	6.32E-02	J	1.36E+00		1.45E-02	8.53E-02	9.20E-02		1.50E+01		N (a)		---
Dibenz(a,h)anthracene	1 / 20	5	1.96E-01	J	1.96E-01	J	8.29E-02	4.86E-01	1.16E-01		1.50E-02		Y	1.54E-01	1.54E-01
Dinitrotoluene, 2,4-	6 / 20	30	5.63E-02	J	4.42E+00		1.29E-02	7.56E-02	2.68E-01		7.20E-01		Y	1.31E+00	1.31E+00
Dinitrotoluene, 2,6- [j]	3 / 20	15	4.11E-02	J	2.18E+00		8.81E-03	5.17E-02	1.26E-01		7.20E-01		Y	3.73E-01	3.73E-01
Fluoranthene	4 / 20	20	2.61E-02	JU	3.05E+00		7.93E-03	4.65E-02	1.76E-01		2.30E+02		N (a)		---
Indeno(1,2,3-cd)pyrene	1 / 20	5	1.06E+00		1.06E+00		1.19E-01	6.98E-01	2.05E-01		1.50E-01		Y	4.37E-01	4.37E-01
Nitroaniline, 3-	1 / 20	5	2.99E-01	J	2.99E-01	J	1.24E-02	7.30E-02	2.80E-02		6.10E+01	k	N (a)		---
Phenanthrene	8 / 20	40	4.27E-02	J	3.92E-01	J	8.92E-03	5.23E-02	5.14E-02		1.70E+02	i	N (a)		---
Pyrene	3 / 20	15	7.26E-02	J	2.22E+00		1.46E-02	8.59E-02	1.38E-01		1.70E+02		N (a)		---

COPC - Chemical of potential concern.
BSC - Background screening criterion.
RBSC - Risk-based screening concentration.
VQ - Validation qualifier.
J - The compound/analyte was positively identified; the reported result is the estimated concentration of the compound/analyte detected in the sample analyzed
Q - Estimated due to instrument response below method criteria.
/U - The compound/analyte was positively identified in one sample averaged with a field duplicate that was nondetect (U qualified)
mg/kg - Milligrams per kilogram.

[a] IT Corporation (IT), 1998, *Site Investigation of Acid Areas*, Plum Brook Ordnance Works, Sandusky, Ohio, August.
[b] Risk-Based Screening Concentrations based on USEPA Regional Screening Level Table (November 2011) residential soil values and are based on a risk level of 1.0E-06 and a hazard index of 0.1.
[c] N - Chemical is not chosen as a COPC:
(a) - Maximum detected concentration is less than the RBSC.
(b) - Maximum detected concentration is less than the BSC.
(c) - Essential nutrient.
[d] Y - Chemical is chosen as COPC.
[e] 95% UCL (Upper confidence limit) determined using ProUCL Version 4.1 (U.S. Environmental Protection Agency [EPA], 2011, ProUCL Version 4.1, Office of Research and Development, Las Vegas, Nevada, and Technology Support Center, Atlanta, GA, May, on line at http://www.epa.gov/esd/tsc/TSC_form.htm).
[f] Concentration used in risk assessment equal to 95% UCL or maximum detected concentration, whichever is lower. The EPC used to evaluate lead using the Lead Model (see text for details) is equal to the arithmetic mean.
[g] Results from the semivolatiles analysis, rather than the explosives analysis, were used in the risk assessment. See Section 2.3 of the text for details
[h] RBSC based on acenaphthene.
[i] RBSC based on pyrene.
[k] RBSC based on 2-nitroaniline.
[j] Results from the explosives, rather than the semivolatiles analysis, was used in the risk assessment. See Section 2.3 of the text for details

Table 2-7

Statistical Summary and Selection of Chemicals of Potential Concern in Bedrock Groundwater
TTNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of values (µg/L) Detected Concentrations Minimum	VQ	Maximum	VQ	Reporting Limits Minimum	Maximum	Arithmetic Mean µg/L	BSC [a] µg/L	RBSC [b] µg/L	COPC? [c,d]	EPC [e] µg/L
Inorganics - Unfiltered													
Aluminum	3 / 3 [f]	100	7.04E+01	J	1.75E+03		1.10E+01	1.65E+01	7.52E+02	3.09E+02	1600	Y	1.75E+03
Arsenic	3 / 4	75	3.49E+01		7.07E+01	J/J	3.60E+00	7.20E+00	3.99E+01	7.40E+00	0.045	Y	7.07E+01
Barium	4 / 4	100	2.28E+02		1.55E+03		5.00E+00	5.00E+00	8.50E+02	1.18E+04	290	N (b)	---
Calcium	4 / 4	100	2.31E+05		6.89E+05		1.00E+02	2.00E+02	4.39E+05	3.16E+05	Nutrient	N (c)	---
Chromium	1 / 4	25	4.00E+00	J/J	4.00E+00	J/J	1.60E+00	1.60E+00	2.20E+00	NA	0.031	Y	4.00E+00
Copper	1 / 4	25	4.95E+00	U/J	4.95E+00	U/J	2.10E+00	2.10E+00	2.81E+00	1.98E+01	62	N (a)	---
Iron	2 / 4	50	6.77E+02		3.24E+03	J/J	2.30E+01	3.45E+01	9.91E+02	1.55E+03	1100	Y	3.24E+03
Magnesium	4 / 4	100	1.33E+05		4.99E+05		1.00E+02	1.50E+02	3.02E+05	2.17E+05	Nutrient	N (c)	---
Manganese	4 / 4	100	1.52E+01		5.06E+02		5.00E-01	7.50E-01	2.77E+02	6.36E+02	32	N (b)	---
Mercury	1 / 4	25	2.30E-01	J	2.30E-01	J	1.40E-01	1.40E-01	1.63E-01	NA	0.43	N (a)	---
Nickel	2 / 4	50	7.60E+00	J/J	7.90E+00	J	2.30E+00	2.30E+00	5.03E+00	8.60E+00	30	N (a)	---
Potassium	4 / 4	100	4.82E+04		1.37E+05	J/J	1.00E+02	5.00E+02	9.00E+04	1.16E+05	Nutrient	N (c)	---
Selenium	4 / 4	100	4.10E+00	J	2.93E+01	J/J	3.10E+00	6.20E+00	1.30E+01	NA	7.8	Y	2.93E+01
Sodium	4 / 4	100	3.34E+05		1.52E+06		5.00E+03	2.00E+04	8.86E+05	1.39E+06	Nutrient	N (c)	---
Vanadium	4 / 4	100	1.40E+00	J	4.00E+00	J/J	6.60E-01	9.80E-01	2.43E+00	NA	7.8	N (a)	---
Zinc	3 / 3 [f]	100	9.10E+00	J	1.51E+01	J/J	3.80E+00	3.80E+00	1.17E+01	5.01E+02	470	N (a)	---
Semivolatile Organic Compounds													
3-Methylphenol and 4-Methylpheno	2 / 4	50	2.80E+00	J	4.05E+00	J/J	9.55E-01	3.90E+00	2.93E+00		67	N (a)	---
Chloro-3-methylphenol, 4-	1 / 4	25	9.80E+00	J	9.80E+00	J	9.55E-01	3.90E+00	3.17E+00		110	N (a)	---
Dimethylphenol, 2,4-	4 / 4	100	3.20E+00	J	9.65E+00		1.15E+00	4.70E+00	6.11E+00		27	N (a)	---
Methylnaphthalene, 2-	4 / 4	100	9.70E+00		3.38E+01		9.55E-01	3.90E+00	1.95E+01		2.7	Y	3.38E+01
Methylphenol, 2-	3 / 4	75	1.20E+00	J	6.35E+00		9.55E-01	3.90E+00	4.06E+00		72	N (a)	---
Naphthalene	4 / 4	100	1.30E+01		3.20E+01		9.55E-01	3.90E+00	2.09E+01		0.14	Y	3.20E+01
Phenol	1 / 4	25	1.03E+00	J/U	1.03E+00	J/U	9.55E-01	3.90E+00	1.71E+00		450	N (a)	---

Table 2-7

Statistical Summary and Selection of Chemicals of Potential Concern in Bedrock Groundwater
TTNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of values (µg/L) Detected Concentrations Minimum	VQ	Maximum	VQ	Reporting Limits Minimum	Maximum	Arithmetic Mean µg/L	BSC [a] µg/L	RBSC [b] µg/L	COPC? [c,d]	EPC [e] µg/L
Volatile Organic Compounds													
Acetone	2 / 3 [f]	67	1.06E+02	J	1.35E+02	J/J	1.00E+01	1.00E+02	1.14E+02		1200	N (a)	---
Benzene	4 / 4	100	1.23E+01		1.47E+02		4.00E-01	4.00E+00	7.25E+01		0.39	Y	1.47E+02
Butanone, 2-	1 / 4	25	3.35E+01		3.35E+01		2.00E+00	2.00E+01	2.09E+01		490	N (a)	---
Carbon disulfide	2 / 4	50	4.05E+00	U/J	6.50E+00	J	4.00E-01	4.00E+00	3.24E+00		72	N (a)	---
Chloroform	1 / 4	25	1.53E+01		1.53E+01		2.80E-01	2.80E+00	4.95E+00		0.19	Y	1.53E+01
Chloromethane	1 / 4	25	4.31E+02		4.31E+02		3.10E+00	6.10E+00	1.11E+02		19	Y	4.31E+02
Dichloropropene, trans-1,3-	1 / 4	25	2.90E+00		2.90E+00		2.10E-01	2.10E+00	2.05E+00		0.41	Y	2.90E+00
Ethylbenzene	4 / 4	100	1.28E+02		1.52E+02		2.20E+00	4.30E+00	1.45E+02		1.3	Y	1.52E+02
Toluene	4 / 4	100	3.52E+02		6.06E+02	J	1.80E+00	3.50E+00	4.68E+02		86	Y	6.06E+02
Xylenes, total	4 / 4	100	6.80E+02		8.12E+02		5.80E+00	1.20E+01	7.36E+02		19	Y	8.12E+02
General Chemistry													
Chloride	4 / 4	100	1.86E+04		5.24E+06	J/J	1.00E+03	1.00E+05	2.61E+06		Nutrient	N (c)	---
Cyanide, total	1 / 3 [f]	33	4.10E+01	J	4.10E+01	J	5.00E+00	2.50E+01	2.37E+01		31	Y	4.10E+01
Nitrate-Nitrite	3 / 4	75	9.30E+01	J	1.50E+03		3.00E+01	3.70E+02	5.35E+02		1000 [h]	Y	1.50E+03
Sulfate	3 / 4	75	2.10E+03	J	4.23E+04		1.00E+03	1.00E+05	4.05E+04		250,000 [i]	N (a)	---

BSC - Background screening concentration.
COPC - Chemical of potential concern.
RBSC - Risk-based screening concentration.
µg/L - Micrograms per liter.
VQ - Validation qualifier.
J - The compound/analyte was positively identified; the reported result is the estimated concentration of the compound/analyte detected in the sample analyzed
/U - The compound/analyte was positively identified in one sample averaged with a field duplicate that was nondetect (U qualified)

[a] Shaw Environmental, Inc. (Shaw), 2005, *2004 Groundwater Data Summary and Evaluation Report*, Final, Former Plum Brook Ordnance Works, Sandusky, Ohio, April.
[b] Risk-Based Screening Concentrations based on EPA Regional Screening Level Table (November 2011) tap water values and are based on a risk level of 1.0E-06 and a hazard index of 0.1.
[c] N - Chemical is not chosen as a COPC:
(a) - Maximum detected concentration is less than the RBSC.
(b) - Maximum detected concentration is less than the BSC.
(c) - Essential nutrient.
[d] Y - Chemical is chosen as COPC.
[e] Exposure point concentration (EPC) used in risk assessment equal to maximum detected concentration.
[f] Some samples were excluded from the data set because of blank contamination.
[g] Screening criteria for lead based on the action level of 15 µg/L (EPA, 1996, *Drinking Water Regulations and Health Advisories*, Office of Water, Washington, D.C., October).
[h] Because no Regional Screening Level exists for nitrate-nitrite, 0.1 X the nitrate-nitrite MCL (10 mg/L) is used for screening
[i] U.S. Environmental Protection Agency (EPA), 2009, *2009 Edition of the Drinking Water Standards and Health Advisories*, Office of Water, October, EPA 822-R-09-011.

Table 2-8

Statistical Summary and Selection of Chemicals of Potential Concern in Overburden Groundwater
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of values (µg/L) Detected Concentrations Minimum	VQ	Maximum	VQ	Reporting Limits Minimum	Maximum	Arithmetic Mean µg/L	BSC [a] µg/L	RBSC [b] µg/L	COPC? [c,d]	95% UCL [e] µg/L	EPC [f] µg/L
Inorganics - Unfiltered														
Aluminum	5 / 5	100	1.12E+02	J	4.97E+02		1.10E+01	1.10E+01	2.79E+02	3.09E+02	1600	N (a)		---
Barium	5 / 5	100	1.54E+01	J	1.26E+02	J	5.00E+00	5.00E+00	8.02E+01	1.18E+04	290	N (a)		---
Calcium	5 / 5	100	5.25E+04		2.78E+05		1.00E+02	1.00E+02	1.47E+05	3.16E+05	Nutrient	N (c)		---
Cobalt	3 / 5	60	4.60E+00	J	2.18E+01	J	8.30E-01	8.30E-01	7.29E+00	1.21E+01	0.47	Y	1.66E+01	1.66E+01
Iron	3 / 5	60	5.20E+02		7.37E+02	J	2.30E+01	2.30E+01	3.74E+02	1.55E+03	1100	N (a)		---
Lead	1 / 5	20	2.70E+00	J	2.70E+00	J	2.00E+00	2.00E+00	2.14E+00	NA	15 [h]	N (a)		---
Magnesium	5 / 5	100	1.35E+04		1.37E+05		1.00E+02	1.00E+02	8.51E+04	2.17E+05	Nutrient	N (c)		---
Manganese	5 / 5	100	1.11E+02		4.01E+02		5.00E-01	5.00E-01	2.32E+02	6.36E+02	32	N (b)		---
Nickel	4 / 5	80	2.40E+00	J	7.38E+01		2.30E+00	2.30E+00	2.72E+01	8.60E+00	30	Y	5.63E+01	5.63E+01
Potassium	5 / 5	100	3.89E+03	J	1.01E+05	J	1.00E+02	2.00E+02	5.03E+04	1.16E+05	Nutrient	N (c)		---
Selenium	2 / 5	40	4.70E+00	J	6.70E+00	J	3.10E+00	3.10E+00	4.14E+00	NA	7.8	N (a)		---
Sodium	5 / 5	100	8.98E+03	J	6.77E+05		5.00E+02	1.00E+04	3.13E+05	1.39E+06	Nutrient	N (c)		---
Thallium	1 / 5	20	4.40E+00	J	4.40E+00	J	3.40E+00	3.40E+00	3.60E+00	NA	0.016	Y	4.06E+00	4.06E+00
Vanadium	4 / 5	80	9.90E-01	J	1.70E+00	J	6.60E-01	6.60E-01	1.11E+00	NA	7.8	N (a)		---
Zinc	2 / 4 [g]	50	8.10E+00	J	1.34E+01	J	3.80E+00	3.80E+00	7.28E+00	5.01E+02	470	N (a)		---
Volatile Organic Compounds														---
Carbon disulfide	1 / 5	20	1.00E+00	J	1.00E+00	J	4.00E-01	4.00E-01	5.20E-01		72	N (a)		---
Ethylbenzene	1 / 5	20	5.70E-01	J	5.70E-01	J	4.30E-01	4.30E-01	4.58E-01		1.3	N (a)		---
Toluene	1 / 5	20	1.00E+00		1.00E+00		3.50E-01	3.50E-01	4.80E-01		86	N (a)		---
Xylenes, total	1 / 5	20	2.10E+00	J	2.10E+00	J	1.20E+00	1.20E+00	1.38E+00		19	N (a)		---
General Chemistry														---
Chloride	5 / 5	100	1.13E+04		1.72E+06	J	1.00E+03	5.00E+04	7.05E+05		Nutrient	N (c)		---
Cyanide, total	1 / 4 [g]	25	1.60E+01		1.60E+01		5.00E+00	5.00E+00	7.75E+00		31	N (a)		---
Nitrate-Nitrite	3 / 5	60	3.60E+01	J	4.50E+01	J	3.00E+01	3.70E+02	1.04E+02		1000 [i]	N (a)		---
Sulfate	5 / 5	100	8.50E+03		1.27E+06		1.00E+03	2.50E+04	2.72E+05		250,000 [j]	Y	1.36E+06	1.27E+06

BSC - Background screening concentration.
COPC - Chemical of potential concern.
RBSC - Risk-based screening concentration.
µg/L - Micrograms per liter.
VQ - Validation qualifier.
J - The compound/analyte was positively identified; the reported result is the estimated concentration of the compound/analyte detected in the sample analyzed

[a] Shaw Environmental, Inc. (Shaw), 2005, *2004 Groundwater Data Summary and Evaluation Report*, Final, Former Plum Brook Ordnance Works, Sandusky, Ohio, April.
[b] Risk-Based Screening Concentrations based on EPA Regional Screening Level Table (November 2011) tap water values and are based on a risk level of 1.0E-06 and a hazard index of 0.1.
[c] N - Chemical is not chosen as a COPC:
(a) - Maximum detected concentration is less than the RBSC.

Table 2-8

Statistical Summary and Selection of Chemicals of Potential Concern in Overburden Groundwater
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

(b) - Maximum detected concentration is less than the BSC.
(c) - Essential nutrient.
[d] Y - Chemical is chosen as COPC.
[e] 95% UCL (Upper confidence limit) determined using ProUCL Version 4.1 (U.S. Environmental Protection Agency [EPA], 2011, ProUCL Version 4.1, Office of Research and Development, Las Vegas, Nevada, and Technology Support Center, Atlanta, GA, May, on line at http://www.epa.gov/esd/tsc/TSC_form.htm).
[f] Concentration used in risk assessment equal to 95% UCL or maximum detected concentration, whichever is lower.
[g] Some samples were excluded from the data set because of blank contamination.
[n] Screening criteria for lead based on the action level of 15 µg/L (EPA, 1996, *Drinking Water Regulations and Health Advisories*, Office of Water, Washington, D.C., October).
i Because no Regional Screening Level exists for nitrate-nitrite, 0.1 X the nitrate-nitrite MCL (10 mg/L) is used for screening.
j U.S. Environmental Protection Agency (EPA), 2009, *2009 Edition of the Drinking Water Standards and Health Advisories*, Office of Water, October, EPA 822-R-09-011.

Table 2-9

Statistical Summary and Selection of Chemicals of Potential Concern in Sediment
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

			Range of Values (mg/kg)										
	Detection	Percent	Detected Concentrations				Method Detection Limits		Mean	RBSC [a]		95% UCL [d]	EPC [e]
Chemical	Frequency	Detection	Minimum	VQ	Maximum	VQ	Minimum	Maximum	mg/kg	mg/kg	COPC? [b,c]	mg/kg	mg/kg
Polychlorinated biphenyls													
Aroclor 1254	5 / 6	83	4.09E-02		2.15E-01		1.00E-02	1.40E-02	9.92E-02	1.10E-01	Y	1.69E-01	1.69E-01

RBSC - Risk-based screening concentration.
COPC - Chemical of potential concern.
mg/kg - Milligrams per kilogram.
VQ - Validation qualifier.

[a] Risk-Based Screening Concentrations based on EPA Regional Screening Level Table (November 2011) residential soil and are based on a risk level of 1.0E-06 and a hazard index of 1.
[b] N - Chemical is not chosen as a COPC:
(a) - Maximum detected concentration is less than the RBSC.
[c] Y - Chemical is chosen as COPC.
[d] 95% UCL determined using ProUCL Version 4.1 (U.S. Environmental Protection Agency [EPA], 2011, ProUCL Version 4.1, Office of Research and Development, Technology Support Center Characterization and Monitoring Branch, Las Vegas, Nevada, February, on line at http://www.epa.gov/esd/tsc/form.htm).
[e] Concentration used in risk assessment equal to 95% UCL or maximum detected concentration, whichever is lower.

Table 3-1

Receptor/Exposure Scenarios
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Source Medium	Model	Exposure Medium	Exposure Route
Groundskeeper – Current			
Surface Soil	None	Soil	Incidental Ingestion
			Dermal Contact
	Dust Emissions Based on Activity	Ambient Air	Inhalation
	Volatilization from Soil	Ambient Air	Inhalation[a]
Subsurface Soil	Not Quantified[b]		
Groundwater	Not Quantified[c]		
Surface Water	Not Quantified[b]		
Sediment	Not Quantified[b]		
Groundskeeper – Future			
Total Soil[d]	None	Soil	Incidental Ingestion
			Dermal Contact
	Dust Emissions Based on Activity	Ambient Air	Inhalation
	Volatilization from Soil	Ambient Air	Inhalation
Groundwater	None	Tap Water	Ingestion
			Dermal Contact
Surface Water	Not Quantified[b]		
Sediment	Not Quantified[b]		
Indoor Worker – Future[c]			
Surface Soil	None	Soil	Incidental Ingestion
			Dermal Contact[a]
	Dust Emissions; Volatilization	Indoor Air	Inhalation[a]
Subsurface Soil	Volatilization from Soil	Indoor Air	Inhalation
Groundwater	None	Tap Water	Ingestion
			Dermal Contact
Surface Water	Not Quantified[b]		
Sediment	Not Quantified[b]		

Table 3-1

Receptor/Exposure Scenarios
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Source Medium	Model	Exposure Medium	Exposure Route
Construction Worker – Current/Future			
Total Soil	None	Soil	Incidental Ingestion
			Dermal Contact
	Dust Emissions Based on Activity	Ambient Air	Inhalation
	Volatilization from Soil	Ambient Air	Inhalation
Groundwater	Not Quantified[b]		
Surface Water	None	Surface Water	Dermal Contact
	Volatilization from Water	Ambient Air	Inhalation[a]
Sediment	None	Sediment	Incidental Ingestion
			Dermal Contact
On-Site Resident – Future			
Total Soil[d]	None	Soil	Incidental Ingestion
			Dermal Contact
	Dust Emissions Based on Wind Erosion	Ambient Air	Inhalation
	Volatilization from Soil	Ambient Air	Inhalation
Subsurface Soil	Volatilization from Soil	Indoor Air	Inhalation
Groundwater	None	Tap Water	Ingestion
			Dermal Contact
	Volatilization from Water	Indoor Air	Inhalation
Surface Water	None	Surface Water	Dermal Contact
	Volatilization from Water	Ambient Air	Inhalation[a]
Sediment	None	Sediment	Incidental Ingestion
			Dermal Contact

Table 3-1

Receptor/Exposure Scenarios
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Source Medium	Model	Exposure Medium	Exposure Route
Hunter – Current/Future			
Surface Soil	None	Soil	Incidental Ingestion
			Dermal Contact
	Dust Emissions, Volatilization	Ambient Air	Inhalation[a]
	Biouptake	Venison	Venison Consumption
Subsurface Soil	Not Quantified[e]		
Surface Water	Not Quantified[b]		
Sediment	Not Quantified[b]		
Hunter's Child – Current/Future			
Surface Soil	Not Quantified[e]		
	Not Quantified[e]		
	Biouptake	Venison	Venison Consumption
Subsurface Soil	Not Quantified[e]		
Surface Water	Not Quantified[e]		
Sediment	Not Quantified[e]		

[a] Although theoretically complete, this pathway is not quantified as explained in text.

[b] Although contact with this medium is possible, exposure would be sporadic, rather than continuous or predictable. Such exposures do not lend themselves to evaluation under the chronic toxicity paradigm used in a baseline risk assessment.

[c] Even though the mixing of surface and subsurface soil described in footnote "d" might otherwise be applicable, this receptor was selected primarily to evaluate exposure to indoor air resulting from subsurface soil contamination. Surface soil was used for direct contact exposure to avoid potential "double counting" of contaminants in subsurface soil (refer to Section 3.1.3.2 of text).

[d] Total soil represents a mixture of surface and subsurface soil. This is assumed for future scenarios where excavation and regrading is assumed to take place.

[e] There is no plausible pathway for exposure.

Table 3-2

Variables Used to Estimate Potential Chemical Intakes and Contact Rates for Receptors
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Pathway Variable	Grounds-keeper	Construction Worker	On-Site Resident	Indoor Worker	Hunter and Hunter's Child
General Variables Used in All Intake Models					
Body weight (BW), kg	70[a]	70[a]	Child: 15[a] Adult: 70[a]	70[a]	Child: 15[a] Adult: 70[a]
Averaging time, noncancer (AT), days[b]	9125	183	Child: 2190 Adult: 8760	9125	Child: 2190 Adult: 10950
Averaging time, cancer (AT), days[b]	25550	25550	25550	25550	25550
Inhalation of VOCs and Resuspended Dust from Surface Soil, Total Soil or Subsurface Soil					
Fraction exposed to contaminated medium (FI_a), unitless	1[c]	1[c]	1[c]	NA	NA
Inhalation rate (IR_a), m^3/day	20[d]	20[d]	Child: 10[e] Adult: 20[d]	NA	NA
Exposure frequency (EF), days/year	250[d]	250[f]	350[a]	NA	NA
Exposure duration (ED), years	25[a]	0.5[f]	Child: 6[a] Adult: 24[a]	NA	NA
Inhalation of VOCs in Indoor Air from Subsurface Soil					
Fraction exposed to contaminated medium (FI_a), unitless	NA	NA	1[c]	1[c]	NA
Inhalation rate (IR_a), m^3/day	NA	NA	Child: 10[e] Adult: 20[d]	20[d]	NA
Exposure frequency (EF), days/year	NA	NA	350[a]	250[a]	NA
Exposure duration (ED), years	NA	NA	Child: 6[a] Adult: 24[a]	25[a]	NA
Incidental Ingestion of Soil					
Fraction exposed to contaminated medium (FI_{so}), unitless	1[c]	1[c]	0.9[g]	1[c]	1[c]

Table 3-2

Variables Used to Estimate Potential Chemical Intakes and Contact Rates for Receptors
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Pathway Variable	Grounds-keeper	Construction Worker	On-Site Resident	Indoor Worker	Hunter and Hunter's Child
Soil incidental ingestion rate (IR_{so}), mg/day	100[a]	330[a]	Child: 200[a] Adult: 100[a]	50[a]	Child: NA Adult: 100[a]
Exposure frequency (EF), days/year	250[d]	250[a]	350[a]	250[a]	14[d]
Exposure duration (ED), years	25[a]	0.5[f]	Child: 6[a] Adult: 24[a]	25[a]	30[a]
Dermal Contact with Soil					
Fraction exposed to contaminated medium (FI_{so}), unitless	1[c]	1[c]	1[c]	NA	1[c]
Body surface area exposed to soil (SA_{so}), cm^2	3,300[h]	3,300[h]	Child: 2,800[h] Adult: 5,700[h]	NA	Child: NA Adult: 3,300[h,i]
Soil-to-skin adherence factor (AF_{so}), mg/cm^2	0.2[h]	0.3[h]	Child: 0.2[h] Adult: 0.07[h]	NA	0.2[h,i]
Dermal absorption factor (ABS), unitless	csv	csv	csv	NA	csv
Exposure frequency (EF), days/year	250[d]	250[a]	350[a]	NA	14[i]
Exposure duration (ED), years	25[a]	0.5[f]	Child: 6[a] Adult: 24[a]	NA	30[a]
Inhalation of VOCs from Groundwater					
Exposure time (ET), hours/day	NA	NA	24[j]	NA	NA
Inhalation rate (IR_a), m^3/hour	NA	NA	Child: 0.416[e] Adult: 0.833[e]	NA	NA
Exposure frequency (EF), days/year	250[d]	NA	350[a]	250[a]	NA

Table 3-2

Variables Used to Estimate Potential Chemical Intakes and Contact Rates for Receptors
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Pathway Variable	Grounds-keeper	Construction Worker	On-Site Resident	Indoor Worker	Hunter and Hunter's Child
Drinking Water Ingestion of Groundwater					
Fraction exposed to contaminated medium (Fl_{gw}), unitless	1[c]	NA	1[c]	1[c]	NA
Drinking water ingestion rate (IR_{gw}), L/day	1[d]	NA	Child: 1[e] Adult: 2[d]	1[d]	NA
Exposure frequency (EF), days/year	250[d]	NA	350[a]	250[a]	NA
Dermal Contact with Groundwater					
Fraction exposed to contaminated medium (Fl_{gw}), unitless	1[c]	NA	1[c]	1[c]	NA
Body surface area exposed to water (SA_{gw}), cm^2	3,300[h,k]	NA	Child: 6,600[l] Adult: 20,000[l]	3,300[l]	NA
Permeability coefficient (PC), cm/hour	csv	NA	csv	csv	NA
Exposure time (ET_{gw}), hours/day	1[c]	NA	Child: 0.333[l] Adult: 0.2[l]	1[c]	NA
Exposure frequency (EF), days/year	250[d]	NA	350[d]	250[a]	NA
Incidental Ingestion of Sediment					
Fraction exposed to contaminated medium (Fl_{sd}), unitless	NA	1[c]	0.1[g]	NA	NA
Sediment incidental ingestion rate (IR_{sd}), mg/day	NA	330[a]	Child: 200[a] Adult: 100[a]	NA	NA
Exposure frequency (EF), days/year	NA	250[f]	350[a]	NA	NA
Exposure duration (ED), years	NA	0.5[f]	Child: 6[a] Adult: 24[a]	NA	NA

Table 3-2

Variables Used to Estimate Potential Chemical Intakes and Contact Rates for Receptors
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Pathway Variable	Grounds-keeper	Construction Worker	On-Site Resident	Indoor Worker	Hunter and Hunter's Child
Dermal Contact with Sediment					
Fraction exposed to contaminated medium (FI_{sd}), unitless	NA	1[f]	0.1[g]	NA	NA
Body surface area exposed to sediment (SA_{sd}), cm^2	NA	3,300[h]	Child: 2,800[h] Adult: 5,700[h]	NA	NA
Sediment-to-skin adherence factor (AF_{sd}), mg/cm^2	NA	0.3[h]	Child: 0.2[h] Adult: 0.07[h]	NA	NA
Dermal absorption factor (ABS), unitless	NA	csv	csv	NA	NA
Exposure frequency (EF), days/year	NA	250[f]	52[m]	NA	NA
Exposure duration (ED), years	NA	0.5[f]	Child: 6[a] Adult: 24[a]	NA	NA
Dermal Contact with Surface Water					
Body surface area exposed to surface water (SA_{sw}), cm^2	NA	3,300[n]	Child: 2,800[n] Adult: 7,000[o]	NA	NA
Permeability coefficient (PC), cm/hour	NA	csv	csv	NA	NA
Exposure time (ET_{sw}), hour/day	NA	4[f]	3[m]	NA	NA
Exposure frequency (EF), days/year	NA	250[f]	52[m]	NA	NA
Exposure duration (ED), years	NA	0.5[f]	Child: 6[a] Adult: 24[a]	NA	NA
Venison Consumption					
Venison ingestion rate (IR_v), kg/day	NA	NA	NA	NA	Child: 0.005[i] Adult: 0.013[p]
Exposure frequency (EF), days/year	NA	NA	NA	NA	350[a]
Exposure duration (ED), years	NA	NA	NA	NA	Child: 6[a] Adult: 30[q]

Table 3-2

Variables Used to Estimate Potential Chemical Intakes and Contact Rates for Receptors
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

[a] U.S. Environmental Protection Agency (EPA), 2002, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*, Office of Solid Waste and Emergency Response, Washington, D.C., 9355.4-24, December.

[b] For noncancer evaluation, calculated as the product of ED (years) x 365 days/year; for cancer evaluation, calculated as the product of 70 years (assumed human lifetime) x 365 days/year. Source: U.S. Environmental Protection Agency (EPA), 1989a, *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)*, Interim Final, Office of Emergency and Remedial Response, Washington, D.C., EPA/540/1-89/002.

[c] Default value which assumes 100 percent of exposure is to contaminated medium.

[d] U.S. Environmental Protection Agency (EPA), 1991, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual Supplemental Guidance, Standard Default Exposure Factors*, Interim Final, Office of Solid Waste and Emergency Response, OSWER Directive: 9285.603.

[e] U.S. Environmental Protection Agency (EPA), 2004a, *User's Guide and Background Technical Document for Region 9 Preliminary Remediation Goals (PRG) Table*, Region 9, San Francisco, California, October, <http://www.epa.gov/region09/waste/sfund /prg/files/04usersguide.pdf>.

[f] Assumed; see Section 3.1.3.4 of text for explanation.

[g] It is assumed that on days when the resident is visiting the ditches and is exposed to sediment that half of the daily exposure via dermal contact and ingestion are associated with the tributary (sediment FI=0.5) and half of the exposure is associated with soil (soil FI=0.5). The resident is assumed to be exposed to soil 350 days/year and to sediment 52 days/year. The FI values of 0.1 for sediment and 0.9 for soil are weighted average daily values as described in Section 3.1.3.5 of the text.

[h] U.S. Environmental Protection Agency (EPA), 2004b, *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part E - Supplemental Guidance for Dermal Risk Assessment)*, Final, Office of Superfund Remediation and Technology Innovation, Washington, D.C., EPA/540/R-99/005, July.

[i] Please see Section 3.1.3.7 of text for detailed explanation.

[j] The *Exposure Factors Handbook* (see reference h) indicates that the 90th percentile for the amount of time spent at a residence is more than 23 hours per day.

[k] Please see Section 3.1.3.2 of text for detailed explanation.

[l] U.S. Environmental Protection Agency (EPA), 1997, *Exposure Factors Handbook*, Final, National Center for Environmental Assessment, Washington, D.C., EPA/600/P-95/002Fa, August.

[m] Assumed; please see Section 3.1.3.5 of text for detailed explanation.

[n] Value for dermal soil exposure (EPA, 2004b) was selected as appropriate for exposure to this medium by this receptor; refer to Section 3.1.3.5 of text for detail.

[o] Value based on the Exposure Factors Handbook (EPA, 1997). See Section 3.1.3.5 of the text for detailed explanation.

[p] Please see Section 3.1.3.5 of the text for detailed explanation.

[q] Assumes deer are hunted for a 30-year duration.

csv – Chemical-specific value. NA – Pathway not applicable for receptor.

Table 3-3

Physical Properties of Site-Related Chemicals[a]
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical of Potential Concern	Soil-to-forage Biotransfer Factor B_p (unitless)	Biotransfer Factor for Beef B_b (days/kg)	Biotransfer Factor for Venison B_v (unitless)	Diffusivity In Air (D_i) (cm^2/second)	Soil Organic Carbon-Water Partition Coefficient K_{oc} (cm^3/g)	log K_{ow}	Absorption Fraction ABS (unitless)	Permeability Coefficient K_p (cm/hour)	*tau* (hour/event)	*t** (hour)	Fraction Absorbed from Water FA (unitless)	B (unitless)	Molecular Weight (g/mole)	Henry's Law Constant (atm-m^3/mole)
Metals														
Aluminum	NA	NA	NA	NA	1.50E+03	NA	NA	NA	NA	NA	NA	NA	26.98	NA
Arsenic	NA	NA	NA	NA	2.90E+01	NA	0.03	1.00E-03	NA	NA	NA	NA	74.92	NA
Chromium, Total	NA	NA	NA	NA	NA	NA	NA	1.00E-03	NA	NA	NA	NA	52	NA
Cobalt	NA	NA	NA	NA	4.50E+01	NA	NA	4.00E-04	NA	NA	NA	NA	58.93	NA
Iron	NA	NA	NA	NA	2.50E+01	NA	NA	1.00E-03	NA	NA	NA	NA	55.845	NA
Nickel	NA	NA	NA	NA	6.50E+01	NA	NA	2.00E-04	NA	NA	NA	NA	58.69	NA
Selenium	2.50E-02	1.50E-02	9.00E-05	NA	5.00E+00	NA	NA	1.00E-03	NA	NA	NA	NA	78.96	NA
Thallium	4.00E-04	4.00E-02	2.40E-04	NA	7.10E+01	NA	NA	1.00E-03	NA	NA	NA	NA	204.38	NA
Pesticides and PCBs														
Aroclor 1016	2.24E-02	1.00E-02	6.00E-05	4.69E-02	9.12E+04	5.60E+00	0.14	4.30E-01	11.3	47.9	0.5	3.2	257.9	2.90E-04
Aroclor 1254	6.78E-03	7.94E-02	4.76E-04	3.99E-02	1.00E+05	6.79E+00	0.14	4.30E-01	11.3	47.9	0.5	3.2	326.4	2.83E-04
Nitroaromatics														
Amino-2,6-dinitrotoluene, 4-	NA	NA	NA	5.61E-02	2.29E+02	1.84E+00	0.006	2.04E-03	1.33	3.2	1	0	197.15	1.62E-10
Amino-4,6-dinitrotoluene, 2-	NA	NA	NA	5.61E-02	2.29E+02	1.84E+00	0.009	2.04E-03	1.33	3.2	1	0	197.15	3.27E-11
Dinitrotoluene, 2,4-	NA	NA	NA	2.03E-01	2.87E+02	1.98E+00	0.102	3.10E-03	1.12	2.69	1	0	182.1	5.40E-08
Dinitrotoluene, 2,6-	NA	NA	NA	5.91E-02	2.87E+02	1.72E+00	0.099	2.10E-03	1.12	2.69	1	0	182.1	7.47E-07
Trinitrotoluene, 2,4,6-	NA	NA	NA	5.10E-02	1.77E+02	1.60E+00	0.032	9.64E-04	1.96	4.71	1	0	227.13	2.08E-08
Semivolatile Organic Compounds														
Benzo(a)anthracene	NA	NA	NA	5.10E-02	3.98E+05	5.66E+00	0.13	4.70E-01	2.03	8.53	1	2.8	228.3	3.34E-06
Benzo(a)pyrene	NA	NA	NA	4.30E-02	1.02E+06	6.10E+00	0.13	7.00E-01	2.69	11.67	1	4.3	252.3	4.57E-07
Benzo(b)fluoranthene	NA	NA	NA	2.26E-02	1.23E+06	6.12E+00	0.13	7.00E-01	2.77	12.03	1	4.3	252.3	6.57E-07
Dibenz(a,h)anthracene	NA	NA	NA	2.02E-02	4.74E+05	6.84E+00	0.13	1.50E+00	3.88	17.57	0.6	9.7	278.4	4.89E-07
Indeno(1,2,3-cd)pyrene	NA	NA	NA	1.90E-02	3.47E+06	6.58E+00	0.13	1.00E+00	3.78	16.83	0.6	6.7	276.3	1.60E-06
Methylnaphthalene, 2-	NA	NA	NA	6.97E-02	3.98E+03	3.86E+00	0.13	8.94E-02	0.657	1.58	1	0.41	142.2	5.18E-04
Naphthalene	NA	NA	NA	5.90E-02	2.00E+03	3.30E+00	0.13	4.70E-02	0.56	1.34	1	0.2	128.2	4.40E-04
Volatile Organic Compounds														
Benzene	NA	NA	NA	8.80E-02	5.89E+01	2.13E+00	NA	1.50E-02	0.29	0.7	1	0.1	78.1	5.55E-03
Chloroform	NA	NA	NA	1.04E-01	3.98E+01	1.97E+00	NA	6.80E-03	0.5	1.19	1	0	119.4	3.67E-03
Chloromethane (Methyl Chloride)	NA	NA	NA	1.39E-01	1.41E+01	9.10E-01	NA	3.30E-03	0.2	0.49	1	0	50.5	8.82E-03
Ethylbenzene	NA	NA	NA	7.50E-02	3.63E+02	3.15E+00	NA	4.90E-02	0.42	1.01	1	0.2	106.2	7.88E-03
Toluene	NA	NA	NA	8.70E-02	1.82E+02	2.73E+00	NA	3.10E-02	0.35	0.84	1	0.1	92.1	6.64E-03
trans-1,3-Dichloropropene	NA	NA	NA	6.26E-02	8.13E+01	2.00E+00	NA	4.30E-03	0.45	1.07	1	0	111	3.55E-03
Xylenes	NA	NA	NA	7.00E-02	4.07E+02	3.20E+00	NA	5.30E-02	0.42	1.01	1	0.2	106.2	7.34E-03
General Chemistry														
Cyanide, total	NA	NA	NA	NA	2.84E+00	NA	NA	1.00E-03	NA	NA	NA	NA	26.02	NA
Nitrate-Nitrite	3.00E+01	NA	NA	NA	NA	NA	NA	1.00E-03	NA	NA	NA	NA	NA	NA
Sulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

tau - Lag time associated with rate at which chemical crosses stratum corneum per event.
t* - Time for absorption across the stratum corneum to reach steady state ; equals 2.4 times tau.
B - Ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis
kg - Kilogram.
g - Gram.
atm-m^3 - Atmospheres per cubic meter.

[a] See Appendix C which provides references for these values.

Table 4-1

Summary of Toxicity Assessment [a]
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

(Page 1 of 2)

Chemical of Potential Concern	GAF	Weight of Evidence	Oral Slope Factor (mg/kg-day) $^{-1}$	Dermal Slope Factor (mg/kg-day) $^{-1}$	Weight of Evidence	Inhalation Unit Risk (µg/m^3) $^{-1}$	Inhalation Slope Factor (mg/kg-day) $^{-1}$
Metals							
Aluminum	NA	D	NA	NA	NA	NA	NA
Arsenic	1	A	1.50E+00	1.50E+00	A	4.30E-03	1.50E+01
Chromium, Total	0.013	D	NA	NA	A	1.20E-02	4.20E+01
Cobalt	1	ND	NA	NA	B	9.00E-03	3.20E+01
Iron	1	ND	NA	NA	ND	NA	NA
Nickel	0.04	D	NA	NA	A	2.40E-04	8.40E-01
Selenium	1	D	NA	NA	D	NA	NA
Thallium	1	D	NA	NA	D	NA	NA
Pesticides and PCBs							
Aroclor 1016	1	B2	7.00E-02	7.00E-02	B2	2.00E-05	7.00E-02
Aroclor 1254	1	B2	2.00E+00	2.00E+00	B2	5.70E-04	2.00E+00
Nitroaromatics							
Amino-2,6-dinitrotoluene, 4-	1	D	NA	NA	D	NA	NA
Amino-4,6-dinitrotoluene, 2-	1	D	NA	NA	D	NA	NA
Dinitrotoluene, 2,4-	1	B2	6.80E-01	6.80E-01	D	NA	NA
Dinitrotoluene, 2,6-	1	B2	6.80E-01	6.80E-01	D	NA	NA
Trinitrotoluene, 2,4,6-	1	C	3.00E-02	3.00E-02	C	NA	NA
Semivolatile Organic Compounds							
Benzo(a)anthracene	1	B2	7.30E-01	7.30E-01	B2	8.80E-05	3.10E-01
Benzo(a)pyrene	1	B2	7.30E+00	7.30E+00	B2	8.80E-04	3.10E+00
Benzo(b)fluoranthene	1	B2	7.30E-01	7.30E-01	B2	8.80E-05	3.10E-01
Dibenz(a,h)anthracene	1	B2	7.30E+00	7.30E+00	B2	8.80E-04	3.10E+00
Indeno(1,2,3-cd)pyrene	1	B2	7.30E-01	7.30E-01	B2	8.80E-05	3.10E-01
Methylnaphthalene, 2-	1	D	NA	NA	D	NA	NA
Naphthalene	1	C	ND	NA	C	3.40E-05	1.20E-01
Volatile Organic Compounds							
Benzene	1	A	5.50E-02	5.50E-02	A	7.80E-06	2.70E-02
Chloroform	1	B2	NC	NA	B2	ND	NC
Chloromethane (Methyl Chloride)	1	D	NA	NA	D	NA	NA
Ethylbenzene	1	D	NA	NA	D	NA	NA
Toluene	1	D	NA	NA	D	NA	NA
trans-1,3-Dichloropropene	1	B2	1.00E-01	1.00E-01	B2	4.00E-06	1.40E-02
Xylenes	1	D	NA	NA	D	NA	NA
General Chemistry							
Cyanide, total	1	D	NA	NA	D	NA	NA
Nitrate-Nitrite	NA	ND	NA	NA	NA	NA	NA
Sulfate	NA	NA	NA	NA	NA	NA	NA

mg/kg-day - Milligrams per kilogram-day.
µg/m^3 - Micrograms per cubic meter.
GAF - Gastrointestinal absorption factor.
NA - Not available or not applicable.
ND - No data or not determined.
NC - Noncancer value is regarded as protective of cancer effects in the Integrated Risk Information System evaluation (EPA, 2010).
[a] See Appendix C which provides references for these values.

Weight of Evidence (WOE) EPA Group:
A - Carcinogenic to humans
B - Likely to be carcinogenic to humans (includes both the former B1 and B2 probable human carcinogens as classified on IRIS)
C - Suggested evidence of carcinogenic potential
D - Inadequate evidence to assess carcinogenic potential

Table 4-1

Summary of Toxicity Assessment [a]
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

		Oral		Dermal	Reference	Inhalation	
Chemical of Potential Concern	GAF	Reference Dose mg/kg-day	Target Organs	Reference Dose mg/kg-day	Concentration mg/m^3	Reference Dose mg/kg-day	Target Organs
Metals							
Aluminum	NA	1.00E+00	CNS	NA	5.00E-03	1.40E-03	CNS
Arsenic	1	3.00E-04	S	3.00E-04	NA	NA	NA
Chromium, Total	0.013	2.10E-02	ND	2.70E-04	7.00E-04	2.03E-04	Lung
Cobalt	1	3.00E-04	Thyroid	3.00E-04	6.00E-06	1.70E-06	RT
Iron	1	7.00E-01	GI	NA	ND	NA	NA
Nickel	0.04	2.00E-02	RB/OW	8.00E-04	NA	NA	NA
Selenium	1	5.00E-03	Selenosis	5.00E-03	2.00E-02	7.00E-02	Eye/NS
Thallium	1	1.00E-05	Hair	1.00E-05	ND	NA	NA
Pesticides and PCBs							
Aroclor 1016	1	7.00E-05	F	7.00E-05	NA	NA	NA
Aroclor 1254	1	2.00E-05	IS	2.00E-05	ND	NA	NA
Nitroaromatics							
Amino-2,6-dinitrotoluene, 4-	1	2.00E-03	CNS,E,L	2.00E-03	ND	NA	NA
Amino-4,6-dinitrotoluene, 2-	1	2.00E-03	CNS,E,L	2.00E-03	ND	NA	NA
Dinitrotoluene, 2,4-	1	2.00E-03	CNS,E,L	2.00E-03	ND	NA	NA
Dinitrotoluene, 2,6-	1	1.00E-03	CNS,E,L	1.00E-03	ND	NA	NA
Trinitrotoluene, 2,4,6-	1	5.00E-04	L	5.00E-04	ND	NA	NA
Semivolatile Organic Compounds							
Benzo(a)anthracene	1	ND	NA	NA	ND	NA	NA
Benzo(a)pyrene	1	ND	NA	NA	ND	NA	NA
Benzo(b)fluoranthene	1	ND	NA	NA	ND	NA	NA
Dibenz(a,h)anthracene	1	ND	NA	NA	ND	NA	NA
Indeno(1,2,3-cd)pyrene	1	ND	NA	NA	ND	NA	NA
Methylnaphthalene, 2-	1	4.00E-03	RT	4.00E-03	ND	NA	NA
Naphthalene	1	2.00E-02	RB/OW	2.00E-02	3.00E-03	8.60E-04	RT
Volatile Organic Compounds							
Benzene	1	4.00E-03	IS	4.00E-03	3.00E-02	8.60E-03	BC
Chloroform	1	1.00E-02	L	1.00E-02	9.80E-02	2.80E-02	L
Chloromethane (Methyl Chloride)	1	ND	NA	NA	9.00E-02	2.60E-02	CNS
Ethylbenzene	1	1.00E-01	L,K	1.00E-01	1.00E+00	2.90E-01	F
Toluene	1	8.00E-02	K	8.00E-02	5.00E+00	1.40E+00	NA
trans-1,3-Dichloropropene	1	3.00E-02	Stomach Irritation	3.00E-02	2.00E-02	5.70E-03	NE
Xylenes	1	2.00E-01	RB/OW, Su	2.00E-01	1.00E-01	2.90E-02	CNS
General Chemistry							
Cyanide, total	1	6.00E-04	Repro	6.00E-04	8.00E-04	2.30E-04	Thyroid
Nitrate-Nitrite	NA	1.00E-01	E	1.00E-01	NA	NA	NA
Sulfate	NA	NA	NA	NA	NA	NA	NA

mg/kg-day - Milligrams per kilogram-day.
mg/m^3 - Milligrams per cubic meter.
GAF - Gastrointestinal absorption factor.
NA - Not available or not applicable.
ND - No data.
NC - Noncancer value is regarded as protective of cancer effects in the Integrated Risk Information System evaluation (EPA, 2010).
[a] See Appendix C which provides references for these values.

Target Organs: BC - blood cells; S - skin; GI - gastrointestinal; CNS - central nervous system; L - liver; F - fetus; NE - nasal epithelium; NS - nervous system; IS - immune system; RB/OW - reduced body/organ weight; SU - reduced survival; RT - respiratory tract; E - Erythrocyte.

Table 5-1

Summary of Risk for All Receptors
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

	Groundskeeper [a]		Construction Worker		Indoor Worker		Resident			Hunter		Hunter's Child	
	Total ILCR	Total HI	Total ILCR	Total HI	Total ILCR	Total HI	Total ILCR	Total Adult - HI	Total Child - HI	Total ILCR	Total HI	Total ILCR	Total HI
Bedrock Groundwater Use													
Exposure Media													
Surface Soil	1.36E-05	0.78	NE	NE	4.28E-06	0.32	NE	NE	NE	9.11E-07	0.044	2.28E-12	0.00001
Total Soil	6.51E-06	0.41	3.45E-07	1.2	NE	NE	2.17E-05	0.48	4.3	NE	NE	NE	NE
Groundwater	4.03E-04	4.0	NE	NE	4.03E-04	4.0	1.73E-03	12	27	NE	NE	NE	NE
Sediment	NE	NE	1.11E-08	0.04	NE	NE	5.64E-08	0.001	0.01	NE	NE	NE	NE
Surface Water	NE	NE	NA	NA	NE	NE	NA	NA	NA	NE	NE	NE	NE
Total ILCR or HI	**4.E-04**	**4**	**4.E-07**	**1**	**4.E-04**	**4**	**2.E-03**	**12**	**32**	**9.E-07**	**0.04**	**2.E-12**	**0.00001**
Overburden Groundwater Use													
Exposure Media													
Surface Soil	1.36E-05	0.78	NE	NE	4.28E-06	0.320	NE	NE	NE	9.11E-07	0.044	2.28E-12	0.00001
Total Soil	6.51E-06	0.4	3.45E-07	1.2	NE	NE	2.17E-05	0.48	4.3	NE	NE	NE	NE
Groundwater	NA	4.6	NE	NE	NA	4.6	NA	12.7	29.7	NE	NE	NE	NE
Sediment	NE	NE	1.11E-08	0.04	NE	NE	5.64E-08	0.001	0.01	NE	NE	NE	NE
Surface Water	NE	NE	NA	NA	NE	NE	NA	NA	NA	NE	NE	NE	NE
Total ILCR or HI	**7.E-06**	**5**	**4.E-07**	**1**	**4.E-06**	**5**	**2.E-05**	**13**	**34**	**9.E-07**	**0.04**	**2.E-12**	**0.00001**

HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - No chemicals of potential concern available for exposure evaluation; risk/hazard is regarded as negligible.
NE - Pathway not evaluated for this receptor.

Note:
[a] Total ILCR and total HI values for the groundskeeper reflect the respective totals for the future groundskeeper assumed to use either bedrock or overburden groundwater. The total ILCR and HI values for the current groundskeeper are simply those shown for surface soil. The current groundskeeper rounded ILCR is 1E-5 and the rounded HI is 0.8

Table 5-2

Summary of Risk for Receptors Excluding Exposure to Groundwater
WWTP1/TNTA Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

	Future Groundskeeper		Indoor Worker		Resident		
	Total ILCR	Total HI	Total ILCR	Total HI	Total ILCR	Total Adult - HI	Total Child - HI
Exposure Media							
Surface Soil	1.36E-05	0.78	4.28E-06	0.32	NE	NE	NE
Total Soil	6.51E-06	0.41	NE	NE	2.17E-05	0.48	4.34
Sediment	NE	NE	NE	NE	2.15E-06	0.004	0.04
Surface Water	NE	NE	NE	NE	NA	NA	NA
Total ILCR or HI	**7.E-06**	**0.4**	**4.E-06**	**0.3**	**2.E-05**	**0.5**	**4**

HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - No chemicals of potential concern available for exposure evaluation.
NE - Pathway not evaluated for this receptor.

Note:
The above receptors are those which were evaluated for groundwater exposure as shown in Table 5-1. Groundwater use is regarded as implausible because of insufficiently low yield and naturally poor quality.

Table 5-3

Summary of Risk for All Receptors Minus Potential Hot Spots [a]
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

	Groundskeeper [b]		Construction Worker		Indoor Worker		Resident			Hunter		Hunter's Child	
	Total ILCR	Total HI	Total ILCR	Total HI	Total ILCR	Total HI	Total ILCR	Total Adult - HI	Total Child - HI	Total ILCR	Total HI	Total ILCR	Total HI
Surface Soil	1.97E-07	NA	NE	NE	5.27E-08	NA	NE	NE	NE	1.32E-08	NA	NA	NA
Total Soil	4.75E-07	0.03	2.53E-08	0.08	NE	NE	1.60E-06	0.03	0.3	NE	NE	NE	NE
Sediment	NE	NE	1.11E-08	0.04	NE	NE	5.64E-08	0.001	0.01	NE	NE	NE	NE
Surface Water	NE	NE	NA	NA	NE	NE	NA	NA	NA	NE	NE	NE	NE
Total ILCR or HI	**5E-07**	**0.03**	**4E-08**	**0.1**	**5E-08**	**NA**	**2E-06**	**0.03**	**0.3**	**1E-08**	**NA**	**NA**	**NA**

HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - No chemicals of potential concern available for exposure evaluation; risk/hazard is regarded as negligible.
NE - Pathway not evaluated for this receptor.

[a] Includes all samples evaluated in Section 5.3 of the Risk Characterization except the soil samples associated with test pit locations TP-27 and TP-33. Please refer to Appendix F for data set, chemical of potential concern evaluation, and risk calculation spreadsheets. Sediment values are the same as those presented in Section 5.3 of the text.
[b] Total ILCR and total HI values for the groundskeeper shown on this line are for the future groundskeeper. The total ILCR and HI values for the current groundskeeper are simply those shown for surface soil. The current groundskeeper rounded ILCR is 2E-6 and the HI is regarded as negligible.

Table 5-4

Risk-Based Remediation Concentrations for Total Soil at the TP-27 Hot Spot
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical of Concern (COC)	Total Soil EPC (mg/kg)	ILCR at EPC[b]	Cancer-Based RBRC with ILCR at[c]: 1.E-06 (mg/kg)	Cancer-Based RBRC with ILCR at[c]: 1.E-05 (mg/kg)	HQ at EPC[d]	Noncancer-Based RBRC with HQ at[e]: 0.1 (mg/kg)	Noncancer-Based RBRC with HQ at[e]: 1 (mg/kg)
Residential-Based COCs/Values							
2,4,6-Trinitotoluene	167	7.86E-06	**21**	**212**	4.23	**3.9**	**39**

mg/kg - milligram(s) per kilogram; RBRC - risk-based remediation concentration; ILCR - incremental lifetime cancer risk; HQ - hazard quotient.

Notes:
[a]The chemicals of concern, exposure point concentrations (EPC), and associated values are based on the results for resident presented in Section 5.3.5 of the BHHRA text.
[b]Value shown is the ILCR at the EPC associated with this receptor for total soil.
[c]Values shown are the RBRCs that are back-calculated from the BHHRA, assuming a cancer risk level of 1E-6 or 1E-5.
[d]Value shown is the HQ at the EPC associated with this receptor for total soil.
[e]Values shown are the RBRCs that are back-calculated from the BHHRA, assuming a noncancer HQ of 0.1 or 1.0.

FIGURES

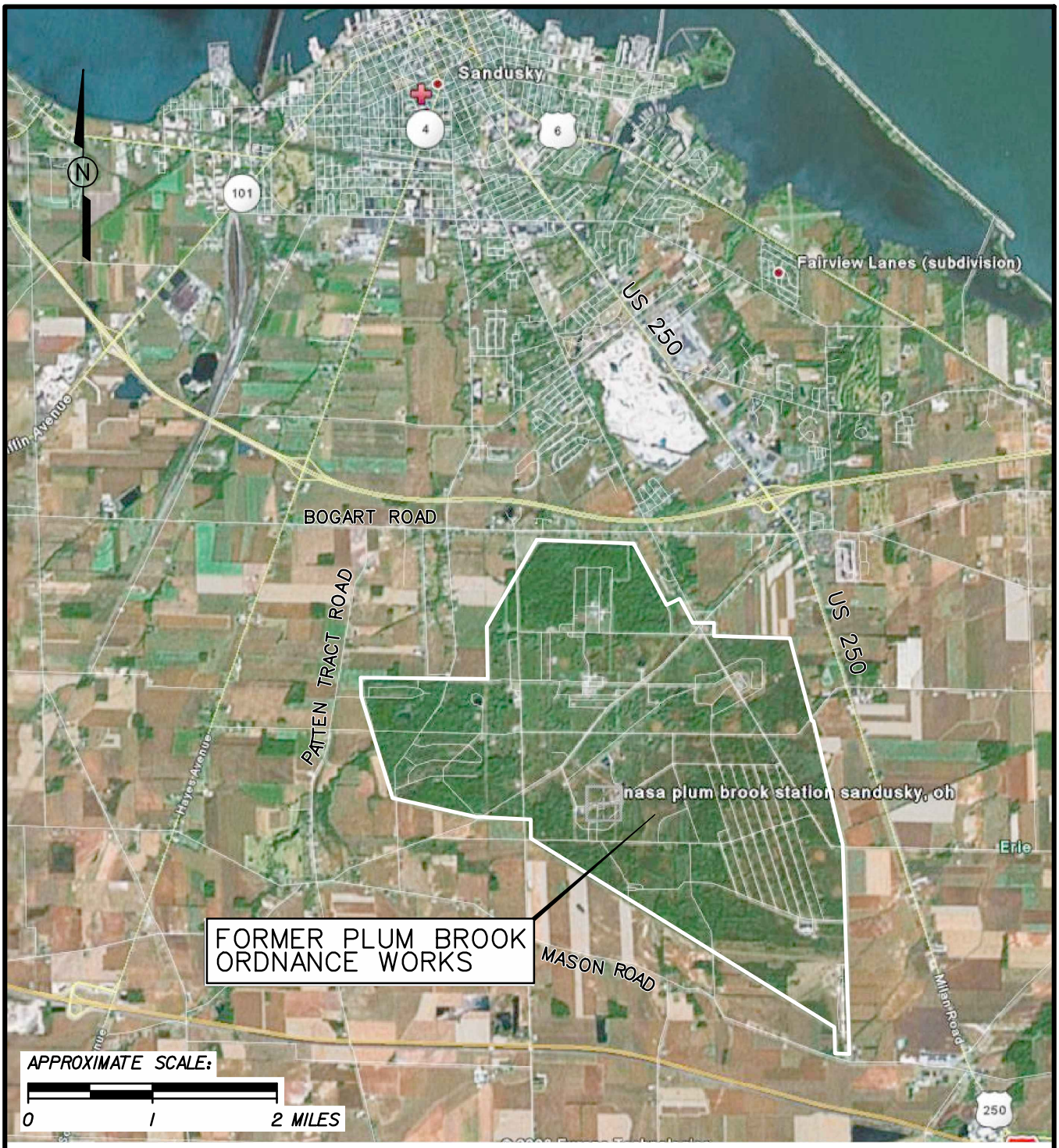

FIGURE 1-1
PBOW VICINITY MAP

TNTA/WWTP1 SEWER LINES BASELINE
HUMAN HEALTH RISK ASSESSMENT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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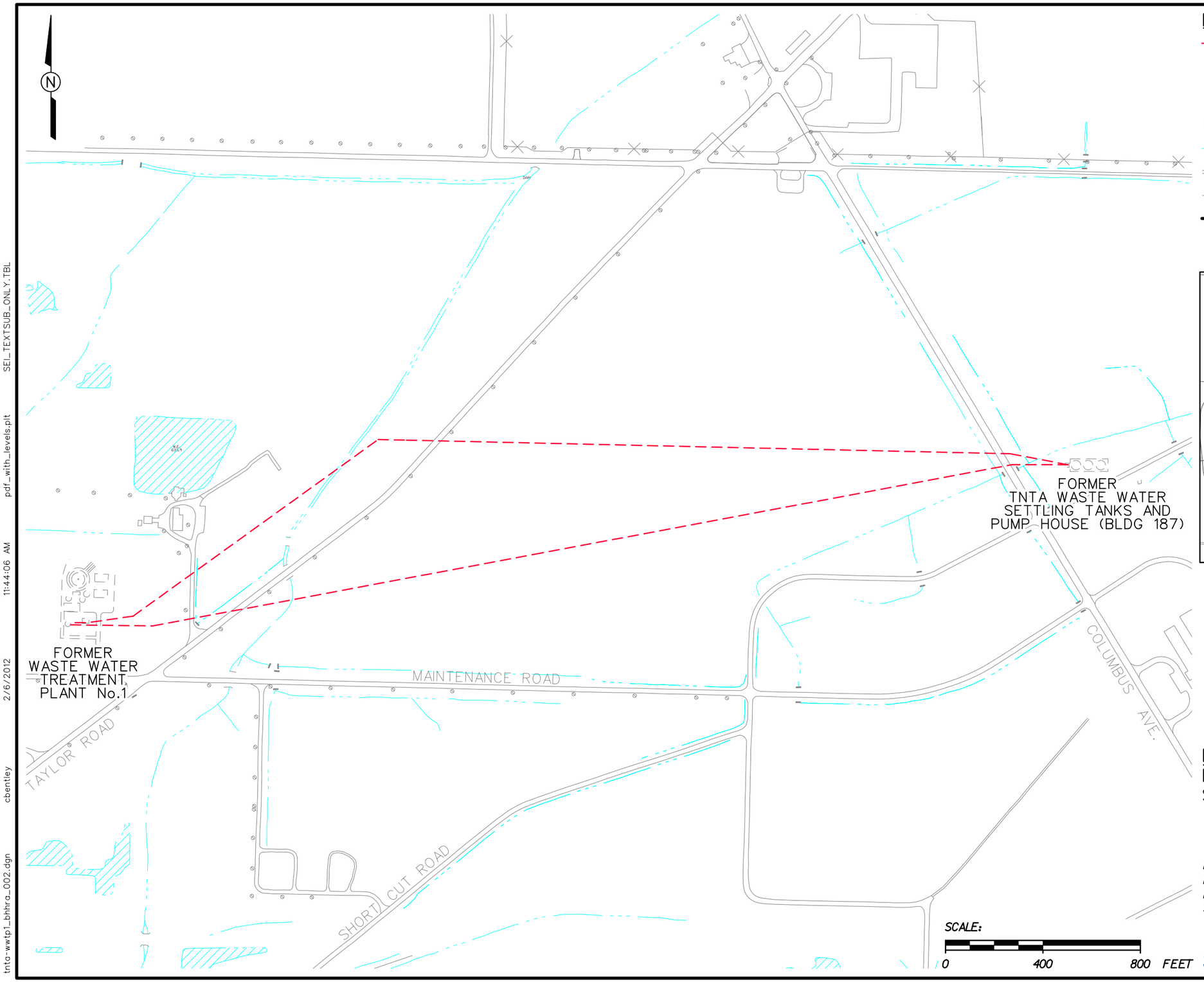
tnta-wwtp1_bhhra_001.dgn cbentley 2/6/2012 11:43:43 AM pdf_with_levels.plt SEI_TEXTSUB_ONLY.TBL



LEGEND:

- APPROXIMATE LOCATION OF TNTA/WWTP1 SEWER LINES
- APPROXIMATE LOCATION OF FORMER STRUCTURES
- POND
- CREEK, DITCH, CONVEYANCE
- ROAD
- FENCE
- FACILITY BOUNDARY

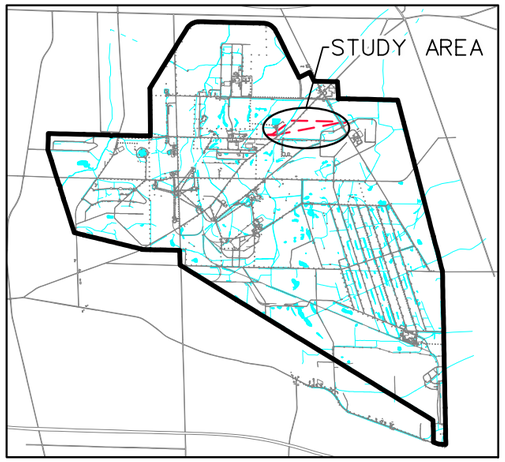


FIGURE 1-2
LOCATION OF TNTA/WWTP1
SEWER LINES AT PBOW

TNTA/WWTP1 SEWER LINES BASELINE
HUMAN HEALTH RISK ASSESSMENT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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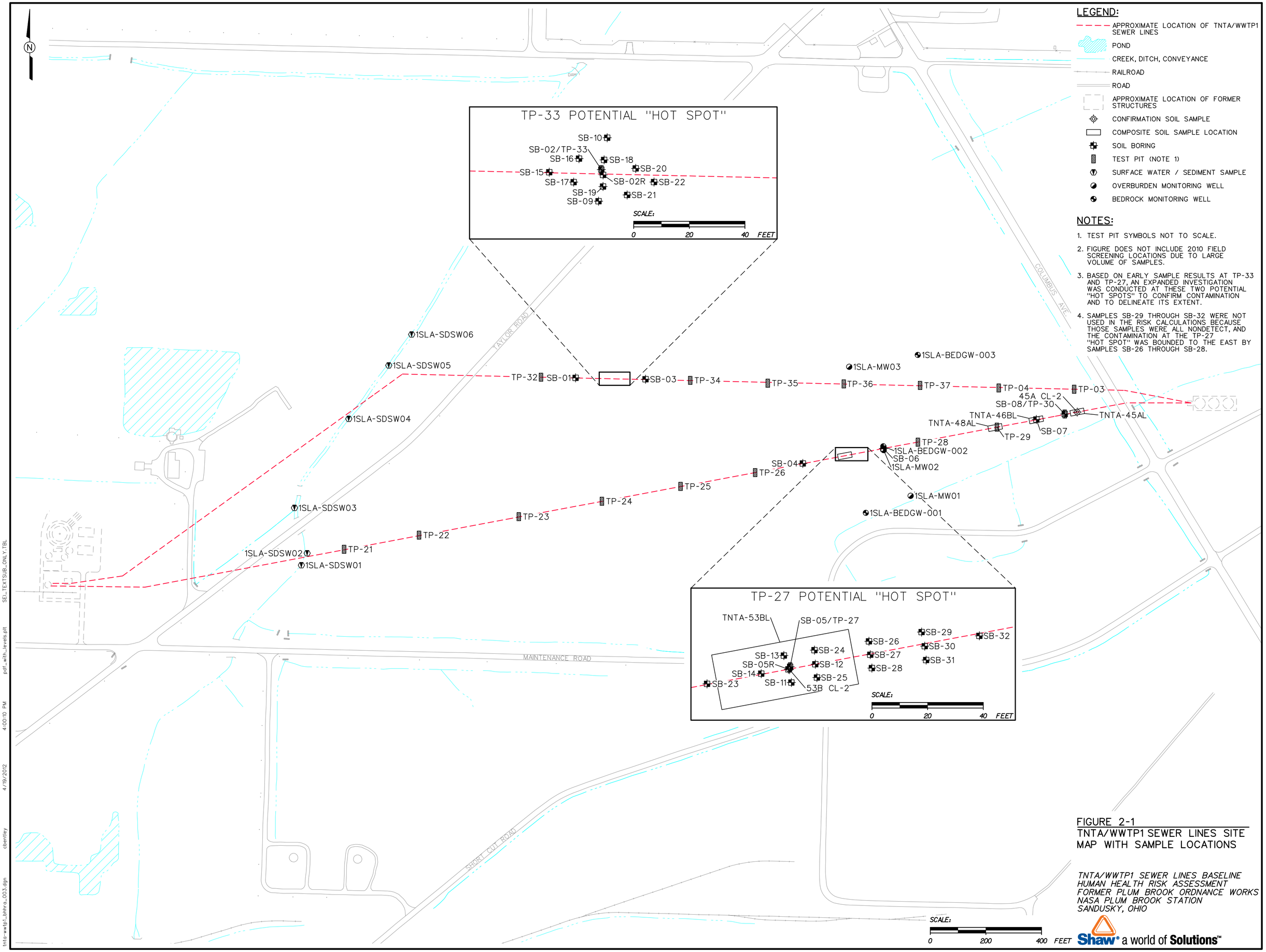
tnta-wwtp1_bhhra_002.dgn cbentley 2/6/2012 11:44:06 AM pdf_with_levels.plt SEL_TEXTSUB_ONLY.TBL



LEGEND:

- APPROXIMATE LOCATION OF TNTA/WWTP1 SEWER LINES
- POND
- CREEK, DITCH, CONVEYANCE
- RAILROAD
- ROAD
- APPROXIMATE LOCATION OF FORMER STRUCTURES
- CONFIRMATION SOIL SAMPLE
- COMPOSITE SOIL SAMPLE LOCATION
- SOIL BORING
- TEST PIT (NOTE 1)
- SURFACE WATER / SEDIMENT SAMPLE
- OVERBURDEN MONITORING WELL
- BEDROCK MONITORING WELL

NOTES:

1. TEST PIT SYMBOLS NOT TO SCALE.
2. FIGURE DOES NOT INCLUDE 2010 FIELD SCREENING LOCATIONS DUE TO LARGE VOLUME OF SAMPLES.
3. BASED ON EARLY SAMPLE RESULTS AT TP-33 AND TP-27, AN EXPANDED INVESTIGATION WAS CONDUCTED AT THESE TWO POTENTIAL "HOT SPOTS" TO CONFIRM CONTAMINATION AND TO DELINEATE ITS EXTENT.
4. SAMPLES SB-29 THROUGH SB-32 WERE NOT USED IN THE RISK CALCULATIONS BECAUSE THOSE SAMPLES WERE ALL NONDETECT, AND THE CONTAMINATION AT THE TP-27 "HOT SPOT" WAS BOUNDED TO THE EAST BY SAMPLES SB-26 THROUGH SB-28.

FIGURE 2-1
TNTA/WWTP1 SEWER LINES SITE MAP WITH SAMPLE LOCATIONS

TNTA/WWTP1 SEWER LINES BASELINE HUMAN HEALTH RISK ASSESSMENT FORMER PLUM BROOK ORDNANCE WORKS NASA PLUM BROOK STATION SANDUSKY, OHIO

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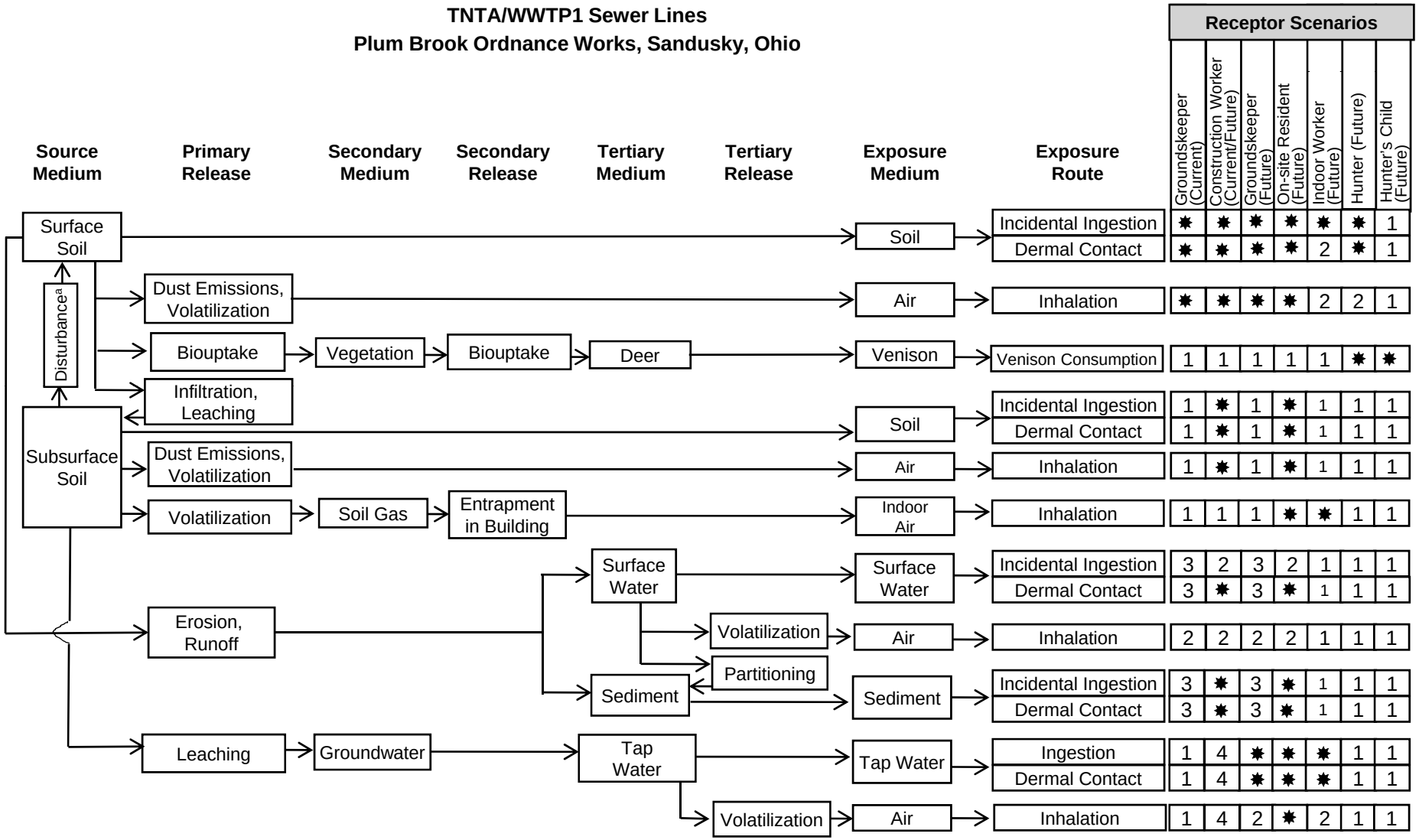
tnta-wwtp1_bhhra_003.dgn cbentley 4/19/2012 4:00:10 PM pdf_with_levels.plt SEL_TEXTSUB_ONLY.TBL

Figure 3-1
Human Health Conceptual Site Exposure Model
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio



[a] = Current surface soil may have been impacted by subsurface soil during sewer line removal.
✸ = Complete exposure route quantified in the risk assessment.
1 = There is no plausible pathway for exposure to this medium.
2 = Although theoretically complete, this pathway is not quantified as explained in text.
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 = For current use there is no plausible exposure pathway. For future use, the pathway is potentially complete, but is not quantified as explained in the text.

KN12/PBOW/WWTP1\TNTA\BHHRA\Draft\Fig3-1/2/17/2010 1:18 PM

APPENDIX A

DATA SUMMARY OF CHEMICALS DETECTED IN OVERBURDEN GROUNDWATER PIEZOMETERS

Table A-1

Summary of Piezometer Groundwater Samples for the Risk Screening
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Location	Sample Number	Sample Purpose	Sample Date	Analyses
Piezometer [a]				
SL-PZ02	SL3001	FD	27-Jan-09	Cyanide, Exp, Gen Chem
SL-PZ02	SL3003	REG	27-Jan-09	Cyanide, Exp, Gen Chem
SL-PZ05	SL3006	REG	30-Jan-09	Cyanide, Exp, Gen Chem
SL-PZ08	SL3009	REG	26-Jan-09	Cyanide, Exp, Gen Chem
SL-PZ09	SL3010	REG	26-Jan-09	Cyanide, Exp, Gen Chem

[a] These samples are summarized and screened, but no exposure calculations are presented.

Exp - Explosives compounds.
FD - Field duplicate; averaged with the regular sample at the same location to create one result.
REG - Regular sample.
Gen Chem - General chemistry.

Table A-2

Statistical Summary and COPC Selection of Chemicals Detected in Piezometer Groundwater
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of values, µg/L: Detected Concentrations Minimum	VQ	Maximum	VQ	Reporting Limits Minimum	Maximum	Arithmetic Mean µg/L	RBSC [b] µg/L	COPC? [c,d]	EPC [e] µg/L
Explosives												
Amino-2,6-dinitrotoluene, 4-	3 / 4	75	1.42E+00		2.07E+00		1.58E-01	2.31E-01	1.31E+00	3.00E+00	N (a)	---
Amino-4,6-dinitrotoluene, 2-	2 / 4	50	1.12E+00		2.03E+00		1.58E-01	2.31E-01	8.84E-01	3.00E+00	N (a)	---
Dinitrotoluene, 2,4-	1 / 4	25	5.03E-01		5.03E-01		1.58E-01	2.31E-01	2.49E-01	2.00E-01	Y	5.03E-01
Tetryl	1 / 4	25	2.40E-01	J	2.40E-01	J	1.58E-01	2.31E-01	1.84E-01	6.30E+00	N (a)	---
Trinitrotoluene, 2,4,6-	3 / 4	75	6.37E-01		5.99E+01		1.58E-01	4.62E+00	1.80E+01	7.60E-01	Y	5.99E+01
General Chemistry												
Chloride	4 / 4	100	1.50E+03	J/J	4.20E+03		1.25E+02	1.25E+02	2.88E+03	Nutrient	N (b)	---
Nitrate-Nitrite	3 / 4	75	2.70E+01	J/UJ	1.80E+02		2.00E+01	2.00E+01	7.20E+01	1.00E+03 h	N (a)	---
Sulfate	4 / 4	100	8.22E+03		1.22E+05		2.50E+02	1.25E+03	8.58E+04	2.50E+05 i	N (a)	---

BSC - Background screening concentration.
COPC - Chemical of potential concern.
RBSC - Risk-based screening concentration.
µg/L - Micrograms per liter.
VQ - Validation qualifier.
J - The compound/analyte was positively identified; the reported result is the estimated concentration of the compound/analyte detected in the sample analyzed.
/U - The compound/analyte was positively identified in one sample averaged with a field duplicate that was nondetect (U qualified).

[b] Risk-based screening concentrations based on EPA Regional Screening Level Table (November 2011) tap water values and are based on a risk level of 1.0E-06 and a hazard index of 0.1.
[c] N - Chemical is not chosen as a COPC:
(a) - Maximum detected concentration is less than the RBSC.
(b) - Essential nutrient.
[d] Y - Chemical is chosen as COPC.
[e] Exposure point concentration (EPC) used in risk assessment equal to maximum detected concentration.
[h] Because no Regional Screening Level exists for nitrate-nitrite, 0.1 X the nitrate-nitrite MCL (10 mg/L) is used for screening.
[i] Environmental Protection Agency (EPA), 2009, ***2009 Edition of the Drinking Water Standards and Health Advisories*** , Office of Water, October, EPA 822-R-09-011.

APPENDIX B

ProUCL OUTPUT FOR UPPER CONFIDENCE LIMITS ON THE MEAN

Input for ProUCL
TNTA/WWTP1 Sewer Lines - Surface Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Aroclor 1016	D_Aroclor 1016	Amino-2,6-dinitrotoluene, 4-	D_Amino-2,6-dinitrotoluene, 4-	Amino-4,6-dinitrotoluene, 2-	D_Amino-4,6-dinitrotoluene, 2-	Dinitrotoluene, 2,4- exp
0.125	1	17.2	1	16	1	1.93
0.0478	1	0.1625	1	0.149	0	0.148
0.0191	1	0.149	0	0.149	0	0.149
1.16	1	0.149	0	0.15	0	0.149
0.0828	1	0.15	0	0.15	0	0.15
0.0828	1	0.15	0	0.149	0	0.15
0.00846	0	0.149	0	0.076	0	0.149
0.00851	0	0.076	0	0.074	0	9.7
		0.074	0	0.147	0	0.097
		0.471	1	0.605	1	0.092
		31.3	1	50.1	1	0.09
		2.04	1	1.63	1	0.147

Input for ProUCL
TNTA/WWTP1 Sewer Lines - Surface Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Dinitrotoluene, 2,6- exp	Trinitrotoluene, 2,4,6-	D_Trinitrotoluene, 2,4,6-	Benzo(a)anthracene	D_Benzo(a)anthracene	Benzo(a)pyrene	D_Benzo(a)pyrene	Benzo(b)fluoranthene
1.475	212.5	1	0.047	1	0.053	1	0.0713
0.148	0.271	1	0.0581	1	0.0281	0	0.0962
0.149	0.532	1	0.0286	0	0.0286	0	0.0725
0.15	0.148	0	0.0285	0	0.0285	0	0.0723
0.15	0.149	0	0.141	0	0.141	0	0.358
0.149	0.149	0	0.0272	0	0.0272	0	0.069
8.7	0.15	0	0.0279	0	0.0279	0	0.0707
0.087	0.15	0	1.54	1	1.18	1	2
0.082	0.076	0					
0.081	0.074	0					
0.149	1200	1					
0.147	18	1					

Input for ProUCL
TNTA/WWTP1 Sewer Lines - Surface Soil
Plum Brook Ordnance Works, Sandusky, Ohio

D_Benzo(b)fluoranthene	Dibenz(a,h)anthracene	Dinitrotoluene, 2,4- SVOC	D_Dinitrotoluene, 2,4- SVOC	Dinitrotoluene, 2,6- SVOC	Indeno(1,2,3-cd)pyrene
1	0.196	0.0615	1	0.0102	0.138
1	0.0965	0.0563	1	0.0111	0.141
0	0.0984	0.015	0	0.0105	0.141
0	0.0981	0.0153	0	0.0104	0.698
0	0.486	0.0152	0	0.00994	0.134
0	0.0936	0.0163	0	0.0112	0.151
0	0.105	0.0149	0	0.010185	0.1375
1	0.0959	4.42	1	2.18	1.06

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Surface Soil
Plum Brook Ordnance Works, Sandusky, Ohio

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	C:\Documents and Settings\debbi.freer\My Documents\PBOW\TNT A SL - HH\UCL input tabs.xls.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Aroclor 1016 - TNTA/WWTP1 SL Surface Soil

General Statistics

Number of Valid Data	8	Number of Detected Data	6
Number of Distinct Detected Data	5	Number of Non-Detect Data	2
		Percent Non-Detects	25.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.0191	Minimum Detected	-3.958
Maximum Detected	1.16	Maximum Detected	0.148
Mean of Detected	0.253	Mean of Detected	-2.319
SD of Detected	0.446	SD of Detected	1.372
Minimum Non-Detect	0.00846	Minimum Non-Detect	-4.772
Maximum Non-Detect	0.00851	Maximum Non-Detect	-4.767

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	2
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	6
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	25.00%

Warning: There are only 6 Detected Values in this data
Note: It should be noted that even though bootstrap may be performed on this data set
the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.574	Shapiro Wilk Test Statistic	0.9
5% Shapiro Wilk Critical Value	0.788	5% Shapiro Wilk Critical Value	0.788
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.191	Mean	-3.105
SD	0.394	SD	1.861
95% DL/2 (t) UCL	0.455	95% H-Stat (DL/2) UCL	14.37
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	0.111	Mean in Log Scale	-3.152
SD	0.447	SD in Log Scale	1.931
95% MLE (t) UCL	0.411	Mean in Original Scale	0.191
95% MLE (Tiku) UCL	0.413	SD in Original Scale	0.394
		95% t UCL	0.455
		95% Percentile Bootstrap UCL	0.464
		95% BCA Bootstrap UCL	0.489
		95% H UCL	21.02

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Surface Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Gamma Distribution Test with Detected Values Only	
k star (bias corrected)	0.435
Theta Star	0.582
nu star	5.217
A-D Test Statistic	0.767
5% A-D Critical Value	0.727
K-S Test Statistic	0.727
5% K-S Critical Value	0.346
Data not Gamma Distributed at 5% Significance Level	
Assuming Gamma Distribution	
Gamma ROS Statistics using Extrapolated Data	
Minimum	0.000001
Maximum	1.16
Mean	0.19
Median	0.0653
SD	0.395
k star	0.213
Theta star	0.891
Nu star	3.406
AppChi2	0.502
95% Gamma Approximate UCL (Use when n >= 40)	1.286
95% Adjusted Gamma UCL (Use when n < 40)	2.193

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only
Data appear Lognormal at 5% Significance Level

Nonparametric Statistics	
Kaplan-Meier (KM) Method	
Mean	0.194
SD	0.367
SE of Mean	0.142
95% KM (t) UCL	0.464
95% KM (z) UCL	0.428
95% KM (jackknife) UCL	0.453
95% KM (bootstrap t) UCL	2.314
95% KM (BCA) UCL	0.487
95% KM (Percentile Bootstrap) UCL	0.466
95% KM (Chebyshev) UCL	0.814
97.5% KM (Chebyshev) UCL	1.081
99% KM (Chebyshev) UCL	1.608
Potential UCLs to Use	
97.5% KM (Chebyshev) UCL	1.081

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Amino-2,6-dinitrotoluene, 4- - TNTA/WWTP1 SL Surface Soil

General Statistics

Number of Valid Data	12	Number of Detected Data	5
Number of Distinct Detected Data	5	Number of Non-Detect Data	7
		Percent Non-Detects	58.33%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.163	Minimum Detected	-1.817
Maximum Detected	31.3	Maximum Detected	3.444
Mean of Detected	10.23	Mean of Detected	0.886
SD of Detected	13.75	SD of Detected	2.258
Minimum Non-Detect	0.074	Minimum Non-Detect	-2.604
Maximum Non-Detect	0.15	Maximum Non-Detect	-1.897

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	7
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	5
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	58.33%

Warning: There are only 5 Detected Values in this data
Note: It should be noted that even though bootstrap may be performed on this data set
the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Surface Soil
Plum Brook Ordnance Works, Sandusky, Ohio

UCL Statistics

Normal Distribution Test with Detected Values Only

Shapiro Wilk Test Statistic	0.809
5% Shapiro Wilk Critical Value	0.762

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

DL/2 Substitution Method	
Mean	4.302
SD	9.807
95% DL/2 (t) UCL	9.386
Maximum Likelihood Estimate(MLE) Method	N/A

MLE yields a negative mean

Lognormal Distribution Test with Detected Values Only

Shapiro Wilk Test Statistic	0.934
5% Shapiro Wilk Critical Value	0.762

Data appear Lognormal at 5% Significance Level

Assuming Lognormal Distribution

DL/2 Substitution Method	
Mean	-1.259
SD	2.346
95% H-Stat (DL/2) UCL	254.5
Log ROS Method	
Mean in Log Scale	-3.441
SD in Log Scale	4.222
Mean in Original Scale	4.266
SD in Original Scale	9.823
95% t UCL	9.359
95% Percentile Bootstrap UCL	9.531
95% BCA Bootstrap UCL	10.88
95% H-UCL	77963190

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.313
Theta Star	32.71
nu star	3.129
A-D Test Statistic	0.331
5% A-D Critical Value	0.718
K-S Test Statistic	0.718
5% K-S Critical Value	0.374

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	0.000001
Maximum	31.3
Mean	4.264
Median	0.000001
SD	9.824
k star	0.123
Theta star	34.65
Nu star	2.954
AppChi2	0.359
95% Gamma Approximate UCL (Use when n >= 40)	35.1
95% Adjusted Gamma UCL (Use when n < 40)	48.93

Data Distribution Test with Detected Values Only

Data appear Normal at 5% Significance Level

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	4.359
SD	9.363
SE of Mean	3.022
95% KM (t) UCL	9.786
95% KM (z) UCL	9.33
95% KM (jackknife) UCL	9.303
95% KM (bootstrap t) UCL	48.76
95% KM (BCA) UCL	18.38
95% KM (Percentile Bootstrap) UCL	11.01
95% KM (Chebyshev) UCL	17.53
97.5% KM (Chebyshev) UCL	23.23
99% KM (Chebyshev) UCL	34.43

Potential UCLs to Use

95% KM (t) UCL	9.786
95% KM (Percentile Bootstrap) UCL	11.01

Note: DL/2 is not a recommended method.

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Surface Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Amino-4,6-dinitrotoluene, 2- - TNTA/WWTP1 SL Surface Soil

General Statistics

Number of Valid Data	12	Number of Detected Data	4
Number of Distinct Detected Data	4	Number of Non-Detect Data	8
		Percent Non-Detects	66.67%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.605	Minimum Detected	-0.503
Maximum Detected	50.1	Maximum Detected	3.914
Mean of Detected	17.08	Mean of Detected	1.668
SD of Detected	23.11	SD of Detected	2.03
Minimum Non-Detect	0.074	Minimum Non-Detect	-2.604
Maximum Non-Detect	0.15	Maximum Non-Detect	-1.897

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	8
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	4
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	66.67%

Warning: There are only 4 Distinct Detected Values in this data
Note: It should be noted that even though bootstrap may be performed on this data set
the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.828	Shapiro Wilk Test Statistic	0.945
5% Shapiro Wilk Critical Value	0.748	5% Shapiro Wilk Critical Value	0.748
Data appear Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	5.738	Mean	-1.29
SD	14.69	SD	2.441
95% DL/2 (t) UCL	13.35	95% H-Stat (DL/2) UCL	428.5
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE yields a negative mean		Mean in Log Scale	-3.471
		SD in Log Scale	4.148
		Mean in Original Scale	5.699
		SD in Original Scale	14.71
		95% t UCL	13.32
		95% Percentile Bootstrap UCL	12.8
		95% BCA Bootstrap UCL	18.17
		95% H-UCL	35870188

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Surface Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.301
Theta Star	56.77
nu star	2.407
A-D Test Statistic	0.294
5% A-D Critical Value	0.679
K-S Test Statistic	0.679
5% K-S Critical Value	0.409

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data

Minimum	0.000001
Maximum	50.1
Mean	5.695
Median	0.000001
SD	14.71
k star	0.116
Theta star	49.21
Nu star	2.777
AppChi2	0.31
95% Gamma Approximate UCL (Use when n >= 40)	51.08
95% Adjusted Gamma UCL (Use when n < 40)	N/A

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data appear Normal at 5% Significance Level

Nonparametric Statistics

Kaplan-Meier (KM) Method

Mean	6.098
SD	13.92
SE of Mean	4.641
95% KM (t) UCL	14.43
95% KM (z) UCL	13.73
95% KM (jackknife) UCL	13.19
95% KM (bootstrap t) UCL	20.09
95% KM (BCA) UCL	N/A
95% KM (Percentile Bootstrap) UCL	21.68
95% KM (Chebyshev) UCL	26.33
97.5% KM (Chebyshev) UCL	35.08
99% KM (Chebyshev) UCL	52.27

Potential UCLs to Use

95% KM (t) UCL	14.43
95% KM (Percentile Bootstrap) UCL	21.68

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Trinitrotoluene, 2,4,6- - TNTA/WWTP1 SL Surface Soil

General Statistics

Number of Valid Data	12	Number of Detected Data	5
Number of Distinct Detected Data	5	Number of Non-Detect Data	7
		Percent Non-Detects	58.33%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.271	Minimum Detected	-1.306
Maximum Detected	1200	Maximum Detected	7.09
Mean of Detected	286.3	Mean of Detected	2.681
SD of Detected	518.6	SD of Detected	3.658
Minimum Non-Detect	0.074	Minimum Non-Detect	-2.604
Maximum Non-Detect	0.15	Maximum Non-Detect	-1.897

Note: Data have multiple DLs - Use of KM Method is recommended
For all methods (except KM, DL/2, and ROS Methods),
Observations < Largest ND are treated as NDs

Number treated as Non-Detect	7
Number treated as Detected	5
Single DL Non-Detect Percentage	58.33%

Warning: There are only 5 Detected Values in this data
Note: It should be noted that even though bootstrap may be performed on this data set
the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Surface Soil
Plum Brook Ordnance Works, Sandusky, Ohio

UCL Statistics

Normal Distribution Test with Detected Values Only

Shapiro Wilk Test Statistic	0.669
5% Shapiro Wilk Critical Value	0.762

Data not Normal at 5% Significance Level

Assuming Normal Distribution

DL/2 Substitution Method	
Mean	119.3
SD	345.7
95% DL/2 (t) UCL	298.5
Maximum Likelihood Estimate(MLE) Method	N/A

MLE yields a negative mean

Lognormal Distribution Test with Detected Values Only

Shapiro Wilk Test Statistic	0.922
5% Shapiro Wilk Critical Value	0.762

Data appear Lognormal at 5% Significance Level

Assuming Lognormal Distribution

DL/2 Substitution Method	
Mean	-0.512
SD	3.587
95% H-Stat (DL/2) UCL	3770000
Log ROS Method	
Mean in Log Scale	-4.31
SD in Log Scale	6.714
Mean in Original Scale	119.3
SD in Original Scale	345.7
95% t UCL	298.5
95% Percentile Bootstrap UCL	303
95% BCA Bootstrap UCL	500
95% H-UCL	5.586E+21

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.229
Theta Star	1248
nu star	2.294
A-D Test Statistic	0.306
5% A-D Critical Value	0.761
K-S Test Statistic	0.761
5% K-S Critical Value	0.385

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	0.000001
Maximum	1200
Mean	119.3
Median	0.000001
SD	345.7
k star	0.11
Theta star	1089
Nu star	2.629
AppChi2	0.272
95% Gamma Approximate UCL (Use when n >= 40)	1155
95% Adjusted Gamma UCL (Use when n < 40)	1608

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data appear Gamma Distributed at 5% Significance Level

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	119.4
SD	330.9
SE of Mean	106.8
95% KM (t) UCL	311.3
95% KM (z) UCL	295.1
95% KM (jackknife) UCL	298.5
95% KM (bootstrap t) UCL	5955
95% KM (BCA) UCL	377.1
95% KM (Percentile Bootstrap) UCL	313.5
95% KM (Chebyshev) UCL	585
97.5% KM (Chebyshev) UCL	786.5
99% KM (Chebyshev) UCL	1182

Potential UCLs to Use

95% KM (t) UCL	311.3

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Surface Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Benzo(a)anthracene - TNTA/WWTP1 SL Surface Soil

General Statistics

Number of Valid Data	8	Number of Detected Data	3
Number of Distinct Detected Data	3	Number of Non-Detect Data	5
		Percent Non-Detects	62.50%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.047	Minimum Detected	-3.058
Maximum Detected	1.54	Maximum Detected	0.432
Mean of Detected	0.548	Mean of Detected	-1.824
SD of Detected	0.859	SD of Detected	1.956
Minimum Non-Detect	0.0272	Minimum Non-Detect	-3.605
Maximum Non-Detect	0.141	Maximum Non-Detect	-1.959

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	7
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	1
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	87.50%

Warning: There are only 3 Distinct Detected Values in this data set
The number of detected data may not be adequate enough to perform GOF tests, bootstrap, and ROS methods.
Those methods will return a 'N/A' value on your output display!

It is necessary to have 4 or more Distinct Values for bootstrap methods.
However, results obtained using 4 to 9 distinct values may not be reliable.
It is recommended to have 10 to 15 or more observations for accurate and meaningful results and estimates.

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.756	Shapiro Wilk Test Statistic	0.795
5% Shapiro Wilk Critical Value	0.767	5% Shapiro Wilk Critical Value	0.767
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.221	Mean	-3.149
SD	0.533	SD	1.611
95% DL/2 (t) UCL	0.579	95% H-Stat (DL/2) UCL	3.394
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	-4.849
		SD in Log Scale	2.753
		Mean in Original Scale	0.207
		SD in Original Scale	0.539
		95% t UCL	0.568
		95% Percentile Bootstrap UCL	0.585
		95% BCA Bootstrap UCL	0.776
		95% H-UCL	1935

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Surface Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Gamma Distribution Test with Detected Values Only	
k star (bias corrected)	N/A
Theta Star	N/A
nu star	N/A
A-D Test Statistic	N/A
5% A-D Critical Value	N/A
K-S Test Statistic	N/A
5% K-S Critical Value	N/A
Data not Gamma Distributed at 5% Significance Level	
Assuming Gamma Distribution	
Gamma ROS Statistics using Extrapolated Data	
Minimum	N/A
Maximum	N/A
Mean	N/A
Median	N/A
SD	N/A
k star	N/A
Theta star	N/A
Nu star	N/A
AppChi2	N/A
95% Gamma Approximate UCL (Use when n >= 40)	N/A
95% Adjusted Gamma UCL (Use when n < 40)	N/A

Data Distribution Test with Detected Values Only
Data appear Lognormal at 5% Significance Level

Nonparametric Statistics	
Kaplan-Meier (KM) Method	
Mean	0.235
SD	0.493
SE of Mean	0.214
95% KM (t) UCL	0.64
95% KM (z) UCL	0.586
95% KM (jackknife) UCL	0.584
95% KM (bootstrap t) UCL	23.75
95% KM (BCA) UCL	1.54
95% KM (Percentile Bootstrap) UCL	1.54
95% KM (Chebyshev) UCL	1.166
97.5% KM (Chebyshev) UCL	1.569
99% KM (Chebyshev) UCL	2.36
Potential UCLs to Use	
97.5% KM (Chebyshev) UCL	1.569

Warning: Recommended UCL exceeds the maximum observation

Note: DL/2 is not a recommended method.

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Benzo(a)pyrene - TNTA/WWTP1 SL Surface Soil

General Statistics

Number of Valid Data	8	Number of Detected Data	2
Number of Distinct Detected Data	2	Number of Non-Detect Data	6
		Percent Non-Detects	75.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.053	Minimum Detected	-2.937
Maximum Detected	1.18	Maximum Detected	0.166
Mean of Detected	0.617	Mean of Detected	-1.386
SD of Detected	0.797	SD of Detected	2.194
Minimum Non-Detect	0.0272	Minimum Non-Detect	-3.605
Maximum Non-Detect	0.141	Maximum Non-Detect	-1.959

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	7
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	1
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	87.50%

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Surface Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Warning: Data set has only 2 Distinct Detected Values.
This may not be adequate enough to compute meaningful and reliable test statistics and estimates.
The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).

Unless Data Quality Objectives (DQOs) have been met, it is suggested to collect additional observations.

The number of detected data may not be adequate enough to perform GOF tests, bootstrap, and ROS methods.
Those methods will return a 'N/A' value on your output display!

It is necessary to have 4 or more Distinct Values for bootstrap methods.
However, results obtained using 4 to 9 distinct values may not be reliable.
It is recommended to have 10 to 15 or more observations for accurate and meaningful results and estimates.

UCL Statistics

Normal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	N/A
5% Shapiro Wilk Critical Value	N/A
Data not Normal at 5% Significance Level	

Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	N/A
5% Shapiro Wilk Critical Value	N/A
Data not Lognormal at 5% Significance Level	

Assuming Normal Distribution	
DL/2 Substitution Method	
Mean	0.172
SD	0.408
95% DL/2 (t) UCL	0.445
Maximum Likelihood Estimate(MLE) Method	N/A
MLE method failed to converge properly	

Assuming Lognormal Distribution	
DL/2 Substitution Method	
Mean	-3.345
SD	1.568
95% H-Stat (DL/2) UCL	2.241
Log ROS Method	
Mean in Log Scale	N/A
SD in Log Scale	N/A
Mean in Original Scale	N/A
SD in Original Scale	N/A
95% t UCL	N/A
95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A
95% H-UCL	N/A

Gamma Distribution Test with Detected Values Only	
k star (bias corrected)	N/A
Theta Star	N/A
nu star	N/A
A-D Test Statistic	N/A
5% A-D Critical Value	N/A
K-S Test Statistic	N/A
5% K-S Critical Value	N/A
Data not Gamma Distributed at 5% Significance Level	
Assuming Gamma Distribution	
Gamma ROS Statistics using Extrapolated Data	
Minimum	N/A
Maximum	N/A
Mean	N/A
Median	N/A
SD	N/A
k star	N/A
Theta star	N/A
Nu star	N/A
AppChi2	N/A

Data Distribution Test with Detected Values Only
Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics	
Kaplan-Meier (KM) Method	
Mean	0.194
SD	0.373
SE of Mean	0.186
95% KM (t) UCL	0.547
95% KM (z) UCL	0.5
95% KM (jackknife) UCL	1.009
95% KM (bootstrap t) UCL	0.194
95% KM (BCA) UCL	1.18
95% KM (Percentile Bootstrap) UCL	1.18
95% KM (Chebyshev) UCL	1.006
97.5% KM (Chebyshev) UCL	1.358
99% KM (Chebyshev) UCL	2.048
Potential UCLs to Use	
99% KM (Chebyshev) UCL	2.048

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Surface Soil
Plum Brook Ordnance Works, Sandusky, Ohio

95% Gamma Approximate UCL (Use when n >= 40)	N/A
95% Adjusted Gamma UCL (Use when n < 40)	N/A

Warning: Recommended UCL exceeds the maximum observation

Note: DL/2 is not a recommended method.

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Benzo(b)fluoranthene - TNTA/WWTP1 SL Surface Soil

General Statistics

Number of Valid Data	8	Number of Detected Data	3
Number of Distinct Detected Data	3	Number of Non-Detect Data	5
		Percent Non-Detects	62.50%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.0713	Minimum Detected	-2.641
Maximum Detected	2	Maximum Detected	0.693
Mean of Detected	0.723	Mean of Detected	-1.43
SD of Detected	1.106	SD of Detected	1.845
Minimum Non-Detect	0.069	Minimum Non-Detect	-2.674
Maximum Non-Detect	0.358	Maximum Non-Detect	-1.027

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	7
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	1
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	87.50%

Warning: There are only 3 Distinct Detected Values in this data set
The number of detected data may not be adequate enough to perform GOF tests, bootstrap, and ROS methods.
Those methods will return a 'N/A' value on your output display!

It is necessary to have 4 or more Distinct Values for bootstrap methods.
However, results obtained using 4 to 9 distinct values may not be reliable.
It is recommended to have 10 to 15 or more observations for accurate and meaningful results and estimates.

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.76	Shapiro Wilk Test Statistic	0.817
5% Shapiro Wilk Critical Value	0.767	5% Shapiro Wilk Critical Value	0.767
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.311	Mean	-2.42
SD	0.684	SD	1.394
95% DL/2 (t) UCL	0.769	95% H-Stat (DL/2) UCL	2.452
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	-3.681
		SD in Log Scale	2.164
		Mean in Original Scale	0.276
		SD in Original Scale	0.698
		95% t UCL	0.743
		95% Percentile Bootstrap UCL	0.763
		95% BCA Bootstrap UCL	0.795
		95% H-UCL	58.11

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Surface Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Gamma Distribution Test with Detected Values Only	
k star (bias corrected)	N/A
Theta Star	N/A
nu star	N/A
A-D Test Statistic	N/A
5% A-D Critical Value	N/A
K-S Test Statistic	N/A
5% K-S Critical Value	N/A
Data not Gamma Distributed at 5% Significance Level	
Assuming Gamma Distribution	
Gamma ROS Statistics using Extrapolated Data	
Minimum	N/A
Maximum	N/A
Mean	N/A
Median	N/A
SD	N/A
k star	N/A
Theta star	N/A
Nu star	N/A
AppChi2	N/A
95% Gamma Approximate UCL (Use when n >= 40)	N/A
95% Adjusted Gamma UCL (Use when n < 40)	N/A

Data Distribution Test with Detected Values Only
Data appear Lognormal at 5% Significance Level

Nonparametric Statistics	
Kaplan-Meier (KM) Method	
Mean	0.316
SD	0.637
SE of Mean	0.276
95% KM (t) UCL	0.838
95% KM (z) UCL	0.769
95% KM (jackknife) UCL	0.762
95% KM (bootstrap t) UCL	17.8
95% KM (BCA) UCL	N/A
95% KM (Percentile Bootstrap) UCL	2
95% KM (Chebyshev) UCL	1.517
97.5% KM (Chebyshev) UCL	2.037
99% KM (Chebyshev) UCL	3.059
Potential UCLs to Use	
97.5% KM (Chebyshev) UCL	2.037

Warning: Recommended UCL exceeds the maximum observation

Note: DL/2 is not a recommended method.

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Dinitrotoluene, 2,4- SVOC - TNTA/WWTP1 SL Surface Soil

General Statistics

Number of Valid Data	8	Number of Detected Data	3
Number of Distinct Detected Data	3	Number of Non-Detect Data	5
		Percent Non-Detects	62.50%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.0563	Minimum Detected	-2.877
Maximum Detected	4.42	Maximum Detected	1.486
Mean of Detected	1.513	Mean of Detected	-1.393
SD of Detected	2.518	SD of Detected	2.494
Minimum Non-Detect	0.0149	Minimum Non-Detect	-4.206
Maximum Non-Detect	0.0163	Maximum Non-Detect	-4.117

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	5
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	3
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	62.50%

Warning: There are only 3 Distinct Detected Values in this data set
The number of detected data may not be adequate enough to perform GOF tests, bootstrap, and ROS methods.
Those methods will return a 'N/A' value on your output display!

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Surface Soil
Plum Brook Ordnance Works, Sandusky, Ohio

It is necessary to have 4 or more Distinct Values for bootstrap methods.
However, results obtained using 4 to 9 distinct values may not be reliable.
It is recommended to have 10 to 15 or more observations for accurate and meaningful results and estimates.

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.751	Shapiro Wilk Test Statistic	0.765
5% Shapiro Wilk Critical Value	0.767	5% Shapiro Wilk Critical Value	0.767
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.572	Mean	-3.567
SD	1.555	SD	2.24
95% DL/2 (t) UCL	1.614	95% H-Stat (DL/2) UCL	111.4
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE yields a negative mean		Mean in Log Scale	-6.85
		SD in Log Scale	4.711
		Mean in Original Scale	0.567
		SD in Original Scale	1.557
		95% t UCL	1.61
		95% Percentile Bootstrap UCL	1.665
		95% BCA Bootstrap UCL	1.688
		95% H-UCL	4.68E+12
Gamma Distribution Test with Detected Values Only		**Data Distribution Test with Detected Values Only**	
k star (bias corrected)	N/A	Data do not follow a Discernable Distribution (0.05)	
Theta Star	N/A		
nu star	N/A		
A-D Test Statistic	N/A	**Nonparametric Statistics**	
5% A-D Critical Value	N/A	Kaplan-Meier (KM) Method	
K-S Test Statistic	N/A	Mean	0.602
5% K-S Critical Value	N/A	SD	1.443
Data not Gamma Distributed at 5% Significance Level		SE of Mean	0.625
		95% KM (t) UCL	1.786
Assuming Gamma Distribution		95% KM (z) UCL	1.63
Gamma ROS Statistics using Extrapolated Data		95% KM (jackknife) UCL	1.633
Minimum	N/A	95% KM (bootstrap t) UCL	486
Maximum	N/A	95% KM (BCA) UCL	N/A
Mean	N/A	95% KM (Percentile Bootstrap) UCL	N/A
Median	N/A	95% KM (Chebyshev) UCL	3.326
SD	N/A	97.5% KM (Chebyshev) UCL	4.504
k star	N/A	99% KM (Chebyshev) UCL	6.819
Theta star	N/A		
Nu star	N/A	Potential UCLs to Use	
AppChi2	N/A	99% KM (Chebyshev) UCL	6.819
95% Gamma Approximate UCL (Use when n >= 40)	N/A		
95% Adjusted Gamma UCL (Use when n < 40)	N/A		

Warning: Recommended UCL exceeds the maximum observation

Note: DL/2 is not a recommended method.

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Surface Soil
Plum Brook Ordnance Works, Sandusky, Ohio

General UCL Statistics for Full Data Sets

User Selected Options

From File	C:\Documents and Settings\debbi.freer\My Documents\PBOW\TNT A SL - HH\UCL input tabs.xls.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Dinitrotoluene, 2,4- exp - TNTA/WWTP1 SL Surface Soil

General Statistics

Number of Valid Observations 12

Number of Distinct Observations 9

Raw Statistics

Minimum	0.09
Maximum	9.7
Mean	1.079
Geometric Mean	0.232
Median	0.149
SD	2.764
Std. Error of Mean	0.798
Coefficient of Variation	2.561
Skewness	3.27

Log-transformed Statistics

Minimum of Log Data	-2.408
Maximum of Log Data	2.272
Mean of log Data	-1.461
SD of log Data	1.424

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.412
Shapiro Wilk Critical Value	0.859

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.607
Shapiro Wilk Critical Value	0.859

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	2.512

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL (Chen-1995)	3.196
95% Modified-t UCL (Johnson-1978)	2.638

Assuming Lognormal Distribution

95% H-UCL	3.187
95% Chebyshev (MVUE) UCL	1.643
97.5% Chebyshev (MVUE) UCL	2.114
99% Chebyshev (MVUE) UCL	3.039

Gamma Distribution Test

k star (bias corrected)	0.374
Theta Star	2.889
MLE of Mean	1.079
MLE of Standard Deviation	1.766
nu star	8.967
Approximate Chi Square Value (.05)	3.307
Adjusted Level of Significance	0.029
Adjusted Chi Square Value	2.804
Anderson-Darling Test Statistic	2.816
Anderson-Darling 5% Critical Value	0.8
Kolmogorov-Smirnov Test Statistic	0.5
Kolmogorov-Smirnov 5% Critical Value	0.261

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL (Use when n >= 40)	2.926
95% Adjusted Gamma UCL (Use when n < 40)	3.452

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL	2.392
95% Jackknife UCL	2.512
95% Standard Bootstrap UCL	2.35
95% Bootstrap-t UCL	101.9
95% Hall's Bootstrap UCL	52.42
95% Percentile Bootstrap UCL	2.666
95% BCA Bootstrap UCL	3.476
95% Chebyshev(Mean, Sd) UCL	4.557
97.5% Chebyshev(Mean, Sd) UCL	6.062
99% Chebyshev(Mean, Sd) UCL	9.017

Potential UCL to Use

Use 95% Chebyshev (Mean, Sd) UCL 4.557

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Surface Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)
and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Dinitrotoluene, 2,6- exp - TNTA/WWTP1 SL Surface Soil

General Statistics

Number of Valid Observations 12

Number of Distinct Observations 9

Raw Statistics

Minimum	0.081
Maximum	8.7
Mean	0.956
Geometric Mean	0.219
Median	0.149
SD	2.47
Std. Error of Mean	0.713
Coefficient of Variation	2.584
Skewness	3.324

Log-transformed Statistics

Minimum of Log Data	-2.513
Maximum of Log Data	2.163
Mean of log Data	-1.52
SD of log Data	1.383

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.403
Shapiro Wilk Critical Value	0.859

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.634
Shapiro Wilk Critical Value	0.859

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	2.236

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL (Chen-1995)	2.859
95% Modified-t UCL (Johnson-1978)	2.35

Assuming Lognormal Distribution

95% H-UCL	2.615
95% Chebyshev (MVUE) UCL	1.449
97.5% Chebyshev (MVUE) UCL	1.86
99% Chebyshev (MVUE) UCL	2.667

Gamma Distribution Test

k star (bias corrected)	0.385
Theta Star	2.48
MLE of Mean	0.956
MLE of Standard Deviation	1.54
nu star	9.246
Approximate Chi Square Value (.05)	3.476
Adjusted Level of Significance	0.029
Adjusted Chi Square Value	2.958
Anderson-Darling Test Statistic	2.722
Anderson-Darling 5% Critical Value	0.797
Kolmogorov-Smirnov Test Statistic	0.492
Kolmogorov-Smirnov 5% Critical Value	0.261

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL (Use when n >= 40)	2.542
95% Adjusted Gamma UCL (Use when n < 40)	2.987

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL	2.128
95% Jackknife UCL	2.236
95% Standard Bootstrap UCL	2.097
95% Bootstrap-t UCL	68.94
95% Hall's Bootstrap UCL	42.01
95% Percentile Bootstrap UCL	2.281
95% BCA Bootstrap UCL	3.099
95% Chebyshev(Mean, Sd) UCL	4.063
97.5% Chebyshev(Mean, Sd) UCL	5.408
99% Chebyshev(Mean, Sd) UCL	8.049

Potential UCL to Use

Use 95% Chebyshev (Mean, Sd) UCL 4.063

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)
and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Surface Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Dibenz(a,h)anthracene - TNTA/WWTP1 SL Surface Soil

General Statistics

Number of Valid Observations 8

Number of Distinct Observations 8

Raw Statistics

Minimum	0.0936
Maximum	0.486
Mean	0.159
Geometric Mean	0.13
Median	0.0983
SD	0.137
Std. Error of Mean	0.0483
Coefficient of Variation	0.861
Skewness	2.519

Log-transformed Statistics

Minimum of Log Data	-2.369
Maximum of Log Data	-0.722
Mean of log Data	-2.037
SD of log Data	0.585

Warning: There are only 8 Values in this data

Note: It should be noted that even though bootstrap methods may be performed on this data set, the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.56
Shapiro Wilk Critical Value	0.818

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.639
Shapiro Wilk Critical Value	0.818

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	0.25

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL (Chen-1995)	0.284
95% Modified-t UCL (Johnson-1978)	0.257

Assuming Lognormal Distribution

95% H-UCL	0.27
95% Chebyshev (MVUE) UCL	0.289
97.5% Chebyshev (MVUE) UCL	0.349
99% Chebyshev (MVUE) UCL	0.466

Gamma Distribution Test

k star (bias corrected)	1.772
Theta Star	0.0895
MLE of Mean	0.159
MLE of Standard Deviation	0.119
nu star	28.36
Approximate Chi Square Value (.05)	17.21
Adjusted Level of Significance	0.0195
Adjusted Chi Square Value	15.05
Anderson-Darling Test Statistic	1.554
Anderson-Darling 5% Critical Value	0.722
Kolmogorov-Smirnov Test Statistic	0.415
Kolmogorov-Smirnov 5% Critical Value	0.297

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL (Use when n >= 40)	0.262
95% Adjusted Gamma UCL (Use when n < 40)	0.299

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL	0.238
95% Jackknife UCL	0.25
95% Standard Bootstrap UCL	0.233
95% Bootstrap-t UCL	2.403
95% Hall's Bootstrap UCL	1.554
95% Percentile Bootstrap UCL	0.244
95% BCA Bootstrap UCL	0.304
95% Chebyshev(Mean, Sd) UCL	0.369
97.5% Chebyshev(Mean, Sd) UCL	0.46
99% Chebyshev(Mean, Sd) UCL	0.639

Potential UCL to Use

Use 95% Chebyshev (Mean, Sd) UCL 0.369

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Surface Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)
and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Dinitrotoluene, 2,6- SVOC - TNTA/WWTP1 SL Surface Soil

General Statistics

Number of Valid Observations 8

Number of Distinct Observations 8

Raw Statistics

Minimum	0.00994
Maximum	2.18
Mean	0.282
Geometric Mean	0.0204
Median	0.0105
SD	0.767
Std. Error of Mean	0.271
Coefficient of Variation	2.723
Skewness	2.828

Log-transformed Statistics

Minimum of Log Data	-4.611
Maximum of Log Data	0.779
Mean of log Data	-3.89
SD of log Data	1.887

Warning: There are only 8 Values in this data
Note: It should be noted that even though bootstrap methods may be performed on this data set,
the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.419
Shapiro Wilk Critical Value	0.818

Data not Normal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	0.795

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL (Chen-1995)	1.018
95% Modified-t UCL (Johnson-1978)	0.841

Gamma Distribution Test

k star (bias corrected)	0.251
Theta Star	1.124
MLE of Mean	0.282
MLE of Standard Deviation	0.563
nu star	4.011
Approximate Chi Square Value (.05)	0.726
Adjusted Level of Significance	0.0195
Adjusted Chi Square Value	0.445
Anderson-Darling Test Statistic	2.488
Anderson-Darling 5% Critical Value	0.81
Kolmogorov-Smirnov Test Statistic	0.548
Kolmogorov-Smirnov 5% Critical Value	0.319

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL (Use when n >= 40)	1.556
95% Adjusted Gamma UCL (Use when n < 40)	2.538

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.439
Shapiro Wilk Critical Value	0.818

Data not Lognormal at 5% Significance Level

Assuming Lognormal Distribution

95% H-UCL	7.683
95% Chebyshev (MVUE) UCL	0.305
97.5% Chebyshev (MVUE) UCL	0.402
99% Chebyshev (MVUE) UCL	0.593

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL	0.728
95% Jackknife UCL	0.795
95% Standard Bootstrap UCL	0.7
95% Bootstrap-t UCL	601.6
95% Hall's Bootstrap UCL	359.8
95% Percentile Bootstrap UCL	0.824
95% BCA Bootstrap UCL	1.095
95% Chebyshev(Mean, Sd) UCL	1.464
97.5% Chebyshev(Mean, Sd) UCL	1.975
99% Chebyshev(Mean, Sd) UCL	2.98

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Surface Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Potential UCL to Use — Use 95% Hall's Bootstrap UCL 359.8

Recommended UCL exceeds the maximum observation

In Case Bootstrap t and/or Hall's Bootstrap yields an unreasonably large UCL value, use 97.5% or 99% Chebyshev (Mean, Sd) UCL

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)
and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Indeno(1,2,3-cd)pyrene - TNTA/WWTP1 SL Surface Soil

General Statistics

Number of Valid Observations 8 — Number of Distinct Observations 7

Raw Statistics		Log-transformed Statistics	
Minimum	0.134	Minimum of Log Data	-2.01
Maximum	1.06	Maximum of Log Data	0.0583
Mean	0.325	Mean of log Data	-1.511
Geometric Mean	0.221	SD of log Data	0.847
Median	0.141		
SD	0.355		
Std. Error of Mean	0.126		
Coefficient of Variation	1.093		
Skewness	1.744		

Warning: There are only 8 Values in this data
Note: It should be noted that even though bootstrap methods may be performed on this data set,
the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.62	Shapiro Wilk Test Statistic	0.631
Shapiro Wilk Critical Value	0.818	Shapiro Wilk Critical Value	0.818
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	0.563	95% H-UCL	0.843
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	0.698
95% Adjusted-CLT UCL (Chen-1995)	0.615	97.5% Chebyshev (MVUE) UCL	0.87
95% Modified-t UCL (Johnson-1978)	0.576	99% Chebyshev (MVUE) UCL	1.209

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Surface Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Gamma Distribution Test

k star (bias corrected)	0.981
Theta Star	0.331
MLE of Mean	0.325
MLE of Standard Deviation	0.328
nu star	15.7
Approximate Chi Square Value (.05)	7.75
Adjusted Level of Significance	0.0195
Adjusted Chi Square Value	6.391
Anderson-Darling Test Statistic	1.637
Anderson-Darling 5% Critical Value	0.729
Kolmogorov-Smirnov Test Statistic	0.449
Kolmogorov-Smirnov 5% Critical Value	0.299

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL (Use when n >= 40)	0.658
95% Adjusted Gamma UCL (Use when n < 40)	0.799

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL	0.532
95% Jackknife UCL	0.563
95% Standard Bootstrap UCL	0.518
95% Bootstrap-t UCL	12.02
95% Hall's Bootstrap UCL	10.79
95% Percentile Bootstrap UCL	0.554
95% BCA Bootstrap UCL	0.601
95% Chebyshev(Mean, Sd) UCL	0.873
97.5% Chebyshev(Mean, Sd) UCL	1.11
99% Chebyshev(Mean, Sd) UCL	1.575

Potential UCL to Use

Use 95% Chebyshev (Mean, Sd) UCL 0.873

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Input for ProUCL
TNTA/WWTP1 Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Aroclor 1016	D_Aroclor 1016	Amino-2,6-dinitrotoluene, 4-	D_Amino-2,6-dinitrotoluene, 4-	Amino-4,6-dinitrotoluene, 2-	D_Amino-4,6-dinitrotoluene, 2-
0.125	1	17.2	1	16	1
0.0478	1	0.209	1	0.149	1
0.0191	1	0.267	1	0.061	0
0.0553	1	0.268	1	0.071	0
1.16	1	0.1625	1	0.056	0
0.0828	1	0.061	0	0.061	0
0.0828	1	0.071	0	0.065	0
0.00846	0	0.056	0	0.064	0
0.00796	0	0.061	0	0.15	0
0.00802	0	0.065	0	0.149	0
0.0077	0	0.064	0	0.149	0
0.00768	0	0.15	0	0.149	0
0.00783	0	0.149	0	0.15	0
0.00762	0	0.149	0	0.149	0
0.00788	0	0.149	0	0.15	0
0.00751	0	0.15	0	0.149	0
0.00806	0	0.149	0	0.144	0
0.00727	0	0.15	0	0.149	0
0.00738	0	0.149	0	0.146	0
0.00851	0	0.144	0	0.147	0
		0.149	0	0.15	0
		0.146	0	0.149	0
		0.147	0	0.149	0
		0.15	0	0.073	0
		0.149	0	0.078	0
		0.149	0	0.076	0
		0.073	0	0.074	0
		0.078	0	0.153	0
		0.076	0	0.147	0
		0.074	0	0.139	0
		0.153	0	0.15	0
		0.147	0	0.14	0
		0.139	0	0.142	0
		0.15	0	0.147	0
		0.14	0	0.141	0
		0.142	0	0.155	0
		0.147	0	0.146	0
		0.141	0	0.145	0
		0.155	0	0.149	0
		0.146	0	0.1125	0
		0.145	0	0.147	0
		0.149	0	0.1475	0
		0.1125	0	0.15	0
		0.1475	0	0.605	1
		0.15	0	50.1	1
		0.471	1	1.63	1
		31.3	1	0.401	1
		2.04	1	0.476	1
		3.78	1	9.98	1
		1.67	1	3.16	1

Input for ProUCL
TNTA/WWTP1 Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Dinitrotoluene, 2,4- exp	D_Dinitrotoluene, 2,4- exp	Dinitrotoluene, 2,6- exp	D_Dinitrotoluene, 2,6- exp	Trinitrotoluene, 2,4,6-	D_Trinitrotoluene, 2,4,6-
0.9225	1	0.3305	1	212.5	1
1.93	1	1.475	1	0.0895	1
0.201	1	0.217	1	0.21	1
0.074	0	0.067	0	0.271	1
0.086	0	0.077	0	0.149	1
0.068	0	0.061	0	1.09	1
0.074	0	0.067	0	690.03965	1
0.078	0	0.16	0	0.532	1
0.078	0	0.07	0	0.061	0
0.148	0	0.148	0	0.056	0
0.15	0	0.149	0	0.061	0
0.149	0	0.149	0	0.064	0
0.149	0	0.15	0	0.148	0
0.149	0	0.147	0	0.15	0
0.15	0	0.15	0	0.149	0
0.149	0	0.149	0	0.149	0
0.15	0	0.144	0	0.149	0
0.144	0	0.149	0	0.15	0
0.149	0	0.146	0	0.147	0
0.146	0	8.7	0	0.15	0
0.147	0	0.087	0	0.144	0
0.15	0	0.079	0	0.146	0
0.149	0	0.084	0	0.147	0
0.149	0	0.082	0	0.15	0
9.7	0	0.081	0	0.149	0
0.097	0	0.153	0	0.149	0
0.088	0	0.147	0	0.073	0
0.094	0	0.139	0	0.076	0
0.092	0	0.15	0	0.074	0
0.09	0	0.137	0	0.153	0
0.153	0	0.14	0	0.147	0
0.147	0	0.142	0	0.139	0
0.139	0	0.147	0	0.15	0
0.15	0	0.141	0	0.137	0
0.137	0	0.155	0	0.14	0
0.14	0	0.146	0	0.142	0
0.142	0	0.145	0	0.147	0
0.147	0	0.15	0	0.155	0
0.141	0	0.149	0	0.146	0
0.155	0	0.149	0	0.201	0
0.146	0	0.147	0	0.149	0
0.145	0	0.15	0	0.1475	0
0.149	0	0.149	0	0.487	1
0.147	0	0.149	0	0.371	1
0.1475	0	0.149	0	1200	1
0.15	0	0.147	0	18	1
0.404	1	0.1475	0	0.549	1
0.624	1	0.15	0	0.68	1
3.25	1	0.526	1	3.35	1
0.896	1	0.529	1	77.8	1

Input for ProUCL
TNTA/WWTP1 Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Benzo(a)anthracene	D_Benzo(a)anthracene	Benzo(a)pyrene	D_Benzo(a)pyrene	Benzo(b)fluoranthene	D_Benzo(b)fluoranthene	Dibenz(a,h)anthracene	D_Dibenz(a,h)anthracene
0.047	1	0.053	1	0.0713	1	0.196	1
0.0581	1	0.0281	0	0.0962	1	0.0965	0
0.0261	0	0.0261	0	0.0663	0	0.0899	0
0.0286	0	0.0286	0	0.0725	0	0.0984	0
0.0263	0	0.0263	0	0.0665	0	0.0903	0
0.0285	0	0.0285	0	0.0723	0	0.0981	0
0.0261	0	0.0261	0	0.0661	0	0.0896	0
0.141	0	0.141	0	0.358	0	0.486	0
0.0254	0	0.0254	0	0.0645	0	0.0875	0
0.0272	0	0.0272	0	0.069	0	0.0936	0
0.0253	0	0.0253	0	0.0641	0	0.087	0
0.0257	0	0.0257	0	0.0652	0	0.0884	0
0.025	0	0.025	0	0.0634	0	0.105	0
0.0259	0	0.0259	0	0.0656	0	0.086	0
0.0243	0	0.0243	0	0.0615	0	0.089	0
0.0264	0	0.0264	0	0.0669	0	0.0834	0
0.0241	0	0.0241	0	0.0611	0	0.0907	0
0.0243	0	0.0243	0	0.0615	0	0.0829	0
0.0279	0	0.0279	0	0.0707	0	0.08345	0
1.54	1	1.18	1	2	1	0.0959	0

Input for ProUCL
TNTA/WWTP1 Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Dinitrotoluene, 2,4-	D_Dinitrotoluene, 2,4-	Dinitrotoluene, 2,6-	D_Dinitrotoluene, 2,6-	Indeno(1,2,3-cd)pyrene	D_Indeno(1,2,3-cd)pyrene
0.0615	1	0.128	1	0.138	0
0.104	1	0.0411	1	0.129	0
0.0563	1	0.0102	0	0.141	0
0.0818	1	0.00955	0	0.13	0
0.015	0	0.0111	0	0.141	0
0.014	0	0.0105	0	0.129	0
0.0153	0	0.00959	0	0.698	0
0.014	0	0.0104	0	0.125	0
0.0152	0	0.00952	0	0.134	0
0.0136	0	0.00929	0	0.125	0
0.0163	0	0.00994	0	0.127	0
0.0134	0	0.0112	0	0.151	0
0.0138	0	0.00913	0	0.123	0
0.013	0	0.00945	0	0.128	0
0.0141	0	0.00887	0	0.12	0
0.0129	0	0.00964	0	0.13	0
0.01295	0	0.00881	0	0.119	0
0.0149	0	0.00887	0	0.1195	0
4.42	1	0.010185	0	0.1375	0
0.434	1	2.18	1	1.06	1

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	base soil UCL input.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Aroclor 1016 - TNTA/WWTP1 SL Total Soil

General Statistics

Number of Valid Data	20	Number of Detected Data	7
Number of Distinct Detected Data	6	Number of Non-Detect Data	13
		Percent Non-Detects	65.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.0191	Minimum Detected	-3.958
Maximum Detected	1.16	Maximum Detected	0.148
Mean of Detected	0.225	Mean of Detected	-2.401
SD of Detected	0.414	SD of Detected	1.271
Minimum Non-Detect	0.00727	Minimum Non-Detect	-4.924
Maximum Non-Detect	0.00851	Maximum Non-Detect	-4.767

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	13
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	7
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	65.00%

Warning: There are only 7 Detected Values in this data

Note: It should be noted that even though bootstrap may be performed on this data set

the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.531	Shapiro Wilk Test Statistic	0.872
5% Shapiro Wilk Critical Value	0.803	5% Shapiro Wilk Critical Value	0.803
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.0812	Mean	-4.443
SD	0.256	SD	1.696
95% DL/2 (t) UCL	0.18	95% H-Stat (DL/2) UCL	0.214
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE yields a negative mean		Mean in Log Scale	-5.075
		SD in Log Scale	2.136
		Mean in Original Scale	0.0796
		SD in Original Scale	0.257
		95% t UCL	0.179
		95% Percentile Bootstrap UCL	0.188
		95% BCA Bootstrap UCL	0.255
		95% H-UCL	0.57

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.478
Theta Star	0.47
nu star	6.691
A-D Test Statistic	0.98
5% A-D Critical Value	0.741
K-S Test Statistic	0.741
5% K-S Critical Value	0.324

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data

Minimum	0.000001
Maximum	1.16
Mean	0.0786
Median	0.000001
SD	0.257
k star	0.127
Theta star	0.619
Nu star	5.08
AppChi2	1.19
95% Gamma Approximate UCL (Use when n >= 40)	0.336
95% Adjusted Gamma UCL (Use when n < 40)	0.381

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data appear Lognormal at 5% Significance Level

Nonparametric Statistics

Kaplan-Meier (KM) Method

Mean	0.0911
SD	0.247
SE of Mean	0.0596
95% KM (t) UCL	0.194
95% KM (z) UCL	0.189
95% KM (jackknife) UCL	0.178
95% KM (bootstrap t) UCL	0.798
95% KM (BCA) UCL	0.231
95% KM (Percentile Bootstrap) UCL	0.216
95% KM (Chebyshev) UCL	0.351
97.5% KM (Chebyshev) UCL	0.464
99% KM (Chebyshev) UCL	0.684

Potential UCLs to Use

95% KM (BCA) UCL	0.231

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Amino-2,6-dinitrotoluene, 4- - TNTA/WWTP1 SL Total Soil

General Statistics

Number of Valid Data	50	Number of Detected Data	10
Number of Distinct Detected Data	10	Number of Non-Detect Data	40
		Percent Non-Detects	80.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.163	Minimum Detected	-1.817
Maximum Detected	31.3	Maximum Detected	3.444
Mean of Detected	5.737	Mean of Detected	0.207
SD of Detected	10.37	SD of Detected	1.881
Minimum Non-Detect	0.056	Minimum Non-Detect	-2.882
Maximum Non-Detect	0.155	Maximum Non-Detect	-1.864

Note: Data have multiple DLs - Use of KM Method is recommended
For all methods (except KM, DL/2, and ROS Methods),
Observations < Largest ND are treated as NDs

Number treated as Non-Detect	40
Number treated as Detected	10
Single DL Non-Detect Percentage	80.00%

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

UCL Statistics

Normal Distribution Test with Detected Values Only

Shapiro Wilk Test Statistic	0.619
5% Shapiro Wilk Critical Value	0.842

Data not Normal at 5% Significance Level

Assuming Normal Distribution

DL/2 Substitution Method	
Mean	1.198
SD	5.001
95% DL/2 (t) UCL	2.384
Maximum Likelihood Estimate(MLE) Method	N/A

MLE yields a negative mean

Lognormal Distribution Test with Detected Values Only

Shapiro Wilk Test Statistic	0.894
5% Shapiro Wilk Critical Value	0.842

Data appear Lognormal at 5% Significance Level

Assuming Lognormal Distribution

DL/2 Substitution Method	
Mean	-2.206
SD	1.494
95% H-Stat (DL/2) UCL	0.629
Log ROS Method	
Mean in Log Scale	-6.177
SD in Log Scale	3.763
Mean in Original Scale	1.149
SD in Original Scale	5.013
95% t UCL	2.338
95% Percentile Bootstrap UCL	2.42
95% BCA Bootstrap UCL	3.252
95% H-UCL	70.7

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.363
Theta Star	15.8
nu star	7.262
A-D Test Statistic	0.787
5% A-D Critical Value	0.791
K-S Test Statistic	0.791
5% K-S Critical Value	0.284

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	0.000001
Maximum	31.3
Mean	1.147
Median	0.000001
SD	5.013
k star	0.0841
Theta star	13.64
Nu star	8.415
AppChi2	2.977
95% Gamma Approximate UCL (Use when n >= 40)	3.243
95% Adjusted Gamma UCL (Use when n < 40)	3.35

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data appear Gamma Distributed at 5% Significance Level

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	1.277
SD	4.933
SE of Mean	0.735
95% KM (t) UCL	2.51
95% KM (z) UCL	2.487
95% KM (jackknife) UCL	2.425
95% KM (bootstrap t) UCL	10.37
95% KM (BCA) UCL	2.86
95% KM (Percentile Bootstrap) UCL	2.519
95% KM (Chebyshev) UCL	4.483
97.5% KM (Chebyshev) UCL	5.87
99% KM (Chebyshev) UCL	8.594

Potential UCLs to Use

95% KM (t) UCL	2.51

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Amino-4,6-dinitrotoluene, 2- - TNTA/WWTP1 SL Total Soil

General Statistics

Number of Valid Data	50	Number of Detected Data	9
Number of Distinct Detected Data	9	Number of Non-Detect Data	41
		Percent Non-Detects	82.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.149	Minimum Detected	-1.904
Maximum Detected	50.1	Maximum Detected	3.914
Mean of Detected	9.167	Mean of Detected	0.729
SD of Detected	16.29	SD of Detected	1.947
Minimum Non-Detect	0.056	Minimum Non-Detect	-2.882
Maximum Non-Detect	0.155	Maximum Non-Detect	-1.864

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	42
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	8
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	84.00%

Warning: There are only 9 Detected Values in this data
Note: It should be noted that even though bootstrap may be performed on this data set
the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.631	Shapiro Wilk Test Statistic	0.954
5% Shapiro Wilk Critical Value	0.829	5% Shapiro Wilk Critical Value	0.829
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	1.702	Mean	-2.168
SD	7.47	SD	1.611
95% DL/2 (t) UCL	3.473	95% H-Stat (DL/2) UCL	0.853
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE yields a negative mean		Mean in Log Scale	-6.342
		SD in Log Scale	3.963
		Mean in Original Scale	1.652
		SD in Original Scale	7.481
		95% t UCL	3.426
		95% Percentile Bootstrap UCL	3.697
		95% BCA Bootstrap UCL	5.11
		95% H-UCL	185.5

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.365
Theta Star	25.11
nu star	6.572
A-D Test Statistic	0.478
5% A-D Critical Value	0.782
K-S Test Statistic	0.782
5% K-S Critical Value	0.296

Data appear Gamma Distributed at 5% Significance Level

Data Distribution Test with Detected Values Only

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data

Minimum	0.000001
Maximum	50.1
Mean	1.65
Median	0.000001
SD	7.482
k star	0.0811
Theta star	20.34
Nu star	8.114
AppChi2	2.801
95% Gamma Approximate UCL (Use when n >= 40)	4.779
95% Adjusted Gamma UCL (Use when n < 40)	4.942

Note: DL/2 is not a recommended method.

Nonparametric Statistics

Kaplan-Meier (KM) Method

Mean	1.772
SD	7.38
SE of Mean	1.107
95% KM (t) UCL	3.628
95% KM (z) UCL	3.593
95% KM (jackknife) UCL	3.377
95% KM (bootstrap t) UCL	8.885
95% KM (BCA) UCL	4.379
95% KM (Percentile Bootstrap) UCL	3.896
95% KM (Chebyshev) UCL	6.597
97.5% KM (Chebyshev) UCL	8.685
99% KM (Chebyshev) UCL	12.79

Potential UCLs to Use

95% KM (t) UCL	3.628

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Dinitrotoluene, 2,4- exp - TNTA/WWTP1 SL Total Soil

General Statistics

Number of Valid Data	50	Number of Detected Data	7
Number of Distinct Detected Data	7	Number of Non-Detect Data	43
		Percent Non-Detects	86.00%

Raw Statistics

Minimum Detected	0.201
Maximum Detected	3.25
Mean of Detected	1.175
SD of Detected	1.07
Minimum Non-Detect	0.068
Maximum Non-Detect	9.7

Log-transformed Statistics

Minimum Detected	-1.604
Maximum Detected	1.179
Mean of Detected	-0.191
SD of Detected	0.931
Minimum Non-Detect	-2.688
Maximum Non-Detect	2.272

Note: Data have multiple DLs - Use of KM Method is recommended
For all methods (except KM, DL/2, and ROS Methods),
Observations < Largest ND are treated as NDs

Number treated as Non-Detect	50
Number treated as Detected	0
Single DL Non-Detect Percentage	100.00%

Warning: There are only 7 Detected Values in this data
Note: It should be noted that even though bootstrap may be performed on this data set
the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

UCL Statistics

Normal Distribution Test with Detected Values Only

Shapiro Wilk Test Statistic	0.843
5% Shapiro Wilk Critical Value	0.803

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

DL/2 Substitution Method	
Mean	0.316
SD	0.848
95% DL/2 (t) UCL	0.517
Maximum Likelihood Estimate(MLE) Method	N/A

MLE method failed to converge properly

Lognormal Distribution Test with Detected Values Only

Shapiro Wilk Test Statistic	0.985
5% Shapiro Wilk Critical Value	0.803

Data appear Lognormal at 5% Significance Level

Assuming Lognormal Distribution

DL/2 Substitution Method	
Mean	-2.313
SD	1.134
95% H-Stat (DL/2) UCL	0.282
Log ROS Method	
Mean in Log Scale	-4.19
SD in Log Scale	1.964
Mean in Original Scale	0.177
SD in Original Scale	0.553
95% t UCL	0.308
95% Percentile Bootstrap UCL	0.31
95% BCA Bootstrap UCL	0.379
95% H-UCL	0.283

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.989
Theta Star	1.188
nu star	13.85
A-D Test Statistic	0.233
5% A-D Critical Value	0.72
K-S Test Statistic	0.72
5% K-S Critical Value	0.317

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	0.000001
Maximum	3.25
Mean	0.165
Median	0.000001
SD	0.557
k star	0.0907
Theta star	1.814
Nu star	9.069
AppChi2	3.369
95% Gamma Approximate UCL (Use when n >= 40)	0.443
95% Adjusted Gamma UCL (Use when n < 40)	0.457

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data appear Normal at 5% Significance Level

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	0.34
SD	0.506
SE of Mean	0.0781
95% KM (t) UCL	0.471
95% KM (z) UCL	0.469
95% KM (jackknife) UCL	0.487
95% KM (bootstrap t) UCL	0.613
95% KM (BCA) UCL	0.969
95% KM (Percentile Bootstrap) UCL	0.791
95% KM (Chebyshev) UCL	0.681
97.5% KM (Chebyshev) UCL	0.828
99% KM (Chebyshev) UCL	1.118

Potential UCLs to Use

95% KM (t) UCL	0.471
95% KM (Percentile Bootstrap) UCL	0.791

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Dinitrotoluene, 2,6- exp - TNTA/WWTP1 SL Total Soil

General Statistics

Number of Valid Data	50	Number of Detected Data	5
Number of Distinct Detected Data	5	Number of Non-Detect Data	45
		Percent Non-Detects	90.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.217	Minimum Detected	-1.528
Maximum Detected	1.475	Maximum Detected	0.389
Mean of Detected	0.616	Mean of Detected	-0.705
SD of Detected	0.499	SD of Detected	0.715
Minimum Non-Detect	0.061	Minimum Non-Detect	-2.797
Maximum Non-Detect	8.7	Maximum Non-Detect	2.163

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	50
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	0
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	100.00%

Warning: There are only 5 Detected Values in this data
Note: It should be noted that even though bootstrap may be performed on this data set
the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.786	Shapiro Wilk Test Statistic	0.942
5% Shapiro Wilk Critical Value	0.762	5% Shapiro Wilk Critical Value	0.762
Data appear Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.206	Mean	-2.47
SD	0.637	SD	0.91
95% DL/2 (t) UCL	0.357	95% H-Stat (DL/2) UCL	0.171
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	-4.586
		SD in Log Scale	1.659
		Mean in Original Scale	0.0716
		SD in Original Scale	0.232
		95% t UCL	0.127
		95% Percentile Bootstrap UCL	0.129
		95% BCA Bootstrap UCL	0.169
		95% H-UCL	0.0852

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	1.105
Theta Star	0.557
nu star	11.05
A-D Test Statistic	0.396
5% A-D Critical Value	0.684
K-S Test Statistic	0.684
5% K-S Critical Value	0.36

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data

Minimum	0.000001
Maximum	1.475
Mean	0.0616
Median	0.000001
SD	0.235
k star	0.0934
Theta star	0.659
Nu star	9.344
AppChi2	3.536
95% Gamma Approximate UCL (Use when n >= 40)	0.163
95% Adjusted Gamma UCL (Use when n < 40)	0.168

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data appear Normal at 5% Significance Level

Nonparametric Statistics

Kaplan-Meier (KM) Method

Mean	0.258
SD	0.187
SE of Mean	0.0298
95% KM (t) UCL	0.308
95% KM (z) UCL	0.307
95% KM (jackknife) UCL	0.334
95% KM (bootstrap t) UCL	0.343
95% KM (BCA) UCL	0.565
95% KM (Percentile Bootstrap) UCL	0.548
95% KM (Chebyshev) UCL	0.388
97.5% KM (Chebyshev) UCL	0.444
99% KM (Chebyshev) UCL	0.554

Potential UCLs to Use

95% KM (t) UCL	0.308
95% KM (Percentile Bootstrap) UCL	0.548

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Trinitrotoluene, 2,4,6- - TNTA/WWTP1 SL Total Soil

General Statistics

Number of Valid Data	50	Number of Detected Data	17
Number of Distinct Detected Data	17	Number of Non-Detect Data	33
		Percent Non-Detects	66.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.0895	Minimum Detected	-2.414
Maximum Detected	1200	Maximum Detected	7.09
Mean of Detected	129.8	Mean of Detected	0.906
SD of Detected	324.2	SD of Detected	3.113
Minimum Non-Detect	0.056	Minimum Non-Detect	-2.882
Maximum Non-Detect	0.155	Maximum Non-Detect	-1.864

Note: Data have multiple DLs - Use of KM Method is recommended
For all methods (except KM, DL/2, and ROS Methods),
Observations < Largest ND are treated as NDs

Number treated as Non-Detect	35
Number treated as Detected	15
Single DL Non-Detect Percentage	70.00%

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

UCL Statistics

Normal Distribution Test with Detected Values Only

Shapiro Wilk Test Statistic	0.476
5% Shapiro Wilk Critical Value	0.892

Data not Normal at 5% Significance Level

Assuming Normal Distribution

DL/2 Substitution Method	
Mean	44.17
SD	195.4
95% DL/2 (t) UCL	90.49
Maximum Likelihood Estimate(MLE) Method	N/A

MLE yields a negative mean

Lognormal Distribution Test with Detected Values Only

Shapiro Wilk Test Statistic	0.835
5% Shapiro Wilk Critical Value	0.892

Data not Lognormal at 5% Significance Level

Assuming Lognormal Distribution

DL/2 Substitution Method	
Mean	-1.526
SD	2.52
95% H-Stat (DL/2) UCL	25.07
Log ROS Method	
Mean in Log Scale	-5.357
SD in Log Scale	5.196
Mean in Original Scale	44.13
SD in Original Scale	195.4
95% t UCL	90.45
95% Percentile Bootstrap UCL	93.14
95% BCA Bootstrap UCL	128.3
95% H-UCL	1845284

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.194
Theta Star	669.7
nu star	6.589
A-D Test Statistic	2.095
5% A-D Critical Value	0.887
K-S Test Statistic	0.887
5% K-S Critical Value	0.232

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	0.000001
Maximum	1200
Mean	44.13
Median	0.000001
SD	195.4
k star	0.0768
Theta star	574.9
Nu star	7.675
AppChi2	2.548
95% Gamma Approximate UCL (Use when n >= 40)	132.9
95% Adjusted Gamma UCL (Use when n < 40)	137.6

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	44.19
SD	193.4
SE of Mean	28.19
95% KM (t) UCL	91.45
95% KM (z) UCL	90.56
95% KM (jackknife) UCL	90.47
95% KM (bootstrap t) UCL	295.8
95% KM (BCA) UCL	95.85
95% KM (Percentile Bootstrap) UCL	94.59
95% KM (Chebyshev) UCL	**167.1**
97.5% KM (Chebyshev) UCL	220.2
99% KM (Chebyshev) UCL	324.7

Potential UCLs to Use

99% KM (Chebyshev) UCL	324.7

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Benzo(a)anthracene - TNTA/WWTP1 SL Total Soil

General Statistics

Number of Valid Data	20	Number of Detected Data	3
Number of Distinct Detected Data	3	Number of Non-Detect Data	17
		Percent Non-Detects	85.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.047	Minimum Detected	-3.058
Maximum Detected	1.54	Maximum Detected	0.432
Mean of Detected	0.548	Mean of Detected	-1.824
SD of Detected	0.859	SD of Detected	1.956
Minimum Non-Detect	0.0241	Minimum Non-Detect	-3.726
Maximum Non-Detect	0.141	Maximum Non-Detect	-1.959

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	19
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	1
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	95.00%

Warning: There are only 3 Distinct Detected Values in this data set
The number of detected data may not be adequate enough to perform GOF tests, bootstrap, and ROS methods.
Those methods will return a 'N/A' value on your output display!

It is necessary to have 4 or more Distinct Values for bootstrap methods.
However, results obtained using 4 to 9 distinct values may not be reliable.
It is recommended to have 10 to 15 or more observations for accurate and meaningful results and estimates.

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.756	Shapiro Wilk Test Statistic	0.795
5% Shapiro Wilk Critical Value	0.767	5% Shapiro Wilk Critical Value	0.767
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.0962	Mean	-3.879
SD	0.34	SD	1.154
95% DL/2 (t) UCL	0.228	95% H-Stat (DL/2) UCL	0.0858
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	-8.572
		SD in Log Scale	3.033
		Mean in Original Scale	0.0823
		SD in Original Scale	0.343
		95% t UCL	0.215
		95% Percentile Bootstrap UCL	0.234
		95% BCA Bootstrap UCL	0.318
		95% H-UCL	1.43

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Gamma Distribution Test with Detected Values Only	
k star (bias corrected)	N/A
Theta Star	N/A
nu star	N/A
A-D Test Statistic	N/A
5% A-D Critical Value	N/A
K-S Test Statistic	N/A
5% K-S Critical Value	N/A
Data not Gamma Distributed at 5% Significance Level	
Assuming Gamma Distribution	
Gamma ROS Statistics using Extrapolated Data	
Minimum	N/A
Maximum	N/A
Mean	N/A
Median	N/A
SD	N/A
k star	N/A
Theta star	N/A
Nu star	N/A
AppChi2	N/A
95% Gamma Approximate UCL (Use when n >= 40)	N/A
95% Adjusted Gamma UCL (Use when n < 40)	N/A

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only
Data appear Lognormal at 5% Significance Level

Nonparametric Statistics	
Kaplan-Meier (KM) Method	
Mean	0.122
SD	0.325
SE of Mean	0.0891
95% KM (t) UCL	0.276
95% KM (z) UCL	0.269
95% KM (jackknife) UCL	0.244
95% KM (bootstrap t) UCL	8.054
95% KM (BCA) UCL	1.54
95% KM (Percentile Bootstrap) UCL	1.54
95% KM (Chebyshev) UCL	**0.511**
97.5% KM (Chebyshev) UCL	0.679
99% KM (Chebyshev) UCL	1.009
Potential UCLs to Use	
97.5% KM (Chebyshev) UCL	0.679

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Benzo(a)pyrene - TNTA/WWTP1 SL Total Soil

General Statistics

Number of Valid Data	20	Number of Detected Data	2
Number of Distinct Detected Data	2	Number of Non-Detect Data	18
		Percent Non-Detects	90.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.053	Minimum Detected	-2.937
Maximum Detected	1.18	Maximum Detected	0.166
Mean of Detected	0.617	Mean of Detected	-1.386
SD of Detected	0.797	SD of Detected	2.194
Minimum Non-Detect	0.0241	Minimum Non-Detect	-3.726
Maximum Non-Detect	0.141	Maximum Non-Detect	-1.959

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	19
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	1
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	95.00%

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Warning: Data set has only 2 Distinct Detected Values.
This may not be adequate enough to compute meaningful and reliable test statistics and estimates.
The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).

Unless Data Quality Objectives (DQOs) have been met, it is suggested to collect additional observations.

The number of detected data may not be adequate enough to perform GOF tests, bootstrap, and ROS methods.
Those methods will return a 'N/A' value on your output display!

It is necessary to have 4 or more Distinct Values for bootstrap methods.
However, results obtained using 4 to 9 distinct values may not be reliable.
It is recommended to have 10 to 15 or more observations for accurate and meaningful results and estimates.

UCL Statistics

Normal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	N/A
5% Shapiro Wilk Critical Value	N/A
Data not Normal at 5% Significance Level	

Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	N/A
5% Shapiro Wilk Critical Value	N/A
Data not Lognormal at 5% Significance Level	

Assuming Normal Distribution	
DL/2 Substitution Method	
Mean	0.0763
SD	0.26
95% DL/2 (t) UCL	0.177
Maximum Likelihood Estimate(MLE) Method	N/A
MLE method failed to converge properly	

Assuming Lognormal Distribution	
DL/2 Substitution Method	
Mean	-3.958
SD	1.082
95% H-Stat (DL/2) UCL	0.068
Log ROS Method	
Mean in Log Scale	N/A
SD in Log Scale	N/A
Mean in Original Scale	N/A
SD in Original Scale	N/A
95% t UCL	N/A
95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A
95% H-UCL	N/A

Gamma Distribution Test with Detected Values Only	
k star (bias corrected)	N/A
Theta Star	N/A
nu star	N/A
A-D Test Statistic	N/A
5% A-D Critical Value	N/A
K-S Test Statistic	N/A
5% K-S Critical Value	N/A
Data not Gamma Distributed at 5% Significance Level	
Assuming Gamma Distribution	
Gamma ROS Statistics using Extrapolated Data	
Minimum	N/A
Maximum	N/A
Mean	N/A
Median	N/A
SD	N/A
k star	N/A
Theta star	N/A
Nu star	N/A

Data Distribution Test with Detected Values Only
Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics	
Kaplan-Meier (KM) Method	
Mean	0.109
SD	0.246
SE of Mean	0.0777
95% KM (t) UCL	0.244
95% KM (z) UCL	0.237
95% KM (jackknife) UCL	0.857
95% KM (bootstrap t) UCL	N/A
95% KM (BCA) UCL	1.18
95% KM (Percentile Bootstrap) UCL	N/A
95% KM (Chebyshev) UCL	0.448
97.5% KM (Chebyshev) UCL	0.594
99% KM (Chebyshev) UCL	0.882
Potential UCLs to Use	

AppChi2	N/A	99% KM (Chebyshev) UCL	0.882
95% Gamma Approximate UCL (Use when n >= 40)	N/A		
95% Adjusted Gamma UCL (Use when n < 40)	N/A		

Note: DL/2 is not a recommended method.

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Benzo(b)fluoranthene - TNTA/WWTP1 SL Total Soil

General Statistics

Number of Valid Data	20	Number of Detected Data	3
Number of Distinct Detected Data	3	Number of Non-Detect Data	17
		Percent Non-Detects	85.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.0713	Minimum Detected	-2.641
Maximum Detected	2	Maximum Detected	0.693
Mean of Detected	0.723	Mean of Detected	-1.43
SD of Detected	1.106	SD of Detected	1.845
Minimum Non-Detect	0.0611	Minimum Non-Detect	-2.795
Maximum Non-Detect	0.358	Maximum Non-Detect	-1.027

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	19
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	1
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	95.00%

Warning: There are only 3 Distinct Detected Values in this data set
The number of detected data may not be adequate enough to perform GOF tests, bootstrap, and ROS methods.
Those methods will return a 'N/A' value on your output display!

It is necessary to have 4 or more Distinct Values for bootstrap methods.
However, results obtained using 4 to 9 distinct values may not be reliable.
It is recommended to have 10 to 15 or more observations for accurate and meaningful results and estimates.

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.76	Shapiro Wilk Test Statistic	0.817
5% Shapiro Wilk Critical Value	0.767	5% Shapiro Wilk Critical Value	0.767
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Assuming Normal Distribution

DL/2 Substitution Method	
Mean	0.144
SD	0.438
95% DL/2 (t) UCL	0.313
Maximum Likelihood Estimate(MLE) Method	N/A

MLE method failed to converge properly

Assuming Lognormal Distribution

DL/2 Substitution Method	
Mean	-3.03
SD	0.989
95% H-Stat (DL/2) UCL	0.143
Log ROS Method	
Mean in Log Scale	-7.357
SD in Log Scale	2.674
Mean in Original Scale	0.109
SD in Original Scale	0.446
95% t UCL	0.281
95% Percentile Bootstrap UCL	0.307
95% BCA Bootstrap UCL	0.411
95% H-UCL	0.685

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	N/A
Theta Star	N/A
nu star	N/A
A-D Test Statistic	N/A
5% A-D Critical Value	N/A
K-S Test Statistic	N/A
5% K-S Critical Value	N/A

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	N/A
Maximum	N/A
Mean	N/A
Median	N/A
SD	N/A
k star	N/A
Theta star	N/A
Nu star	N/A
AppChi2	N/A
95% Gamma Approximate UCL (Use when n >= 40)	N/A
95% Adjusted Gamma UCL (Use when n < 40)	N/A

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data appear Lognormal at 5% Significance Level

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	0.169
SD	0.42
SE of Mean	0.115
95% KM (t) UCL	0.368
95% KM (z) UCL	0.358
95% KM (jackknife) UCL	0.32
95% KM (bootstrap t) UCL	6.037
95% KM (BCA) UCL	N/A
95% KM (Percentile Bootstrap) UCL	N/A
95% KM (Chebyshev) UCL	**0.671**
97.5% KM (Chebyshev) UCL	0.888
99% KM (Chebyshev) UCL	1.314

Potential UCLs to Use

97.5% KM (Chebyshev) UCL	0.888

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Dinitrotoluene, 2,4- SVOC - TNTA/WWTP1 SL Total Soil

General Statistics

Number of Valid Data	20	Number of Detected Data	6
Number of Distinct Detected Data	6	Number of Non-Detect Data	14
		Percent Non-Detects	70.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.0563	Minimum Detected	-2.877
Maximum Detected	4.42	Maximum Detected	1.486
Mean of Detected	0.86	Mean of Detected	-1.63
SD of Detected	1.75	SD of Detected	1.697
Minimum Non-Detect	0.0129	Minimum Non-Detect	-4.351
Maximum Non-Detect	0.0163	Maximum Non-Detect	-4.117

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	14
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	6
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	70.00%

Warning: There are only 6 Detected Values in this data
Note: It should be noted that even though bootstrap may be performed on this data set
the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.554	Shapiro Wilk Test Statistic	0.791
5% Shapiro Wilk Critical Value	0.788	5% Shapiro Wilk Critical Value	0.788
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.263	Mean	-3.955
SD	0.983	SD	1.789
95% DL/2 (t) UCL	0.643	95% H-Stat (DL/2) UCL	0.476
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE yields a negative mean		Mean in Log Scale	-5.9
		SD in Log Scale	3.027
		Mean in Original Scale	0.258
		SD in Original Scale	0.985
		95% t UCL	0.639
		95% Percentile Bootstrap UCL	0.692
		95% BCA Bootstrap UCL	0.946
		95% H-UCL	20.09

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Gamma Distribution Test with Detected Values Only	
k star (bias corrected)	0.33
Theta Star	2.602
nu star	3.964
A-D Test Statistic	0.944
5% A-D Critical Value	0.745
K-S Test Statistic	0.745
5% K-S Critical Value	0.351
Data not Gamma Distributed at 5% Significance Level	
Assuming Gamma Distribution	
Gamma ROS Statistics using Extrapolated Data	
Minimum	0.000001
Maximum	4.42
Mean	0.258
Median	0.000001
SD	0.985
k star	0.112
Theta star	2.294
Nu star	4.497
AppChi2	0.928
95% Gamma Approximate UCL (Use when n >= 40)	1.25
95% Adjusted Gamma UCL (Use when n < 40)	1.433

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only	
Data appear Lognormal at 5% Significance Level	
Nonparametric Statistics	
Kaplan-Meier (KM) Method	
Mean	0.297
SD	0.949
SE of Mean	0.233
95% KM (t) UCL	0.699
95% KM (z) UCL	0.68
95% KM (jackknife) UCL	0.671
95% KM (bootstrap t) UCL	18.84
95% KM (BCA) UCL	0.757
95% KM (Percentile Bootstrap) UCL	0.733
95% KM (Chebyshev) UCL	1.311
97.5% KM (Chebyshev) UCL	1.75
99% KM (Chebyshev) UCL	2.611
Potential UCLs to Use	
97.5% KM (Chebyshev) UCL	1.75

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Dinitrotoluene, 2,6- SVOC - TNTA/WWTP1 SL Total Soil

General Statistics

Number of Valid Data	20	Number of Detected Data	3
Number of Distinct Detected Data	3	Number of Non-Detect Data	17
		Percent Non-Detects	85.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.0411	Minimum Detected	-3.192
Maximum Detected	2.18	Maximum Detected	0.779
Mean of Detected	0.783	Mean of Detected	-1.489
SD of Detected	1.211	SD of Detected	2.045
Minimum Non-Detect	0.00881	Minimum Non-Detect	-4.732
Maximum Non-Detect	0.0112	Maximum Non-Detect	-4.492

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	17
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	3
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	85.00%

Warning: There are only 3 Distinct Detected Values in this data set
The number of detected data may not be adequate enough to perform GOF tests, bootstrap, and ROS methods.
Those methods will return a 'N/A' value on your output display!

It is necessary to have 4 or more Distinct Values for bootstrap methods.
However, results obtained using 4 to 9 distinct values may not be reliable.
It is recommended to have 10 to 15 or more observations for accurate and meaningful results and estimates.

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

UCL Statistics

Normal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.78
5% Shapiro Wilk Critical Value	0.767
Data appear Normal at 5% Significance Level	

Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.942
5% Shapiro Wilk Critical Value	0.767
Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution	
DL/2 Substitution Method	
Mean	0.122
SD	0.485
95% DL/2 (t) UCL	0.309
Maximum Likelihood Estimate(MLE) Method	N/A
MLE yields a negative mean	

Assuming Lognormal Distribution	
DL/2 Substitution Method	
Mean	-4.748
SD	1.555
95% H-Stat (DL/2) UCL	0.102
Log ROS Method	
Mean in Log Scale	-11.57
SD in Log Scale	4.477
Mean in Original Scale	0.117
SD in Original Scale	0.486
95% t UCL	0.306
95% Percentile Bootstrap UCL	0.335
95% BCA Bootstrap UCL	0.455
95% H-UCL	2126

Gamma Distribution Test with Detected Values Only	
k star (bias corrected)	N/A
Theta Star	N/A
nu star	N/A
A-D Test Statistic	N/A
5% A-D Critical Value	N/A
K-S Test Statistic	N/A
5% K-S Critical Value	N/A
Data not Gamma Distributed at 5% Significance Level	

Data Distribution Test with Detected Values Only
Data appear Normal at 5% Significance Level

Assuming Gamma Distribution	
Gamma ROS Statistics using Extrapolated Data	
Minimum	N/A
Maximum	N/A
Mean	N/A
Median	N/A
SD	N/A
k star	N/A
Theta star	N/A
Nu star	N/A
AppChi2	N/A
95% Gamma Approximate UCL (Use when n >= 40)	N/A
95% Adjusted Gamma UCL (Use when n < 40)	N/A

Nonparametric Statistics	
Kaplan-Meier (KM) Method	
Mean	0.152
SD	0.466
SE of Mean	0.127
95% KM (t) UCL	0.373
95% KM (z) UCL	0.362
95% KM (jackknife) UCL	0.309
95% KM (bootstrap t) UCL	2.159
95% KM (BCA) UCL	2.18
95% KM (Percentile Bootstrap) UCL	2.18
95% KM (Chebyshev) UCL	0.708
97.5% KM (Chebyshev) UCL	0.949
99% KM (Chebyshev) UCL	1.421

Potential UCLs to Use	
95% KM (t) UCL	0.373
95% KM (Percentile Bootstrap) UCL	2.18

Note: DL/2 is not a recommended method.

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

General UCL Statistics for Full Data Sets

User Selected Options

From File	base soil UCL input.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Dibenz(a,h)anthracene - TNTA/WWTP1 SL Total Soil

General Statistics

Number of Valid Observations 20

Number of Distinct Observations 20

Raw Statistics

Minimum	0.0829
Maximum	0.486
Mean	0.116
Geometric Mean	0.103
Median	0.0901
SD	0.0904
Std. Error of Mean	0.0202
Coefficient of Variation	0.78
Skewness	4.028

Log-transformed Statistics

Minimum of Log Data	-2.49
Maximum of Log Data	-0.722
Mean of log Data	-2.278
SD of log Data	0.409

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.369
Shapiro Wilk Critical Value	0.905

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.486
Shapiro Wilk Critical Value	0.905

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	0.151

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL (Chen-1995)	0.169
95% Modified-t UCL (Johnson-1978)	0.154

Assuming Lognormal Distribution

95% H-UCL	0.134
95% Chebyshev (MVUE) UCL	0.156
97.5% Chebyshev (MVUE) UCL	0.176
99% Chebyshev (MVUE) UCL	0.215

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Gamma Distribution Test

k star (bias corrected)	3.633
Theta Star	0.0319
MLE of Mean	0.116
MLE of Standard Deviation	0.0608
nu star	145.3
Approximate Chi Square Value (.05)	118.5
Adjusted Level of Significance	0.038
Adjusted Chi Square Value	116.6
Anderson-Darling Test Statistic	4.661
Anderson-Darling 5% Critical Value	0.745
Kolmogorov-Smirnov Test Statistic	0.415
Kolmogorov-Smirnov 5% Critical Value	0.195

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL (Use when n >= 40)	0.142
95% Adjusted Gamma UCL (Use when n < 40)	0.144

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL	0.149
95% Jackknife UCL	0.151
95% Standard Bootstrap UCL	0.149
95% Bootstrap-t UCL	0.526
95% Hall's Bootstrap UCL	0.311
95% Percentile Bootstrap UCL	0.154
95% BCA Bootstrap UCL	0.178
95% Chebyshev(Mean, Sd) UCL	0.204
97.5% Chebyshev(Mean, Sd) UCL	0.242
99% Chebyshev(Mean, Sd) UCL	0.317

Potential UCL to Use

Use 95% Student's-t UCL 0.151
or 95% Modified-t UCL 0.154

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)
and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Indeno(1,2,3-cd)pyrene - TNTA/WWTP1 SL Total Soil

General Statistics

Number of Valid Observations 20

Number of Distinct Observations 16

Raw Statistics

Minimum	0.119
Maximum	1.06
Mean	0.205
Geometric Mean	0.157
Median	0.13
SD	0.238
Std. Error of Mean	0.0532
Coefficient of Variation	1.159
Skewness	3.197

Log-transformed Statistics

Minimum of Log Data	-2.129
Maximum of Log Data	0.0583
Mean of log Data	-1.85
SD of log Data	0.588

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.392
Shapiro Wilk Critical Value	0.905

Data not Normal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	0.297

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL (Chen-1995)	0.333
95% Modified-t UCL (Johnson-1978)	0.304

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.457
Shapiro Wilk Critical Value	0.905

Data not Lognormal at 5% Significance Level

Assuming Lognormal Distribution

95% H-UCL	0.248
95% Chebyshev (MVUE) UCL	0.296
97.5% Chebyshev (MVUE) UCL	0.345
99% Chebyshev (MVUE) UCL	0.439

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Gamma Distribution Test

k star (bias corrected)	1.754
Theta Star	0.117
MLE of Mean	0.205
MLE of Standard Deviation	0.155
nu star	70.17
Approximate Chi Square Value (.05)	51.88
Adjusted Level of Significance	0.038
Adjusted Chi Square Value	50.64
Anderson-Darling Test Statistic	5.456
Anderson-Darling 5% Critical Value	0.752
Kolmogorov-Smirnov Test Statistic	0.469
Kolmogorov-Smirnov 5% Critical Value	0.196

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL (Use when n >= 40)	0.278
95% Adjusted Gamma UCL (Use when n < 40)	0.284

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL	0.293
95% Jackknife UCL	0.297
95% Standard Bootstrap UCL	0.29
95% Bootstrap-t UCL	2.403
95% Hall's Bootstrap UCL	0.996
95% Percentile Bootstrap UCL	0.3
95% BCA Bootstrap UCL	0.336
95% Chebyshev(Mean, Sd) UCL	0.437
97.5% Chebyshev(Mean, Sd) UCL	0.537
99% Chebyshev(Mean, Sd) UCL	0.735

Potential UCL to Use

Use 95% Chebyshev (Mean, Sd) UCL 0.437

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Input for ProUCL
TNTA/WWTP1 Sewer Lines - Overburden Groundwater
Plum Brook Ordnance Works, Sandusky, Ohio

Cobalt	D_Cobalt	Nickel	D_Nickel	Thallium	Sulfate	D_Sulfate
4.6	1	23.1	1	3.4	38200	1
0.83	0	2.3	0	3.4	8500	1
21.8	1	73.8	1	4.4	1270000	1
8.4	1	34.6	1	3.4	26000	1
0.83	0	2.4	1	3.4	16000	1

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Overburden Groundwater
Plum Brook Ordnance Works, Sandusky, Ohio

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	C:\Documents and Settings\debbi.freer\My Documents\PBOW\TNT A SL\TNT A SL - HH\Soil Files\UCL files\UCL
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Cobalt - Overburden Groundwater

General Statistics

Number of Valid Data	5	Number of Detected Data	3
Number of Distinct Detected Data	3	Number of Non-Detect Data	2
		Percent Non-Detects	40.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	4.6	Minimum Detected	1.526
Maximum Detected	21.8	Maximum Detected	3.082
Mean of Detected	11.6	Mean of Detected	2.245
SD of Detected	9.035	SD of Detected	0.785
Minimum Non-Detect	0.83	Minimum Non-Detect	-0.186
Maximum Non-Detect	0.83	Maximum Non-Detect	-0.186

Warning: There are only 3 Distinct Detected Values in this data set
The number of detected data may not be adequate enough to perform GOF tests, bootstrap, and ROS methods.
Those methods will return a 'N/A' value on your output display!

It is necessary to have 4 or more Distinct Values for bootstrap methods.
However, results obtained using 4 to 9 distinct values may not be reliable.
It is recommended to have 10 to 15 or more observations for accurate and meaningful results and estimates.

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.906	Shapiro Wilk Test Statistic	0.983
5% Shapiro Wilk Critical Value	0.767	5% Shapiro Wilk Critical Value	0.767
Data appear Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	7.126	Mean	0.995
SD	8.852	SD	1.799
95% DL/2 (t) UCL	15.57	95% H-Stat (DL/2) UCL	27909
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	3.988	Mean in Log Scale	1.265
SD	11.68	SD in Log Scale	1.483
95% MLE (t) UCL	15.12	Mean in Original Scale	7.314
95% MLE (Tiku) UCL	16.56	SD in Original Scale	8.679
		95% t UCL	15.59
		95% Percentile Bootstrap UCL	13.43
		95% BCA Bootstrap UCL	15.01
		95% H UCL	1966

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Overburden Groundwater
Plum Brook Ordnance Works, Sandusky, Ohio

Gamma Distribution Test with Detected Values Only	
k star (bias corrected)	N/A
Theta Star	N/A
nu star	N/A
A-D Test Statistic	N/A
5% A-D Critical Value	N/A
K-S Test Statistic	N/A
5% K-S Critical Value	N/A
Data not Gamma Distributed at 5% Significance Level	
Assuming Gamma Distribution	
Gamma ROS Statistics using Extrapolated Data	
Minimum	N/A
Maximum	N/A
Mean	N/A
Median	N/A
SD	N/A
k star	N/A
Theta star	N/A
Nu star	N/A
AppChi2	N/A
95% Gamma Approximate UCL (Use when n >= 40)	N/A
95% Adjusted Gamma UCL (Use when n < 40)	N/A

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only
Data appear Normal at 5% Significance Level

Nonparametric Statistics	
Kaplan-Meier (KM) Method	
Mean	8.8
SD	6.665
SE of Mean	3.65
95% KM (t) UCL	16.58
95% KM (z) UCL	14.8
95% KM (jackknife) UCL	15.97
95% KM (bootstrap t) UCL	24.8
95% KM (BCA) UCL	16.44
95% KM (Percentile Bootstrap) UCL	21.8
95% KM (Chebyshev) UCL	24.71
97.5% KM (Chebyshev) UCL	31.6
99% KM (Chebyshev) UCL	45.12
Potential UCLs to Use	
95% KM (t) UCL	16.58
95% KM (Percentile Bootstrap) UCL	21.8

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Nickel - Overburden Groundwater

General Statistics

Number of Valid Data	5	Number of Detected Data	4
Number of Distinct Detected Data	4	Number of Non-Detect Data	1
		Percent Non-Detects	20.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	2.4	Minimum Detected	0.875
Maximum Detected	73.8	Maximum Detected	4.301
Mean of Detected	33.48	Mean of Detected	2.965
SD of Detected	30	SD of Detected	1.474
Minimum Non-Detect	2.3	Minimum Non-Detect	0.833
Maximum Non-Detect	2.3	Maximum Non-Detect	0.833

Warning: There are only 4 Distinct Detected Values in this data
Note: It should be noted that even though bootstrap may be performed on this data set
the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Overburden Groundwater
Plum Brook Ordnance Works, Sandusky, Ohio

UCL Statistics

Normal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.963
5% Shapiro Wilk Critical Value	0.748
Data appear Normal at 5% Significance Level	

Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.9
5% Shapiro Wilk Critical Value	0.748
Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution	
DL/2 Substitution Method	
Mean	27.01
SD	29.73
95% DL/2 (t) UCL	55.36
Maximum Likelihood Estimate(MLE) Method	
Mean	23.49
SD	31.41
95% MLE (t) UCL	53.44
95% MLE (Tiku) UCL	53.83

Assuming Lognormal Distribution	
DL/2 Substitution Method	
Mean	2.4
SD	1.796
95% H-Stat (DL/2) UCL	110160
Log ROS Method	
Mean in Log Scale	2.229
SD in Log Scale	2.083
Mean in Original Scale	26.88
SD in Original Scale	29.88
95% t UCL	55.36
95% Percentile Bootstrap UCL	49
95% BCA Bootstrap UCL	49.38
95% H UCL	2114022

Gamma Distribution Test with Detected Values Only	
k star (bias corrected)	0.43
Theta Star	77.92
nu star	3.437
A-D Test Statistic	0.266
5% A-D Critical Value	0.666
K-S Test Statistic	0.666
5% K-S Critical Value	0.402
Data appear Gamma Distributed at 5% Significance Level	

Data Distribution Test with Detected Values Only
Data appear Normal at 5% Significance Level

Assuming Gamma Distribution	
Gamma ROS Statistics using Extrapolated Data	
Minimum	0.000001
Maximum	73.8
Mean	26.78
Median	23.1
SD	29.99
k star	0.213
Theta star	125.5
Nu star	2.134
AppChi2	0.17
95% Gamma Approximate UCL (Use when n >= 40)	335.8
95% Adjusted Gamma UCL (Use when n < 40)	N/A

Note: DL/2 is not a recommended method.

Nonparametric Statistics	
Kaplan-Meier (KM) Method	
Mean	27.26
SD	26.36
SE of Mean	13.61
95% KM (t) UCL	56.27
95% KM (z) UCL	49.65
95% KM (jackknife) UCL	56.3
95% KM (bootstrap t) UCL	59.59
95% KM (BCA) UCL	55.82
95% KM (Percentile Bootstrap) UCL	50.28
95% KM (Chebyshev) UCL	86.59
97.5% KM (Chebyshev) UCL	112.3
99% KM (Chebyshev) UCL	162.7
Potential UCLs to Use	
95% KM (t) UCL	56.27
95% KM (Percentile Bootstrap) UCL	50.28

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Overburden Groundwater
Plum Brook Ordnance Works, Sandusky, Ohio

Sulfate - Overburden Groundwater

General Statistics

Number of Valid Observations 5

Number of Distinct Observations 5

Raw Statistics

Minimum	8500
Maximum	1270000
Mean	271740
Geometric Mean	44348
Median	26000
SD	558156
Std. Error of Mean	249615
Coefficient of Variation	2.054
Skewness	2.234

Log-transformed Statistics

Minimum of Log Data	9.048
Maximum of Log Data	14.05
Mean of log Data	10.7
SD of log Data	1.958

Warning: A sample size of 'n' = 5 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!
If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Warning: There are only 5 Values in this data
Note: It should be noted that even though bootstrap methods may be performed on this data set,
the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.571
Shapiro Wilk Critical Value	0.762

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.816
Shapiro Wilk Critical Value	0.762

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	803880

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL (Chen-1995)	948771
95% Modified-t UCL (Johnson-1978)	845441

Assuming Lognormal Distribution

95% H-UCL	2.44E+09
95% Chebyshev (MVUE) UCL	657339
97.5% Chebyshev (MVUE) UCL	873636
99% Chebyshev (MVUE) UCL	1298511

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Overburden Groundwater
Plum Brook Ordnance Works, Sandusky, Ohio

Gamma Distribution Test

k star (bias corrected)	0.281
Theta Star	968738
MLE of Mean	271740
MLE of Standard Deviation	513074
nu star	2.805
Approximate Chi Square Value (.05)	0.317
Adjusted Level of Significance	0.0086
Adjusted Chi Square Value	0.119
Anderson-Darling Test Statistic	0.862
Anderson-Darling 5% Critical Value	0.73
Kolmogorov-Smirnov Test Statistic	0.427
Kolmogorov-Smirnov 5% Critical Value	0.377

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL (Use when n >= 40)	2403844
95% Adjusted Gamma UCL (Use when n < 40)	6415139

Data Distribution

Data appear Lognormal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	682320
95% Jackknife UCL	803880
95% Standard Bootstrap UCL	636181
95% Bootstrap-t UCL	19118047
95% Hall's Bootstrap UCL	10642551
95% Percentile Bootstrap UCL	768400
95% BCA Bootstrap UCL	772840
95% Chebyshev(Mean, Sd) UCL	1359785
97.5% Chebyshev(Mean, Sd) UCL	1830584
99% Chebyshev(Mean, Sd) UCL	2755375

Potential UCL to Use — Use 99% Chebyshev (Mean, Sd) UCL 2755375

Recommended UCL exceeds the maximum observation

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)
and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

General UCL Statistics for Full Data Sets

User Selected Options

From File	C:\Documents and Settings\debbi.freer\My Documents\PBOW\TNT A SL\TNT A SL - HH\Soil Files\UCL files\UCL
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Thallium - Overburden Groundwater

General Statistics

Number of Valid Observations 5 — Number of Distinct Observations 2

Raw Statistics

Minimum	3.4
Maximum	4.4
Mean	3.6
Geometric Mean	3.58
Median	3.4
SD	0.447
Std. Error of Mean	0.2
Coefficient of Variation	0.124
Skewness	2.236

Log-transformed Statistics

Minimum of Log Data	1.224
Maximum of Log Data	1.482
Mean of log Data	1.275
SD of log Data	0.115

Warning: There are only 2 Distinct Values in this data
There are insufficient Distinct Values to perform some GOF tests and bootstrap methods.
Those methods will return a 'N/A' value on your output display!

Output for ProUCL
TNTA/WWTP1 Sewer Lines - Overburden Groundwater
Plum Brook Ordnance Works, Sandusky, Ohio

It is necessary to have 4 or more Distinct Values to compute bootstrap methods.
However, results obtained using 4 to 9 distinct values may not be reliable.
It is recommended to have 10-15 or more observations for accurate and meaningful bootstrap results.

Warning: A sample size of 'n' = 5 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!
If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.552
Shapiro Wilk Critical Value	0.762

Data not Normal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	4.026

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL (Chen-1995)	4.143
95% Modified-t UCL (Johnson-1978)	4.06

Gamma Distribution Test

k star (bias corrected)	35.96
Theta Star	0.1
MLE of Mean	3.6
MLE of Standard Deviation	0.6
nu star	359.6
Approximate Chi Square Value (.05)	316.7
Adjusted Level of Significance	0.0086
Adjusted Chi Square Value	298.9
Anderson-Darling Test Statistic	1.332
Anderson-Darling 5% Critical Value	0.678
Kolmogorov-Smirnov Test Statistic	0.492
Kolmogorov-Smirnov 5% Critical Value	0.357

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL (Use when n >= 40)	4.088
95% Adjusted Gamma UCL (Use when n < 40)	4.332

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.552
Shapiro Wilk Critical Value	0.762

Data not Lognormal at 5% Significance Level

Assuming Lognormal Distribution

95% H-UCL	4.058
95% Chebyshev (MVUE) UCL	4.408
97.5% Chebyshev (MVUE) UCL	4.757
99% Chebyshev (MVUE) UCL	5.445

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL	3.929
95% Jackknife UCL	N/A
95% Standard Bootstrap UCL	N/A
95% Bootstrap-t UCL	N/A
95% Hall's Bootstrap UCL	N/A
95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A
95% Chebyshev(Mean, Sd) UCL	4.472
97.5% Chebyshev(Mean, Sd) UCL	4.849
99% Chebyshev(Mean, Sd) UCL	5.59

Potential UCL to Use

Use 95% Student's-t UCL 4.026
or 95% Modified-t UCL 4.06

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)
and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Input for ProUCL
MPHS Sewer Lines - Surface Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Benzo(a)pyrene
0.0281
0.0286
0.0285
0.0272
0.0279
0.053

Output for ProUCL
MPHS Sewer Lines - Surface Soil
Plum Brook Ordnance Works, Sandusky, Ohio

General UCL Statistics for Full Data Sets

User Selected Options

From File	C:\Documents and Settings\debbi.freer\My Documents\PBOW\TNT A SL\TNT A SL - HH\Soil Files\UCL files\UCL
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Benzo(a)pyrene - MPHS Surface Soil

General Statistics

Number of Valid Observations 6 | Number of Distinct Observations 6

Raw Statistics

Minimum	0.0272
Maximum	0.053
Mean	0.0322
Geometric Mean	0.0312
Median	0.0283
SD	0.0102
Std. Error of Mean	0.00416
Coefficient of Variation	0.316
Skewness	2.436

Log-transformed Statistics

Minimum of Log Data	-3.605
Maximum of Log Data	-2.937
Mean of log Data	-3.468
SD of log Data	0.26

Warning: A sample size of 'n' = 6 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!
If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Warning: There are only 6 Values in this data
Note: It should be noted that even though bootstrap methods may be performed on this data set,
the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.545
Shapiro Wilk Critical Value	0.788

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.564
Shapiro Wilk Critical Value	0.788

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	0.0406

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL (Chen-1995)	0.0435
95% Modified-t UCL (Johnson-1978)	0.0413

Assuming Lognormal Distribution

95% H-UCL	0.0415
95% Chebyshev (MVUE) UCL	0.0469
97.5% Chebyshev (MVUE) UCL	0.0534
99% Chebyshev (MVUE) UCL	0.066

Output for ProUCL
MPHS Sewer Lines - Surface Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Gamma Distribution Test

k star (bias corrected)	7.938
Theta Star	0.00406
MLE of Mean	0.0322
MLE of Standard Deviation	0.0114
nu star	95.26
Approximate Chi Square Value (.05)	73.74
Adjusted Level of Significance	0.0122
Adjusted Chi Square Value	66.94
Anderson-Darling Test Statistic	1.48
Anderson-Darling 5% Critical Value	0.698
Kolmogorov-Smirnov Test Statistic	0.48
Kolmogorov-Smirnov 5% Critical Value	0.332

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL (Use when n >= 40)	0.0416
95% Adjusted Gamma UCL (Use when n < 40)	0.0458

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL	0.0391
95% Jackknife UCL	0.0406
95% Standard Bootstrap UCL	0.0385
95% Bootstrap-t UCL	0.17
95% Hall's Bootstrap UCL	0.124
95% Percentile Bootstrap UCL	0.0404
95% BCA Bootstrap UCL	0.0407
95% Chebyshev(Mean, Sd) UCL	0.0504
97.5% Chebyshev(Mean, Sd) UCL	0.0582
99% Chebyshev(Mean, Sd) UCL	0.0736

Potential UCL to Use

Use 95% Student's-t UCL 0.0406
or 95% Modified-t UCL 0.0413

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Input for ProUCL
MPHS Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Dinitrotoluene, 2,4- exp	D_Dinitrotoluene, 2,4- exp	Trinitrotoluene, 2,4,6-	D_Trinitrotoluene, 2,4,6-	Benzo(a)pyrene
0.201	1	0.0895	1	0.0281
0.074	0	0.149	1	0.0261
0.086	0	1.09	1	0.0286
0.068	0	0.21	1	0.0263
0.074	0	0.532	1	0.0285
0.078	0	0.271	1	0.0261
0.078	0	0.061	0	0.0272
0.153	0	0.056	0	0.0253
0.147	0	0.061	0	0.0279
0.139	0	0.064	0	0.0257
0.15	0	0.153	0	0.053
0.137	0	0.147	0	0.025
0.14	0	0.139	0	0.0259
0.142	0	0.15	0	0.0243
0.147	0	0.137	0	0.0264
0.141	0	0.14	0	0.0241
0.155	0	0.142	0	
0.146	0	0.147	0	
0.145	0	0.155	0	
0.148	0	0.146	0	
0.15	0	0.148	0	
0.149	0	0.15	0	
0.149	0	0.149	0	
0.15	0	0.149	0	
0.15	0	0.15	0	
0.144	0	0.147	0	
0.149	0	0.15	0	
0.146	0	0.144	0	
0.147	0	0.146	0	
0.15	0	0.147	0	
0.149	0	0.15	0	
0.149	0	0.149	0	
0.1475	0	0.149	0	
0.15	0	0.201	1	
0.147	0	0.1475	0	
0.624	1	0.487	1	
3.25	1	0.68	1	
0.896	1	3.35	1	
0.404	1	77.8	1	

Output for ProUCL
MPHS Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	C:\Documents and Settings\debbi.freer\My Documents\PBOW\TNT A SL\TNT A SL - HH\Soil Files\UCL files\UCL
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Dinitrotoluene, 2,4- exp - MPHS Sewer Line Total Soil

General Statistics

Number of Valid Data	39	Number of Detected Data	5
Number of Distinct Detected Data	5	Number of Non-Detect Data	34
		Percent Non-Detects	87.18%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.201	Minimum Detected	-1.604
Maximum Detected	3.25	Maximum Detected	1.179
Mean of Detected	1.075	Mean of Detected	-0.383
SD of Detected	1.243	SD of Detected	1.035
Minimum Non-Detect	0.068	Minimum Non-Detect	-2.688
Maximum Non-Detect	0.155	Maximum Non-Detect	-1.864

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	34
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	5
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	87.18%

Warning: There are only 5 Detected Values in this data
Note: It should be noted that even though bootstrap may be performed on this data set
the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.745	Shapiro Wilk Test Statistic	0.972
5% Shapiro Wilk Critical Value	0.762	5% Shapiro Wilk Critical Value	0.762
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.196	Mean	-2.426
SD	0.528	SD	0.895
95% DL/2 (t) UCL	0.339	95% H-Stat (DL/2) UCL	0.184
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE yields a negative mean		Mean in Log Scale	-5.461
		SD in Log Scale	2.391
		Mean in Original Scale	0.142
		SD in Original Scale	0.542
		95% t UCL	0.288
		95% Percentile Bootstrap UCL	0.296
		95% BCA Bootstrap UCL	0.407
		95% H-UCL	0.401

Output for ProUCL
MPHS Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.629
Theta Star	1.709
nu star	6.289
A-D Test Statistic	0.357
5% A-D Critical Value	0.689
K-S Test Statistic	0.689
5% K-S Critical Value	0.363

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	0.000001
Maximum	3.25
Mean	0.138
Median	0.000001
SD	0.543
k star	0.093
Theta star	1.482
Nu star	7.254
AppChi2	2.311
95% Gamma Approximate UCL (Use when n >= 40)	0.433
95% Adjusted Gamma UCL (Use when n < 40)	0.454

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data appear Gamma Distributed at 5% Significance Level

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	0.313
SD	0.494
SE of Mean	0.0884
95% KM (t) UCL	0.462
95% KM (z) UCL	0.458
95% KM (jackknife) UCL	0.468
95% KM (bootstrap t) UCL	0.688
95% KM (BCA) UCL	0.956
95% KM (Percentile Bootstrap) UCL	0.833
95% KM (Chebyshev) UCL	0.698
97.5% KM (Chebyshev) UCL	0.865
99% KM (Chebyshev) UCL	1.193

Potential UCLs to Use

95% KM (t) UCL	0.462

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Trinitrotoluene, 2,4,6- - MPHS Sewer Line Total Soil

General Statistics

Number of Valid Data	39	Number of Detected Data	11
Number of Distinct Detected Data	11	Number of Non-Detect Data	28
		Percent Non-Detects	71.79%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.0895	Minimum Detected	-2.414
Maximum Detected	77.8	Maximum Detected	4.354
Mean of Detected	7.715	Mean of Detected	-0.443
SD of Detected	23.26	SD of Detected	1.884
Minimum Non-Detect	0.056	Minimum Non-Detect	-2.882
Maximum Non-Detect	0.155	Maximum Non-Detect	-1.864

Note: Data have multiple DLs - Use of KM Method is recommended
For all methods (except KM, DL/2, and ROS Methods),
Observations < Largest ND are treated as NDs

Number treated as Non-Detect	30
Number treated as Detected	9
Single DL Non-Detect Percentage	76.92%

Output for ProUCL
MPHS Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

UCL Statistics

Normal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.372
5% Shapiro Wilk Critical Value	0.85
Data not Normal at 5% Significance Level	

Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.827
5% Shapiro Wilk Critical Value	0.85
Data not Lognormal at 5% Significance Level	

Assuming Normal Distribution	
DL/2 Substitution Method	
Mean	2.224
SD	12.43
95% DL/2 (t) UCL	5.581
Maximum Likelihood Estimate(MLE) Method	N/A
MLE yields a negative mean	

Assuming Lognormal Distribution	
DL/2 Substitution Method	
Mean	-2.09
SD	1.449
95% H-Stat (DL/2) UCL	0.71
Log ROS Method	
Mean in Log Scale	-4.635
SD in Log Scale	3.074
Mean in Original Scale	2.179
SD in Original Scale	12.44
95% t UCL	5.538
95% Percentile Bootstrap UCL	6.14
95% BCA Bootstrap UCL	10.03
95% H-UCL	16.35

Gamma Distribution Test with Detected Values Only	
k star (bias corrected)	0.265
Theta Star	29.16
nu star	5.82
A-D Test Statistic	1.989
5% A-D Critical Value	0.828
K-S Test Statistic	0.828
5% K-S Critical Value	0.277
Data not Gamma Distributed at 5% Significance Level	

Data Distribution Test with Detected Values Only
Data do not follow a Discernable Distribution (0.05)

Assuming Gamma Distribution	
Gamma ROS Statistics using Extrapolated Data	
Minimum	0.000001
Maximum	77.8
Mean	2.176
Median	0.000001
SD	12.44
k star	0.0885
Theta star	24.58
Nu star	6.905
AppChi2	2.118
95% Gamma Approximate UCL (Use when n >= 40)	7.092
95% Adjusted Gamma UCL (Use when n < 40)	7.454

Note: DL/2 is not a recommended method.

Nonparametric Statistics	
Kaplan-Meier (KM) Method	
Mean	2.241
SD	12.27
SE of Mean	2.061
95% KM (t) UCL	5.715
95% KM (z) UCL	5.63
95% KM (jackknife) UCL	5.557
95% KM (bootstrap t) UCL	143
95% KM (BCA) UCL	6.367
95% KM (Percentile Bootstrap) UCL	6.213
95% KM (Chebyshev) UCL	**11.22**
97.5% KM (Chebyshev) UCL	15.11
99% KM (Chebyshev) UCL	22.74
Potential UCLs to Use	
97.5% KM (Chebyshev) UCL	15.11

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Output for ProUCL
MPHS Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

General UCL Statistics for Full Data Sets

User Selected Options

From File	C:\Documents and Settings\debbi.freer\My Documents\PBOW\TNT A SL\TNT A SL - HH\Soil Files\UCL files\UCL
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Benzo(a)pyrene - MPHS Sewer Line Total Soil

General Statistics

Number of Valid Observations 16

Number of Distinct Observations 15

Raw Statistics

Minimum	0.0241
Maximum	0.053
Mean	0.028
Geometric Mean	0.0275
Median	0.0262
SD	0.0068
Std. Error of Mean	0.0017
Coefficient of Variation	0.243
Skewness	3.72

Log-transformed Statistics

Minimum of Log Data	-3.726
Maximum of Log Data	-2.937
Mean of log Data	-3.593
SD of log Data	0.183

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.463
Shapiro Wilk Critical Value	0.887

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.547
Shapiro Wilk Critical Value	0.887

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	0.031

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL (Chen-1995)	0.0325
95% Modified-t UCL (Johnson-1978)	0.0313

Assuming Lognormal Distribution

95% H-UCL	0.0304
95% Chebyshev (MVUE) UCL	0.0335
97.5% Chebyshev (MVUE) UCL	0.0359
99% Chebyshev (MVUE) UCL	0.0407

Output for ProUCL
MPHS Sewer Lines - Total Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Gamma Distribution Test

k star (bias corrected)	21.7
Theta Star	0.00129
MLE of Mean	0.028
MLE of Standard Deviation	0.00602
nu star	694.4
Approximate Chi Square Value (.05)	634.2
Adjusted Level of Significance	0.0335
Adjusted Chi Square Value	627.7
Anderson-Darling Test Statistic	2.846
Anderson-Darling 5% Critical Value	0.736
Kolmogorov-Smirnov Test Statistic	0.371
Kolmogorov-Smirnov 5% Critical Value	0.215

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL (Use when n >= 40)	0.0307
95% Adjusted Gamma UCL (Use when n < 40)	0.031

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL	0.0308
95% Jackknife UCL	0.031
95% Standard Bootstrap UCL	0.0307
95% Bootstrap-t UCL	0.039
95% Hall's Bootstrap UCL	0.0421
95% Percentile Bootstrap UCL	0.0312
95% BCA Bootstrap UCL	0.0334
95% Chebyshev(Mean, Sd) UCL	0.0354
97.5% Chebyshev(Mean, Sd) UCL	0.0386
99% Chebyshev(Mean, Sd) UCL	0.0449

Potential UCL to Use

Use 95% Student's-t UCL 0.031
or 95% Modified-t UCL 0.0313

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

APPENDIX C

TOXICOLOGICAL PROFILES

Introduction to the Toxicological Profiles

1.0 Purpose and Use of the Toxicological Profiles

Human health toxicological profiles are presented for each chemical of potential concern (COPC), each chemical for which documentation of chemical-specific values is required or about which there are chemical-specific issues that require resolution. The toxicological profiles provide documentation of the chemical-specific physical properties and toxicity values used in the risk assessment (RA). They also discuss the identity, classification and uses of the chemical, the common sources of release to the environment and the fate of the chemical in the environment, including the relevance of aquatic and terrestrial food-chain pathways to human health. A brief review of toxicokinetics discusses absorption, distribution, metabolism or biotransformation, excretion of the parent compound and metabolites, and mechanism of toxicity including identifying the ultimate toxicant – i.e., the moiety (parent chemical or metabolite) identified as most likely responsible for the adverse effects associated with the chemical. This information may be helpful to determine whether laboratory animals may serve as appropriate models for toxicity to humans, and to clarify the nature of toxicological interactions with other chemicals. A discussion of dermal exposure provides perspective on the significance of dermal uptake, and documents the development of dermal toxicity values and the extent or rate of dermal uptake from soil or water according to the latest USEPA (2004) guidance.

The noncancer effects evaluation and carcinogenicity evaluation provide an overall perspective on the nature of the adverse effects associated with the chemical, as well as documentation of the toxicity values. Chemical-specific issues or controversies that may influence the interpretation or application of the results of the RA are also discussed herein. The toxicity values used in the RA are summarized in a table.

The overall purpose of the toxicological profiles is to provide perspective on characteristics of each of the chemicals included in the RA so that the numerical risk estimates can be interpreted and applied wisely in the management of the site.

2.0 Chemical Identity

The identity of the chemical or chemical class is given in the title of each profile; additional information or clarification is provided in the *Introduction and Physical Properties* Section as required. The hyphenated number in parentheses following the chemical name is its unique Chemical Abstract Service (CAS) registration number. The CAS number may be located in the profile title, text, or in the case of multiple isomers or members of a chemical class, in the table that provides the physical properties.

3.0 Physical Properties

The toxicological profiles also provide documentation for the physical properties or constants that are important for chemical transport modeling, such as molecular weight (MW) in grams per mole (g/mole), the log of the octanol/water partition coefficient (log K_{ow}), Henry's Law constant (H) in atmosphere-cubic meters per mole (atm-m^3/mole), the soil/water partition coefficient (K_d) in liters per kilogram (L/kg) for metals, the log of the soil/organic carbon partition coefficient (log K_{oc}) (unitless) for organic chemicals, diffusivity in air (D_a) in square centimeters per second

(cm^2/s), diffusivity in water (D_w) in cm^2/s, vapor pressure (VP) in atmospheres (atm), solubility in water (S) in milligrams per liter (mg/L), and, for volatile organic compounds (VOC), boiling point of pure compound (T_b) in degrees Kelvin (°K), critical temperature (T_c) in °K, and enthalpy of vaporization at the boiling point ($\Delta H_{v,b}$) in calories per mole (cal/mol). Organic chemicals are designated as VOCs or semivolatile organic compounds (SVOC) based on their propensity to volatilize from environmental media. Chemicals designated as VOCs generally have an H greater than 1E-5 atm-m^3/mole (EPA, 2002).

The physical constants generally are taken from the most reliable source (i.e., the source that provides the highest level of documentation). Values for interrelated properties are usually taken from the same source (e.g., H is often estimated from VP and S; therefore, the same source is generally used for all three property values). When one source provides several values for a given property, professional judgment is used to select the most appropriate. Obvious outliers may be dropped from consideration. The average or the midpoint of a range of values may be selected. K_d values for metals and K_{oc} values for ionizing organic compound are based on a default pH of 6.8 (EPA, 2002) if the data are available. VP, S and H values are limited to those provided for normal ambient temperatures (0 to 30 °C) and the reference temperature is provided.

When values for H are not located, they are calculated as follows, provided the requisite information is available (EPA, 1998):

$$H = \frac{VP \bullet MW}{S}$$

where:

H	=	Henry's law constant (atm-m^3/mole, calculated)
VP	=	vapor pressure (atm)
MW	=	molecular weight (g/mole)
S	=	solubility in water (mg/L).

When values for K_{oc} are not located, they are calculated as follows for phthalates and polyaromatic aromatic hydrocarbons (PAH) provided log K_{ow} is available (EPA, 1998):

$$\log K_{oc} = 0.97 \log K_{ow} - 0.094$$

where:

K_{oc}	=	soil/organic carbon partition coefficient (unitless, calculated)
K_{ow}	=	octanol/water partition coefficient (unitless).

K_{oc} for other organic chemicals is calculated as follows provided log K_{ow} is available (EPA, 1998):

$$\log K_{oc} = 0.78 \log K_{ow} + 0.151$$

where:

K_{oc} = soil/organic carbon partition coefficient (unitless, calculated)
K_{ow} = octanol/water partition coefficient (unitless).

When values for D_a are not located, they are calculated as follows (EPA, 1998):

$$D_a = \frac{1.9}{MW^{2/3}}$$

where:

D_a = diffusivity in air (cm^2/s, calculated)
MW = molecular weight (g/mole).

When values for D_w are not located, they are calculated as follows (EPA, 1998):

$$D_w = \frac{22E{-}5}{MW^{2/3}}$$

where:

D_w = diffusivity in water (cm^2/s, calculated)
MW = molecular weight (g/mole).

Values for T_b, T_c and $\Delta H_{v,b}$ for VOCs are preferentially taken from EPA (2004), unless there is evidence that values provided by other sources (HSDB, 2012; NIST, 2012) are more reliable. If values are not located for these variables, they may be estimated by the most appropriate technique for the specific chemical or class to which it belongs as recommended by Lyman et al. (1990). The estimation method used is identified by footnote in the table of physical properties.

4.0 Environmental Release, Fate and Transport

The toxicological profiles also present the predominant sources of release to the environment as well as a qualitative or semi-quantitative description of the fate and transport of the chemical in air, water, sediment, and soil. No attempt is made to present detailed quantitative data because environmental fate is usually highly dependent on climatic conditions and the characteristics of the medium of interest, both of which may differ from location to location and change from time to time. The source and fate information may provide perspective regarding the likelihood that the chemical's presence is related to site activities, that the chemical will migrate across media, or that the chemical will persist at toxicologically significant levels.

Biotransfer factors are provided for chemicals for which food-chain pathways may be significant, which includes a few inorganic chemicals and those organic chemicals that are highly lipophilic, persist in the environment, and are resistant to metabolism by lower trophic organisms in the food chain. High lipophilicity is indicated by a log K_{ow} greater than 3 (Lyman et al., 1990). Lipophilicity enhances partitioning to biomedia and passage across biological

membranes. Persistence in the environment is evidence that the chemical might resist biotransformation and, therefore, remain in edible tissues at toxicologically significant concentrations. Toxicokinetic data, when available, clarify the potential for biotransfer. Biotransformation products may be more toxic than the parent compound, but they tend to be short-lived or more quickly removed from the body, reducing the likelihood of significant bioaccumulation. Similarly, VOCs tend to be mobile and labile (i.e., subject to rapid and extensive biotransformation and excretion), and generally do not participate significantly in food-chain pathways. Therefore, biotransfer factors are not estimated for VOCs, with few exceptions. Some SVOCs, however, are highly lipophilic and may persist. Biotransfer factors generally are not estimated unless empirical data suggest that participation in food-chain pathways is likely to be significant.

The biotransfer factors of interest are water-to-fish bioconcentration factors (BCF) or bioaccumulation factors (BAF), or biota-sediment accumulation factors (BSAF), soil-to-plant biotransfer factors (Bp), cattle ingestion-to-beef factors (Bb) and cattle ingestion-to-milk factors (Bm). Separate soil-to-plant biotransfer factors are available for the reproductive parts of plants (e.g., fruits, seeds) and the vegetative parts of plants (e.g., stems, leaves) for inorganic and some organic chemicals. Soil-to-plant factors for the reproductive parts of plants are designated Bpr; soil-to-plant factors for the vegetative parts of plants are designated Bpv.

Most chemicals in surface water bodies remain predominantly in the dissolved phase in the water column or partition to sediment, which generally settles to the bottom. The difference in concentration between surface water and sediment is usually upwards of an order of magnitude. Theoretically it is appropriate to evaluate biotransfer from both media, using BCF to quantify uptake from water and BSAF to quantify uptake from sediment. Quantification of biotransfer, however, is accompanied by considerable uncertainty and variability because field conditions cannot be readily duplicated in the laboratory where BCF values are generally measured. Therefore, the biotransfer models for either medium are intentionally designed to be very conservative to ensure protection of human health. Consequently, evaluating biotransfer from both water and sediment captures the conservatism of both models and is likely to grossly overestimate total biotransfer. Therefore, most chemicals with the potential to participate significantly in aquatic food chain pathways are evaluated for bioconcentration from surface water *or* bioaccumulation from sediment, depending on which pathway is expected to predominate, but not both.

BCF values are adopted from empirical data when the data are clearly the best choice (i.e., similar results in multiple species of fin fish). When the empirical data are few or inconsistent, BCFs for inorganic chemicals are taken from various sources. BCF values for organic chemicals are generally estimated from the Bintein and Devillers model (Devillers et al., 1996):

$$\log BCF = 0.910 \log K_{ow} - 1.975 \log(6.8E{-}7 K_{ow} + 1) - 0.786$$

where:

BCF = bioconcentration factor (L/kg, calculated)
K_{ow} = octanol/water partition coefficient (unitless).

The Bintein and Devillers model is selected over simpler models adopted by the EPA largely because the Bintein and Devillers approach has undergone scrutiny since first published (Bintein and Devillers, 1993), and considerable effort was expended to validate the model; i.e., to compare modeled and empirical results. The Bintein and Devillers model is probably more realistic than simpler models, particularly for chemicals with higher log K_{ow} values. BSAF values are chosen instead of BCFs for those very highly lipophilic chemicals such as the polychlorinated biphenyls (PCB), polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/PCDF) and selected organochlorine pesticides expected to partition almost entirely to benthic sediment.

Soil-to-plant biotransfer factors (Bp) for SVOCs are estimated by a simple model by Travis and Arms (1988), which is based only on log K_{ow}:

$$\log Bp = 1.588 - 0.578 \log K_{ow}$$

where:

Bp = soil-to-plant biotransfer factor (unitless, calculated)
K_{ow} = octanol/water partition coefficient (unitless).

Separate biotransfer factors are not estimated for the reproductive parts of plants (Bpr) and the vegetative parts of plants (Bpv) by the Travis and Arms model.

Cattle ingestion-to-beef factors (Bb) for SVOCs are estimated by a simple model by Travis and Arms (1988), which is based only on log K_{ow}:

$$\log Bb = -7.6 + \log K_{ow}$$

where:

Bb = cattle ingestion-to-beef biotransfer factor (days/kg, calculated)
K_{ow} = octanol/water partition coefficient (unitless).

Cattle ingestion-to-milk factors (Bm) for SVOCs are estimated by a simple model by Travis and Arms (1988), which is based only on log K_{ow}:

$$\log Bm = -8.10 + \log K_{ow}$$

where:

Bm = cattle ingestion-to-milk biotransfer factor (days/kg, calculated)
K_{ow} = octanol/water partition coefficient (unitless).

It should be understood that the biotransfer models described above depend only on one or two physical property values that are related largely to the propensity for transfer across biological membranes. Many compounds have relatively large log K_{ow} values, indicating ready passage across membranes; however, they are sufficiently volatile, or are otherwise mobile or labile so

they are unable to persist in biological tissues. For example, many constituents with high log K_{ow} values are efficiently metabolized by lower trophic organisms in the food chain so that significant human exposure does not occur. Such is the case for practically all VOCs and most SVOCs; relatively few compounds participate significantly in food-chain pathways. Therefore, biotransfer is evaluated as a potential pathway only for those chemicals with empirical data that indicate food-chain exposure could be significant.

5.0 Toxicokinetics

A toxicokinetics section was added to the toxicological profiles in early 2004. Toxicokinetics describes the uptake or absorption of the chemical from contact media, the distribution of the chemical (or its metabolites) within the body following absorption, the metabolism or biotransformation of the chemical, and the mechanisms of excretion of the parent compound and its biotransformation products from the body. The toxicokinetics section documents the gastrointestinal (GI) absorption factor (GAF) required to develop toxicity factors for dermal exposure, because dermal risk characterization depends on an absorbed dose rather than an exposure dose. The toxicokinetics section also identifies the compounds that are rapidly metabolized or eliminated, which justifies excluding their evaluation in food-chain pathways even though they may have a large K_{ow} that indicates ready passage across cell membranes. This section also tries to identify the ultimate toxicant and elucidate the most important mechanism(s) of toxicity.

6.0 Dermal Exposure

The toxicological profiles provide the documentation for the GAF, which is used to develop the dermal toxicity values. The toxicological profiles also provide documentation for the dermal absorption factor (ABS), which describes the extent of dermal uptake from soil, and the time for dermal uptake to reach steady state (t*), the permeability coefficient (K_p), the lag time for chemical to cross the stratum corneum (τ), the fraction absorbed (FA), and the ratio of the permeability coefficient for passage across the stratum corneum to the permeability coefficient for passage across the viable epidermis (B), all which are used to estimate the rate of dermal uptake from water. These values are taken from EPA (2004) if available. Otherwise, they are estimated by the EPA (2004) methods.

7.0 Toxicity Evaluation

The toxicological profile contains a brief description of the nature of the adverse effects associated with the chemical. It is important to note that a discussion of adverse effects without a discussion of dose is incomplete and potentially misleading, because virtually any chemical may be toxic at some dose, and many chemicals (e.g., nutritionally required minerals, vitamins, amino acids, etc.) enhance human health at some low dose. An ever growing and compelling body of evidence suggests that many environmental contaminants also enhance health at low doses (Hart and Frame, 1996).

7.1 Noncancer Evaluation

The toxicity values for noncancer effects include a reference dose (RfD) expressed in milligrams per kilogram per day (mg/kg-day) for chronic or subchronic oral exposure, and a reference concentration (RfC), in milligrams per cubic meter (mg/m^3), for chronic or subchronic inhalation exposure. The inhalation RfC in units of mg/m^3 may be converted to an equivalent inhalation

RfD by assuming continuous chronic exposure of humans with a body weight of 70 kg and an inhalation rate of 20 m^3/day (EPA, 1989, 1991). In other words, the RfC expressed as mg/m^3 is multiplied by the inhalation rate of 20 m^3/day, and the result is divided by the assumed adult body weight of 70 kg to yield an inhalation RfD expressed as mg/kg-day.

RfD and RfC values are usually derived from empirical benchmark doses (BMD) or concentrations called no-observed-effect levels (NOEL) or no-observed-adverse-effect levels (NOAEL) from animal toxicity or human epidemiology studies. If the data do not permit identifying a NOEL or NOAEL, a lowest-observed-adverse-effect level (LOAEL) or lowest-effect level (LEL) may be used. A frank-effect level (FEL), e.g., mortality, shortened life span or serious physiologic, neurologic or behavioral disturbances, is generally considered an inappropriate benchmark from which to develop an RfD or RfC. Some RfD and RfC derivations employ a BMD that is a statistically estimated dose for humans at which some low proportion of the population may experience some minimally adverse effect. A BMD at which 10 percent of the population may be expected to experience such an effect is expressed as BMD_{10}. The RfD or RfC is derived by dividing the benchmark level (e.g., NOAEL or BMD_{10}) by a series of uncertainty and modifying factors, which collectively are designated the uncertainty factor (UF).

RfD and RfC values are not currently available for acute toxicity and acute exposure is not evaluated in the RA. Nonetheless, the levels associated with acute lethality and data regarding the effects of acute exposure to levels higher than ordinarily observed in chronic environmental exposure provide additional perspective regarding the toxicity of the chemical. Therefore, information regarding acute toxicity, when available, is included in the profiles. Lethality data for laboratory animals are generally expressed as the oral dose associated with lethality of 50 percent of an exposed population (LD_{50}) or the concentration in air associated with lethality of 50 percent of an exposed population (LC_{50}). Occasionally the dose associated with lethality in a low percentage of an exposed population (LD_{LO}) is presented.

RfD and RfC values are derived for both chronic and subchronic exposure. For purposes of the RA, chronic exposure is defined as equal to or greater than 7 years, i.e., at least 10 percent of expected life span; subchronic exposure is defined as 2 weeks to 7 years.

Under the assumption of monotonicity (i.e., incidence, intensity, or severity of effects can increase, but cannot decrease, with increasing magnitude or duration of exposure), a chronic RfD may be considered sufficiently protective for subchronic exposure, but a subchronic RfD may not be protective for chronic exposure. Currently, verified subchronic RfD values are unavailable. Provisional subchronic RfDs exist for few chemicals and are compiled in the Health Effects Assessment Summary Tables (HEAST) (EPA, 1997) and some National Center for Environmental Assessment (NCEA) or Provisional Peer Reviewed Toxicity Value (PPRTV) derivations. Although once updated semi-annually, the HEAST is no longer updated, because the EPA (2005) Integrated Risk Information System (IRIS) is generally considered the source of the highest quality toxicity values. For some chemicals the PPRTV derivations are more recent and it is known that summaries on IRIS will be replaced with the PPRTV derivations. In these cases the PPRTV values will be selected preferentially to those on IRIS. Subchronic RfD and RfC values are generally obtained from EPA (1997) or more recent NCEA or PPRTV evaluations, or they may be derived *de novo* from the toxicological data set or from chronic RfD values as follows:

- If the UF applied in the derivation of the chronic RfD does not provide for expansion from subchronic to chronic exposure (e.g., if the chronic RfD was derived from a chronic study), the chronic RfD is adopted as being sufficiently protective for subchronic exposure.

- If the UF applied in the derivation of the chronic RfD contains a component to expand from subchronic to chronic exposure, the subchronic RfD is derived by multiplying the chronic RfD by the component of the UF used to expand from subchronic to chronic exposure (e.g., if a factor of 10 was used to expand from subchronic to chronic exposure, the subchronic RfD will be 10 times larger than the chronic RfD).

7.2 Carcinogenicity Evaluation

The evaluation of the potential carcinogenicity of a chemical includes both a qualitative and a quantitative aspect (EPA, 1986, 2005). EPA (2005) recognizes five weight-of-evidence group classifications for carcinogenicity. Formerly, EPA (1986) used a letter-based system to describe the weight of evidence for carcinogenicity. Reference to this former system is included because many of the carcinogenicity assessments listed on the Integrated Risk Information System (IRIS) use the former letter-based system (EPA, 2012). The five EPA weight-of-evidence classifications are as follows:

- ***Carcinogenic to Humans*** (corresponds to the former Group A - Human Carcinogen).

- ***Likely to be Carcinogenic to Humans*** (includes both the former Group B1 and Group B2-Probable Human Carcinogens)

- ***Suggestive Evidence of Carcinogenic Potential*** (corresponds to the former Group C - Possible Human Carcinogen)

- ***Inadequate Information to Assess Carcinogenic Potential*** (corresponds to the former Group D - Not Classifiable as to Human Carcinogenicity)

- ***Not Likely to be Carcinogenic to Humans*** (corresponds to the former Group E - Evidence of Noncarcinogenicity to Humans).

Toxicity values for cancer risk include a slope factor (SF) for oral exposure, expressed as the risk per mg/kg-day ingested dose, and a unit risk factor (URF) for inhalation exposure, expressed as the risk per microgram per cubic meter ($\mu g/m^3$) in ambient air. These quantitative estimates are generally provided for chemicals in EPA weight-of-evidence Groups A, B and C if the data are adequate. The SF or URF is usually estimated as an upper bound on the slope of the dose- or concentration-response curve from animal toxicity or human epidemiology studies. The inhalation URF in units of risk per $\mu g/m^3$ may be converted to an equivalent inhalation SF in units of risk per mg/kg-day by assuming continuous lifetime exposure of humans with a body weight to 70 kg and an inhalation rate of 20 m^3/day. In other words, the URF expressed as risk per $\mu g/m^3$ is divided by the inhalation rate of 20 m^3/day, and multiplied by the assumed body weight of 70 kg and a conversion factor of 1000 µg/mg.

EPA (1986, 2005) generally assumes that there are no thresholds for carcinogenic expression; therefore, any exposure represents some quantifiable risk. A few potential carcinogens are understood to require a threshold for carcinogenic expression. Such chemicals are more appropriately evaluated with an RfD developed as described above.

7.3 Hierarchy for Selecting Toxicity Data

Toxicity values generally are chosen using the following hierarchy, consistent with the EPA Office of Solid Waste and Emergency Response Directive 9285.7-53 (EPA, 2003):

- Tier 1 values: The EPA's (2012) on-line IRIS database containing toxicity values that have undergone the most rigorous Agency review.

- Tier 2 values: EPA's provisional peer-reviewed toxicity values (PPRTV) derivations for the Superfund Technical Support Center (STSC); there may be individual chemicals for which the PPRTV derivations supercede those on IRIS.

- Tier 3 Values: Older NCEA derivations for the STSC, PRRTV screening values, HEAST (EPA, 1997), Minimal Risk Levels (MRL) from the Agency for Toxic Substances Disease Registry (ATSDR) toxicological profiles, U.S. Army Center for Health Promotion and Preventive Medicine (CHPPM) values, California Environmental Protection Agency (2012) Toxicity Criteria Database values, or other EPA documents or memoranda.

The primary literature may be surveyed to determine whether sufficient data exist to derive a toxicity value using the EPA methodology. The use of surrogate chemicals is also considered if the chemical structure, adverse effects, and toxic potency of the surrogate and chemical of interest are judged to be sufficiently similar.

The Environmental Council of the States-U.S. Department of Defense (2007) has issued a toxicity value hierarchy that basically supports the EPA (2003) hierarchy but places higher emphasis on the necessity for external peer review.

GAFs, used to derive dermal RfD values and SFs from the corresponding oral toxicity values, are obtained from the following hierarchy:

- EPA (2004)

- Empirical data

- PPRTV summaries or NCEA position papers

- Federal agency reviews of the empirical data, such as ATSDR toxicological profiles and various EPA criteria documents

- Other published reviews of the empirical data.

8.0 References

Bintein, S. and J. Devillers, 1993, "Nonlinear Dependence of Fish Bioconcentration on n-Octanol/Water Partition Coefficient," ***SAR and QSAR in Environmental Research***, 1: 29-39.

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Metals

ALUMINUM (7429-90-5)

1.0 Introduction and Physical Properties

Aluminum is a naturally occurring **metal** (ATSDR, 2008). It is the third most abundant element in nature, constituting approximately 8 percent of the minerals in the earth's crust. Aluminum is highly reactive; thus, is always found in combination with other substances such as oxygen, fluoride or silica. Aluminum is used in a wide variety of metallurgical applications, including packaging (particularly food items), kitchen utensils, auto bodies and components, airplanes, building components, electrical transmission, and to adsorb occluded gases in making steel (ATSDR, 2008; Elinder and Sjogren, 1986; HSDB, 2012). Aluminum compounds are used in testing for gold, arsenic and mercury, in metal alloys, in protective coatings, paints and printer inks, in cosmetics, food additives and some pharmaceuticals, as coagulating agents in the treatment of drinking water, and in photography flash bulbs and fireworks. Relevant physical properties are compiled below:

MW	log K_{ow}	H	K_d	D_a	D_w	VP	S
26.98[a] (Element)	NA	NA	1500[b]	NA	NA	NA	Note 1[c]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; K_d = soil/water partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; NA = not applicable.
[a]Hazardous Substance Data Bank (HSDB), 2012, National Library of Medicine, on line.
[b]Baes, C.F., R.D. Sharp, A.L. Sjoreen, R.W. Shor, 1984, ***A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture***, Health and Safety Division, Oak Ridge National Laboratory, ORNL-5786, September.
[c]Solubility of aluminum compounds varies from essentially insoluble in hot or cold water to highly soluble to highly reactive (e.g., aluminum chloride reacts explosively with water liberating heat and hydrogen chloride gas). Agency for Toxic Substances and Disease Registry (ATSDR), 2008, ***Update Toxicological Profile for Aluminum***, U.S. Department of Health and Human Services, Atlanta, Georgia, July, on line.

2.0 Environmental Fate and Transport

Aluminum is one of the few elements for which natural release far outweighs anthropogenic release (ATSDR, 2008; HSDB, 2012). The predominant natural process is the weathering and release of dust from soil and rocks into the air. Major anthropogenic sources include aluminum mining and smelting, coal combustion, and other mining or industrial activities that process crustal materials and release aluminum to the atmosphere. Aluminum exists in the air as particulates that presumably are subject to wet and dry deposition. Large particulates predominate, which suggests that deposition occurs not far from the point of release.

Aluminum is deposited on soil from the atmosphere (ATSDR, 2008). Other anthropogenic sources to soil include wastes from mines, smelters and coal combustion. Aluminum in soil exists in several soluble and insoluble forms, depending on pH and the nature of the minerals and organic material present in the soil. Generally, increasing acidity (decreasing pH) mobilizes aluminum and facilitates leaching.

Aluminum exists naturally in water in several hydrated and complexed forms (ATSDR, 2008). Sources include solution from surrounding soil, precipitation, and runoff and erosion from soil.

The extent to which aluminum in water settles out is highly variable and depends on pH and the other constituents present in the water with which aluminum may form compounds and complexes. Generally an equilibrium is established between soluble and insoluble forms.

Bioconcentration in fish is largely a function of water quality (e.g., pH and total organic carbon). Highest concentrations of aluminum are generally found in the gills and lowest concentrations are found in edible muscle tissue. Concentrations decrease as the fish pass through the larval and juvenile stages. Therefore, the bioconcentration of aluminum in edible fish tissues is not expected to represent a toxicologically significant source to humans (EPA, 1995).

Acid conditions in soil mobilize aluminum for uptake by plants, but the extent of uptake and the distribution between the roots and the aerial parts is highly dependent on the species of plant (ATSDR, 2008). Teas and some herbs may bioconcentrate aluminum; however, these items are unlikely to contribute significantly to the diet. Aluminum does not accumulate significantly in cow's milk or beef, and is not expected to undergo biomagnification in terrestrial food chains. For these reasons biotransfer is not expected to contribute significantly to human exposure and biotransfer factors are not compiled or estimated.

3.0 Toxicokinetics

Aluminum is poorly absorbed following inhalation exposure (ATSDR, 2008). Evidence suggests that the epithelium of the upper and lower respiratory tract can absorb aluminum, and that absorption is somewhat more efficient for aluminum fumes (occupational exposure) rather than dust. Aluminum can be retained in the lungs for long periods. Also, it has been shown that aluminum absorbed by the olfactory epithelium can reach the brain directly via axonal transfer.

Dietary aluminum is absorbed from the GI tract in the range of 0.1 to 0.3 or perhaps 0.5 percent (ATSDR, 2008). Unusually bioavailable forms such as carboxylic acid complexes may be absorbed at 1 percent of the administered dose. Ingestion of large amounts of aluminum in antacid preparations can increase total absorption, but factors other than the amount ingested appear to reduce the proportion of the total dose that is absorption.

ATSDR (2008) concluded that aluminum is "essentially not absorbed dermally," although the data are confusing and one study in mice verifies that dermal uptake occurs. Quantitative data were not located.

Normal humans have a body burden of aluminum in the 30 to 50 mg range, with approximately one-half located in the skeleton and one-fourth in the lungs (ATSDR, 2008). Body burden generally increases with age. The amount in the lungs probably reflects accumulation from inhalation of aluminum in dust. Levels in brain tissue range from 0.25 to 0.75 mg/kg wet weight in the white matter and approximately twice that in the gray matter.

Aluminum following inhalation exposure is associated largely with the lungs and thoracic lymph nodes (ATSDR, 2008). In humans, increased levels are seen also in the liver and spleen. Increased levels in these tissues have not been seen in animals exposed via inhalation. Some inhaled particulates are cleared from the respiratory tract by mucocilliary elevation and are swallowed, thereby becoming available for GI absorption.

Animal studies with ingested aluminum suggest that distribution is preferentially to various regions of the brain (ATSDR, 2008). Prolonged studies with rats indicate that distribution also occurs to bone, muscle and kidneys, but that tissue levels return to normal shortly after exposure ceases. Limited evidence in animals suggests that transplacental distribution and excretion via lactation also occur. Vitamin D and related compounds may increase uptake and tissue retention. Distribution studies following administration by various parenteral routes yielded quite variable results, suggesting that the target tissues may be specific to the form of aluminum administered. The brain was clearly not reported as the most predictable target tissue for all forms of aluminum administered to all species by parenteral routes.

Aluminum in the body may occur in the form of free ions (Al^{+3}), low-molecular-weight complexes (particularly stable chelates), macromolecular complexes, or covalently bound macromolecular complexes (ATSDR, 2008). All forms may be metabolically active. Essentially irreversible complexes may be formed in the nucleus and chromatin material of the cell.

The kidney is the primary organ for excretion of absorbed aluminum (ATSDR, 2008). Urinary excretion patterns after inhalation exposure (i.e., prolongation of elevated urinary levels of aluminum) indicate that body burden and excretion half-life both increase with prolonged exposure. Excretion is lower in premature infants than full-term infants, probably because glomerular filtration is underdeveloped before birth. This suggests that the unborn and premature may be unusually sensitive to the effects of aluminum.

4.0 Dermal Exposure

As noted above, ATSDR (2008) concluded that aluminum is essentially not absorbed dermally. Therefore, the likelihood of systemic toxic effects arising from dermal exposure to aluminum is very small, and no attempt is made to quantify dermal uptake or risk.

5.0 Noncancer Effects Evaluation

Aluminum is relatively nontoxic via ingestion to physiologically normal humans, but recently concern has arisen regarding neurological effects, including Alzheimer's disease and similar forms of dementia (EPA, 2006). Much of this concern stems from studies with large oral doses of soluble aluminum salts (e.g., aluminum hydroxide) and from medical procedures that bypass the GI absorption barrier (i.e., parenteral administration). A review of several animal studies with many different forms of aluminum suggests that the developing infant is potentially the most sensitive member of the human population. A provisional chronic oral RfD of 1E+0 mg/kg-day was derived from a LOAEL of 100 mg/kg-day for minimal and equivocal neurological effects in the offspring of mice. The mice were fed diets fortified with aluminum lactate throughout gestation and lactation. An uncertainty factor of 100 (factor of 10 for interspecies extrapolation, and factors of 3 each for a minimal LOAEL and for intraspecies variation) was used. Confidence in the oral RfD is low. The nervous system is the target organ for oral exposure to aluminum. (The nervous system rather than the CNS is chosen as the target organ because it cannot be stated unequivocally that some of the neurologic effects observed do not involve the peripheral nerves.)

EPA (1997) provides no subchronic oral RfD for aluminum, and one cannot be derived from the key study for the chronic oral RfD. Therefore, the chronic oral RfD of 1E+0 mg/kg-day is adopted as sufficiently protective for subchronic oral exposure.

Occupational exposure to aluminum metal dust and aluminum oxide is associated with pulmonary fibrosis and related respiratory effects such as cough, emphysema, pneumonia and decreased pulmonary function (ACGIH, 1991). The toxicity of occupational exposure to dusts of aluminum pyro powders is somewhat higher, and occupational exposure to salts such as the sulfate and chloride may yield hydrolysis to the corresponding acids, which are irritants in their own right. Pulmonary effects were also observed in animals exposed to powders and dusts of metallic aluminum and various aluminum compounds.

Results of testing Canadian gold and uranium miners prophylactically treated with aluminum oxide powders to prevent silicosis associated aluminum exposure with impaired cognitive performance (EPA, 2006). The likelihood of cognitive impairment was directly related to the duration of exposure. Neurological performance was also impaired in aluminum foundry workers exposed to fumes and aluminum dust (4.6 to 11.5 mg aluminum/m^3) for a mean of 12 years. Other studies also implicate aluminum as a cause of neurological impairment and neurophysical effects in exposed smelter workers and aluminum welders. A provisional inhalation RfC is based on the LOAEL of 4.6 mg aluminum/m^3 in the study of foundry workers described above. The lower end of the exposure concentration adjusted for intermittent exposure is 1.64 mg/m^3. Application of an uncertainty factor of 300 (factors of 10 each to estimate a NOAEL from a LOAEL and for interspecies extrapolation, and a factor of 3 to address deficiencies in the inhalation toxicity data base) yields an RfC of 5E-3 mg/m^3, which is equivalent to a chronic inhalation RfD of 1.4E-3 mg/kg-day. Confidence in the inhalation RfC is medium. The nervous system is the target organ for inhalation exposure to aluminum.

EPA (1997) provides no subchronic inhalation RfC for aluminum, nor can one be estimated from the key study used for the chronic RfC. Therefore, the chronic inhalation RfC of 5E-3 mg/m^3 (1.4E-3 mg/kg-day) is adopted as sufficiently protective for subchronic oral exposure.

6.0 Carcinogenicity Evaluation

EPA (2006) reviewed the human and laboratory animal data regarding the potential carcinogenicity of aluminum and concluded that the carcinogenicity cannot be determined. The human data are insufficient for drawing conclusions and the animal data are largely negative. Potency factors are not derived.

7.0 Toxicity Summary

Toxicity values for aluminum are summarized as follows:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
1E+0	1E+0	NS	5E-3/ 1.4E-3	5E-3/ 1.4E-3	NS	D	ND	D	ND	ND

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data.
Target organ or critical effect abbreviations: NS = nervous system.
[a]Dermal exposure is not evaluated.

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ARSENIC (7440-38-2)

1.0 Introduction and Physical Properties

Arsenic is a natural **metalloid**, the 20th most abundant element in the earth's crust that occurs in both inorganic and organic forms (ATSDR, 2000; HSDB, 2012). Elemental arsenic is a steel-grey material that may occur naturally. However, arsenic is usually found in the environment combined with other elements such as oxygen, chlorine, and sulfur. Most inorganic and organic arsenic compounds are non-volatile, odorless and tasteless white or colorless powders. Inorganic arsenic occurs naturally in soil and in many kinds of rock, especially in minerals and ores that contain copper or lead. Inorganic arsenic is more toxic than organic forms. Major uses of arsenic in the U.S. include its incorporation into wood preservatives and other agricultural chemicals. It is also used as a metal in various electrical devices and is alloyed with lead and copper in the manufacture of lead bullets or shot (Lewis, 1997). Arsenic is also a component of the chemical warfare agent Lewisite (Opresko et al., 1998). Lewisite is manufactured by the condensation of arsenic trichloride with acetylene in the presence of aluminum, copper or mercuric chloride (Lewis, 1997). Relevant physical properties are compiled below:

MW	log K_{ow}	H	K_d	D_a	D_w	VP	S
74.92[a]	NA	NA	2.9E+1[b]	NA	NA	Note 1[c]	Note 2[c]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; K_d = soil/water partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; NA = not applicable.
Note 1: Variable: inorganic arsenic compounds are not likely to volatilize; some organic arsenic compounds are low-boiling liquids or gases at normal temperatures.
Note 2: Variable: inorganic arsenic compounds range from practically insoluble to freely miscible in water; most organic arsenic compounds are not readily soluble, most arsenic acid compounds are soluble to freely miscible.
[a] Hazardous Substance Data Bank (HSDB), 2012, National Library of Medicine, on line.
[b]U.S. Environmental Protection Agency (EPA), 2002, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***,, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, December.
[c]Agency for Toxic Substances and Disease Registry, (ATSDR), 2000, ***Update Toxicological Profile for Arsenic***, U.S. Public Health Service, Atlanta, Georgia, September, on line.

2.0 Environmental Fate and Transport

The production of arsenic and its use in nonferrous alloys and in the manufacture of semiconductors may result in its release to the environment through various waste streams HSDB, 2012). Other important anthropogenic releases are metal smelting, coal burning, and other industrial activities. Arsenic may be present at military sites as a result of training with or demilitarization or disposal of Lewisite. Most (approximately 80 percent) of anthropogenic releases are initially to soil (ATSDR, 2000).

Arsenic occurs in the air as a combination of trivalent and pentavalent forms almost entirely adsorbed to small particles that permit dispersion over long distances (ATSDR, 2000). Residence time in the atmosphere averages approximately nine days. Removal is largely by wet and dry deposition. Arsenic in surface water can undergo a variety of reactions and exist as several different soluble compounds. Sorption to sediment is often an important removal process, but biotransformation in sediment may return soluble forms to the water. Arsenic in soil generally exists as insoluble forms sorbed to clay or organic matter or complexed with calcium or iron. Mobility is low and leaching is not generally significant, except that increasing soil pH can dramatically increase solubility and mobility.

Arsenic has been shown to bioconcentrate in aquatic organisms, mainly at the water-algae interface (ATSDR, 2000). There is no evidence for biomagnification through the various trophic levels, nor do there appear to be significant differences between bottom-feeders and predatory fish. Arsenic is among the metals listed as being of no concern for bioaccumulation in fish (EPA, 1995). Empirical data suggest that bioconcentration through terrestrial food chain pathways is unlikely to be significant (ATSDR, 2000). Therefore, biotransfer factors are not developed for arsenic.

3.0 Toxicokinetics

All forms of inorganic arsenic are readily absorbed by the lungs and GI tract; the extent of absorption is greater for more soluble compounds than for more insoluble compounds (ATSDR, 2000). Dermal absorption has not been well characterized but is significantly less than inhalation or oral absorption. GI and dermal absorption of arsenic from soil is much lower than from aqueous solution. Distribution is generally widespread throughout the body following absorption.

Metabolism of inorganic arsenic involves reduction of As^{+5} to As^{+3}, and oxidation of As^{+3} to As^{+5} so that arsenic is present systemically as a mixture of arsenate and arsenite (ATSDR, 2000). Arsenite is readily oxidized and methylated primarily in the liver to form the organic compounds monomethyl arsonic acid and dimethyl arsinic acid, which are rapidly excreted in the urine.

4.0 Dermal Exposure

EPA (2004) concluded that a GAF should not be estimated for the purpose of adjusting oral toxicity values for dermal exposure. Therefore, the oral toxicity values described below are used directly without adjustment for evaluating dermal exposure.

EPA (2004) cites empirical data indicating that dermal uptake of arsenic from soil approximates 3 percent. The ABS of 0.03 recommended by EPA (2004) is used herein. Empirical data regarding the uptake of soluble forms of arsenic from water were not located. The EPA (2004) default K_p for inorganic chemicals of 1E-3 cm/hour is selected for arsenic.

5.0 Noncancer Effects Evaluation

Inorganic arsenic may be an essential nutrient, at least for food-producing domestic animals, exerting beneficial effects on growth, health and feed conversion efficiency (Underwood, 1977). A lethal dose of arsenic trioxide in humans is 70-180 mg, approximately 50 to 140 mg arsenic (Ishinishi et al., 1986). Acute oral exposure of humans to high doses of arsenic produces liver swelling, skin lesions, disturbed heart function and neurological effects. The only noncancer effects in humans clearly attributable to chronic oral exposure to arsenic are dermal hyper pigmentation and keratosis, as revealed by studies of several hundred Chinese exposed to naturally occurring arsenic in well water (EPA, 2012). Similar effects were observed in persons exposed to high levels of arsenic in water in Utah and the northern part of Mexico. EPA (2012) verified an RfD of 3E-4 mg/kg-day for chronic oral exposure, based on a NOAEL of 8E-4 mg/kg-day for hyper pigmentation and kertatosis of the skin from the Chinese data. An uncertainty factor of 3 was applied. An increased incidence of Blackfoot disease was also observed, which may not be related to arsenic alone. Goyer (1991) describes black-foot disease as a peripheral vascular disorder manifested as acrocyanosis and Raynaud's disease, which may progress to gangrene. EPA (2012) notes that the skin is the more sensitive target organ.

Nonetheless, in keeping with EPA (1989) guidance regarding selection of target organ, both the skin and peripheral vascular system are selected as target organs for prolonged oral exposure to arsenic. Confidence in the RfD is medium.

The available data do not suggest a significant difference between chronic and subchronic exposure regarding the threshold for noncancer effects. Therefore, EPA (1997) adopted the chronic oral RfD as the provisional subchronic oral RfD for arsenic.

Occupational (predominantly inhalation) exposure is also associated with neurological deficits, anemia, and vascular effects (Ishinishi et al., 1986). However, concomitant exposure to other chemicals cannot be ruled out in the occupational studies. Therefore, the data are not sufficient for estimation of an inhalation RfC.

6.0 Carcinogenicity Evaluation

Inorganic arsenic is clearly a carcinogen in humans. Inhalation exposure is associated with increased risk of lung cancer in persons employed as smelter workers, in arsenical pesticide applicators, and in a population residing near a pesticide manufacturing plant (EPA, 2012). Oral exposure to high levels in well water is associated with increased risk of skin cancer and several forms of internal cancer, although the role of other chemicals in the internal cancers is unclear. Extensive animal testing with various forms of arsenic given by many routes of exposure to several species, however, has not demonstrated the carcinogenicity of arsenic, indicating that the common laboratory animals are not good models for carcinogenicity to humans. EPA (2012) classified inorganic arsenic in cancer weight-of-evidence Group A (human carcinogen), and recommended an oral SF of 1.5E+0 per mg/kg-day, based on the incidence of skin cancer in the Chinese study. EPA (200) noted that arsenic probably functions via several different mechanisms of toxicity not including direct interaction with DNA. These appear to obey thresholds or to generate a non-linear slope that approaches 0 in the low-dose range. The SF probably exaggerates cancer risk in the low dose range associated with most environmental exposures, although the extent is unclear.

An inhalation URF of 4.3E-3 per $\mu g/m^3$, equivalent to an inhalation SF of 1.5E+1 per mg/kg-day, was derived for inorganic arsenic from the incidence of lung cancer in occupationally exposed men (EPA, 2012).

7.0 Toxicity Summary

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
3E-4	3E-4	S, PVS	ND	ND	NA	A	1.5E+0	A	4.3E-3	1.5E+1

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.
Target organ or critical effect abbreviations: S = skin; PVS = peripheral vascular system.
[a]sRfDo, cRfDo and SFo should be used for dermal exposure without adjustment for GI absorption.

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CHROMIUM (7440-47-3)

1.0 Introduction and Physical Properties

Chromium is a naturally occurring **metal** (ATSDR, 2000). It occurs in several valence states; chromium (III) (16065-83-1) and chromium (VI) (18540-29-9) are the forms most commonly encountered in environmental media. Chromium is used largely in the metallurgical, refractory and chemical industries. The largest amount is used in the metallurgical industry in various steels and nonferrous alloys. The second largest use is by the chemical industry in pigments, metal finishing, leather tanning and wood treatment. Relevant physical properties are compiled below:

MW	log K_{ow}	H	K_d	D_a	D_w	VP	S
52.00[a] (element)	NA	NA	1.8E+6 (CrIII) 1.9E+1 (CrVI)[b]	NA	NA	ND	Note 1[a]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; K_d = soil/water partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; NA = not applicable; ND = no data.
Note 1: Chromium compounds vary from insoluble to highly soluble.
[a]Agency for Toxic Substances and Disease Registry, (ATSDR), 2000, ***Toxicological Profile for Chromium***, U.S. Public Health Service, Atlanta, Georgia, September, on line.
U.S. Environmental Protection Agency (EPA), 2002, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Office of Solid Waste and Emergency Response, Washington, D.C., 9355.4-24, December.

2.0 Environmental Fate and Transport

Chromium is released into the atmosphere from natural gas, oil and coal combustion, and from use by the industries mentioned above (ATSDR, 2000). Other sources include wind transport from road dust, cement producing plants, the wearing down of asbestos brake linings from automobiles, incineration of municipal refuse and sewage sludge, exhaust emission from automotive catalytic converters, and emissions from cooling towers that use chromium compounds as rust inhibitors. Significant quantities of chromium are released to surface water from industrial use. Land disposal of chromium-containing commercial products, solid waste and slag from chromate manufacture, and coal ash, primarily from electric utilities and other operations that burn coal, are the major releases to soil.

Chromium releases from combustion processes and ore processing are generally in the form of chromium (III) oxide; however, chromium (VI) has been identified in fly ash from coal combustion at chromate manufacturing and user sites (ATSDR, 2000). Airborne chromium exists in particulate form that may travel great distances from the point of emissions; wet and dry deposition account for the majority of removal from air.

Most chromium released to surface water eventually adsorbs to particles and becomes deposited in bottom sediment, but small quantities may remain in the water in both soluble and insoluble forms (ATSDR, 2000). The soluble forms are usually chromium (VI) salts and soluble chromium (III) compounds. Chromium (VI) may be found in water, but eventually organic matter and other reducing agents will reduce chromium (VI) to chromium (III). Chromium in soil is present

mainly as insoluble chromium (III) carbonates and oxides that are unlikely to be mobile to any significant extent. However, soluble forms may also be present, depending on the form of the chemical released, that may be quite mobile in soil. Also, lower pH facilitates complexation with organic matter and increases mobility.

Empirical evidence suggests that chromium is unlikely to participate significantly in food chain pathways (ATSDR, 2000; EPA, 1995); therefore, biotransfer factors are not compiled.

3.0 Toxicokinetics

Identification of chromium in urine, serum and tissues of occupationally exposed humans confirms that soluble chromium (III) and chromium (VI) compounds are absorbed from the lung (ATSDR, 2000). The rate of absorption, however, depends largely on the physical and chemical characteristics of the chromium compound involved, as shown in numerous animal inhalation studies. Chromium (VI) compounds are more readily absorbed because the chromate anion participates in facilitated diffusion mechanisms not available to chromium (III).

Absorption of dietary sources of chromium from the GI tract in humans ranges from approximately 0.5 to 2 percent, as inferred from urinary excretion data (ATSDR, 2000). The extent of absorption appears to be inversely related to dietary chromium content. A review of several studies suggests that 0.4 to 14.5 percent of orally administered chromium not related to dietary sources is absorbed by the GI tract of humans, but valence and chemical form and nutritional status (fed vs. fasting) appear to influence efficiency of absorption (ATSDR, 2000). Chromium (VI) sources are more efficiently absorbed than chromium (III) sources as described above for inhalation exposure. Experiments with laboratory animals showed that the stomach has the ability to reduce chromium (VI) to chromium (III), reducing the extent of absorption when chromium (VI) compounds were administered *per os* compared with injection directly into the jejunum.

Both chromium (III) and chromium (VI) can penetrate intact human skin, and dermal uptake is increased if the skin is damaged (ATSDR, 2000). In some cases, dermal uptake was sufficient to result in signs of toxicity. The form and the vehicle greatly influence the rate of dermal uptake.

Inhaled particles of chromium compounds can remain in the lungs for years (ATSDR, 2000). Chromium absorbed into the blood is distributed throughout the body with highest levels frequently located in the kidneys. Chromium has been shown to cross the placenta and to be excreted via lactation. Autopsy studies in the US show that highest concentrations in newborns occur in the kidney, liver, aorta, heart, pancreas and spleen, and that tissue levels decline with age.

The main feature of the metabolism of chromium involves reduction of chromium (VI) to chromium (III) via the formation of chromium (V) and chromium (IV) intermediates (ATSDR, 2000). Reduction of chromium (VI) to chromium (III) occurs in the acid milieu of the stomach, primarily by reaction with ascorbate. Ascorbate, glutathione and other substrates effectively reduce absorbed chromium (VI) to chromium (III). Chromium (III) is considered a nutritionally essential element required for the proper metabolism of glucose, proteins and lipids. It acts as part of a complex known as GTF, which facilitates the action of insulin. Although chromium (III) complexes are generally thought to be inert, there is recent evidence that chromium (III)

may be reduced to chromium (II), which could catalyze the Haber-Weiss reaction resulting in the production of genotoxic hydroxyl radicals.

Absorbed chromium is excreted primarily in the urine (ATSDR, 2000).

4.0 Dermal Exposure

EPA (2004) recommends GAFs of 0.013 for chromium (III) and 0.025 for chromium (VI), generally consistent with the toxicokinetic data reviewed above, which are used in this evaluation. The GAF of 0.013 for chromium (III) should be used for total chromium, which is assumed to consist of 6 parts of chromium (III) to 1 part of chromium (VI) (EPA, 2004b, 2012).

Data were not located regarding the extent of dermal uptake of chromium from soil, and EPA (2004) provides no estimate of the extent of dermal absorption (ABS). EPA (2004) recommends that dermal uptake from soil should not be quantified for chemicals without ABS recommendations, but that these chemicals should be discussed qualitatively as a source of uncertainty. EPA (2004) recommends average K_p values of 1E-4 cm/hour and 1E-3 cm/hour for for chromium (III) and chromium (VI), respectively. The K_p of 1E-3 cm/hour for chromium (III) should be used for total chromium for reasons explained in the previous paragraph.

5.0 Noncancer Effects Evaluation

As mentioned above, chromium (III) is an essential nutrient involved in maintenance of normal metabolism (ATSDR, 2000). EPA (2012) verified an RfD of 1.5E+0 mg/kg-day for chronic oral exposure to chromium (III) by applying an uncertainty factor of 1000 to a NOEL of 1800 g/kg (1.468 mg/kg body weight/day) as an average total ingested dose in a dietary study in which rats were given 600 feedings of chromic oxide baked into bread. No other dose levels were tested. Confidence in the RfD is low. No target organ or critical effect was identified for the toxicity of oral exposure to chromium (III).

The available data do not suggest a significant difference between chronic and subchronic exposure regarding the threshold for the noncancer effects of chromium (III). Therefore, EPA (1997) adopted the verified chronic oral RfD, which at the time was listed on IRIS as 1E+0 mg/kg-day, as the provisional subchronic oral RfD for chromium (III). Subsequently, EPA (2012) recalculated the average daily dose, which led to revising the chronic oral RfD from 1E+0 to 1.5E+0 mg/kg-day. Since the only change between the earlier and the present verified oral RfD reflects a recalculation, it is recommended that the current verified chronic oral RfD of 1.5E+0 mg/kg-day should also be used for subchronic exposure.

EPA (2012) verified an RfD for chronic oral exposure to chromium (VI) of 3E-3 mg/kg-day based on a NOAEL of 25 mg/L (2.5 mg/kg-day) in the drinking water of rats exposed for one year. An overall uncertainty factor of 900 was applied. The uncertainty factor consists of factors of 10 each for inter- and intra-species variation, a factor of 3 to expand from subchronic to chronic exposure, and a modifying factor of 3 to address concerns that relatively low levels may induce GI effects and possibly some forms of cancer in humans. Inclusion of the modifying factor of 3 was a relatively recent (1998) revision to a previously verified derivation. Nonetheless, EPA (2012) notes that confidence in the chronic oral RfD is low.

EPA (1997) presented a provisional subchronic oral RfD of 2E-2 mg/kg-day for chromium (VI) based on the same drinking water study and an uncertainty factor of 200 (not otherwise explained). Presumably, this derivation reflects the earlier IRIS evaluation before inclusion of the modifying factor of 3. However, the concern for GI effects that gave rise to the modifying factor could apply to subchronic as well as chronic exposure. Therefore, it is recommended that a new preliminary subchronic oral RfD should be calculated for chromium (VI). This is done by applying an overall uncertainty factor of 300 to the NOAEL of 2.5 mg/kg-day from the drinking water study. The uncertainty factor of 300 reflects the overall uncertainty factor of 900 used for the chronic RfD without the factor of 3 to expand from subchronic to chronic exposure. The preliminary subchronic oral RfD for chromium (VI) so calculated is 8E-3 mg/kg-day.

The data summarized by EPA (2012) are insufficient to identify a mechanism of toxicity or target organ(s) for chronic oral exposure to chromium (VI). Data from other sources, however, are sufficient to identify potential target organs. Goyer (1991) reported that renal tubular necrosis is the major effect in humans from ingestion of chromium compounds. The context, however, suggests that this effect is associated with acute exposure to high doses (e.g., accidental or attempted suicide ingestion); therefore, the kidney may not be an acceptable candidate as a target organ for chronic oral exposure. Furthermore, a review of human and animal studies by EPA (1998a) did not implicate the kidney as a target organ for chronic oral exposure. EPA (1998a), however, reported GI effects in a cohort of 155 Chinese villagers who consumed water from a well located adjacent to a chromium alloy plant. Symptoms included oral ulcers, diarrhea, abdominal pain, indigestion, and leukocytosis with a left shift. The dose rate of chromium (VI) was estimated at 0.57 mg/kg-day, nearly 200 times the oral RfD. It is likely that the GI symptoms reflect the irritant nature of chromium (VI).

EPA (1998a) also reviewed several reproductive studies. An early and inadequately conducted study reported no effects in rats fed a diet containing 0.125 percent K_2CrO_4. A diet containing 0.25 percent resulted in “subnormal condition” (including rough coat) and “subnormal” offspring; a diet containing 0.5 percent resulted in diarrhea and sterility. Assuming rats consume food equivalent to 5 percent of their body weight each day (EPA, 1980), dietary levels of 0.125, 0.25 and 0.5 percent correspond to chromium (VI) dose rates of 17, 33, and 67 mg/kg-day, respectively. Drinking water studies consistently report developmental effects and impaired reproduction in rats and mice ingesting approximately 20 mg chromium (VI)/kg-day. A well controlled study reported slightly decreased erythrocyte size and hemoglobin content in rats and mice of either sex fed diets containing 400 ppm potassium chromate. The effects were interpreted as “suggestive of a potential bone marrow/erythroid response.” The 400 ppm diet is equivalent to chromium (VI) dose rates of 6.4 mg/kg-day in rats (EPA, 1998a) and approximately 11 mg/kg-day in mice, assuming that mice consume food equivalent to 10 percent of their body weight/day (EPA, 1980). In addition, cytoplasmic vacuolization of hepatocytes was observed in mice fed diets containing 50, 100 or 400 ppm potassium chromate, but it is not clear if either the incidence or intensity occurred in a dose-related manner. The 50 ppm diet, the lowest associated with hepatocellular vacuolization, is equivalent to a chromium (VI) intake rate of approximately 1.3 mg/kg-day. A subsequent study reported decreased erythrocyte hemoglobin content in female mice fed a diet containing 100 ppm potassium chromate, equivalent to a chromium (VI) dose rate of 6.0 mg/kg-day.

The GI signs reported in humans are clearly an indication of adverse effects; therefore, the GI tract is selected as a target organ. The mechanism of toxicity is assumed to be the irritation

induced by tissue contact with chromium (VI). The slight hematologic changes observed in rats and mice and the hepatocellular vacuolization observed in mice do not appear to be sufficiently threatening to be considered adverse. Therefore, target organs selected for chronic oral exposure to chromium (VI) include the GI tract, unborn child (fetus), and reproductive system.

Inhalation (occupational) exposure to chromium may induce respiratory symptoms, changes in lung function and irritation, erosion or perforation of the nasal septum, depending in part on the exposure level (EPA, 2012). No adverse effects were observed in workers exposed to 1E-3 mg/m^3 for 0.2 to 23.6 years (average 2.5 years). EPA (1998b, 2012) reviewed several human and animal studies, and determined that effects observed from inhalation exposure to chromium (VI) are not relevant to exposure to chromium (III). EPA (1998c) concluded that chromium (VI) is the only form of chromium of concern for inhalation exposure.

EPA (2012) developed separate chronic inhalation RfC values for human exposure to chromic acid mists and dissolved chromium (VI) aerosols, and for exposure to chromium (VI) particulates. A verified chronic inhalation RfC of 8E-6 mg/m^3 for chromic acid mists and dissolved chromium (VI) aerosols is based on an adjusted LOAEL of 7.14E-4 mg/m^3 associated with atrophy of the nasal septum in subchronically occupationally exposed humans. An overall uncertainty factor of 90 was used, consisting of factors of 10 for intraspecies variation, 3 to estimate a NOAEL from a LOAEL, and 3 to expand from subchronic to chronic exposure. Confidence in the inhalation RfC is low. The upper respiratory tract is considered the target organ for inhalation exposure to chromic acid mists and dissolved chromium (VI) aerosols. The chronic inhalation RfC is equivalent to a chronic inhalation RfD of 2.3E-6 mg/kg-day.

Inhalation exposure to chromium (VI) particulates is associated with pneumocyte toxicity; i.e., with effects on the lungs themselves. EPA (2012) derived an RfC of 1E-4 mg/m^3 for chronic inhalation exposure to chromium (VI) particulates from an adjusted benchmark concentration of 3.4E-2 mg/m^3 associated with altered enzyme activity in bronchioalveolar lavage fluid from rats exposed to sodium dichromate dust intermittently for up to 90 days. An uncertainty factor of 300 was used, consisting of a factor of 10 to provide additional protection to unusually sensitive individuals, and factors of 3 each to cover for physiologic differences between rats and humans, and to expand from subchronic to chronic exposure. Confidence in the RfC is medium. The RfC is equivalent to a chronic inhalation RfD of 2.9E-5 mg/kg-day. The lung is considered to be the target organ for chronic inhalation exposure to chromium (VI) particulates.

No current EPA-derived subchronic inhalation evaluation exists for chromic acid mists and dissolved chromium (VI) aerosols. However, a preliminary subchronic inhalation RfC can be derived by excluding the uncertainty factor of 3 for expanding from subchronic to chronic exposure. Application of the remaining overall uncertainty factor of 30 to the adjusted LOAEL of 7.14E-4 mg/m^3 yields a preliminary subchronic inhalation RfC of 2E-5 mg/m^3 for chromic acid mists and dissolved chromium (VI) aerosols. The preliminary subchronic inhalation RfC is equivalent to a subchronic inhalation RfD of 6.8E-6 mg/kg-day.

No current EPA-derived subchronic inhalation evaluation exists for chromium (VI) particulates. However, a preliminary subchronic inhalation RfC can be derived by excluding the uncertainty factor of 3 for expanding from subchronic to chronic exposure. Application of the remaining overall uncertainty factor of 100 to the adjusted LOAEL benchmark concentration of 3.4E-2 mg/m^3 yields a preliminary subchronic inhalation RfC of 3E-4 mg/m^3 for chromium (VI)

particulates. The preliminary subchronic inhalation RfC is equivalent to a subchronic inhalation RfD of 9.7E-5 mg/kg-day.

EPA (1998c) noted that exposure to chromic acid mists and dissolved chromium (VI) aerosols is likely to be restricted to occupational settings and that most environmental exposures would involve exposure to chromium (VI) particulates. Therefore, the chronic inhalation RfC and RfD for chromium particulates will be used in this evaluation.

6.0 Carcinogenicity Evaluation

EPA (2012) classified chromium (III) in cancer weight-of-evidence group D – not classified as to carcinogenicity to humans – because of inadequate data. Chromium (VI) is classified in cancer weight-of-evidence group A – known human carcinogen – based on the consistent finding of lung cancer in epidemiologic studies of occupationally exposed workers in chromate production and the chrome pigment industry (EPA, 2012). Conclusions regarding the human data are corroborated by data from animal experiments. There is no evidence that oral exposure to chromium (VI) induces cancer, and EPA (2012) assigned chromium (VI) to Group D for oral exposure.

An inhalation URF of 1.2E-2 per ug/m^3, equivalent to an inhalation SF of 4.2E+1 per mg/kg-day, was based on increased risk of lung cancer deaths in chromate production workers (EPA, 2012). It should be noted that the quantitative assessment is based on the concentration of total chromium to which the workers were exposed, including insoluble (trivalent) and soluble (hexavalent) forms. It was assumed that chromium (VI) constituted not less than one-seventh of the total chromium; i.e., a ratio of 1 part of chromium (VI) to 6 parts of chromium (III). However, the forms of chromium in the air were not identified, and chromium (VI) may have constituted a significantly much greater portion of total airborne chromium. EPA (200) presented the URF of 1.2E-2 per ug/m^3 as a verified potency estimate for chromium (VI), but noted that this estimate may underestimate the potency of exposure to pure chromium (VI) by as much as seven-fold.

7.0 Toxicity Summary

Toxicity values for chromium (III) and chromium (VI) are summarized below. Theoretical noncancer toxicity values are calculated for total chromium assuming a chromium (III)/chromium (VI) ratio of 6 to 1. Note that the URF is based on a mixture of chromium (III) and chromium (VI).

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
Chromium (III)										
1.5E+0	1.5E+0	ND	ND	ND	NA	D	ND	D	ND	ND
Chromium (VI)[b]										
8E-3	3E-3	GI, F, Re	3E-4/ 9.7E-5	1E-4/ 2.9E-5	Lu	D	ND	A	1.2E-2	4.2E+1
Total Chromium[c]										
NA	2.1E-2	GI, F, Re	NA	7E-4/ 2.0E-4	Lu	D	ND	A	1.2E-2	4.2E+1

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi

concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.
Target organ or critical effect abbreviations: GI = gastrointestinal tract, F = unborn child (fetus), Re = reproductive system, Lu = lung.
[a]sRfDo and cRfDo should be adjusted by the appropriate GAF values described above when used for dermal exposure.
[b]Inhalation RfC/RfD values listed are those for chromium (VI) particulates. Values for chromic acid mists and dissolved chromium (VI) aerosols are not relevant to environmental exposures.
[c]For noncancer effects is based on the assumption that total chromium consists of 1 part of chromium (VI) and 6 parts of chromium (III); note that the URF assumed a mixture of chromium (III) to chromium (VI) at a ratio of approximately 6:1 (EPA 2012; EPA, 2004).

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COBALT (7440-48-4)

1.0 Introduction and Physical Properties

Cobalt is a relatively scarce **metal**, constituting about 0.001 percent of the earth's crust (Elinder and Friberg, 1986). It often occurs in association with nickel, silver, lead, copper and iron ores. Cobalt is used in forming special metal alloys with unusual and useful properties (ATSDR, 2004; HSDB, 2012). It is also used in cutting materials, lacquers, varnishes, paint driers, enamels, inks, glazes, glass manufacture, as a catalyst in petroleum refining, and as a supplement in animal and human nutrition. Relevant physical properties are compiled below:

MW	log K_{ow}	H	K_d	D_a	D_w	VP	S
58.93[a]	NA	NA	45[b]	NA	NA	ND	Note 1[c]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; K_d = soil/water partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; NA = not applicable; ND = no data.
Note 1: Cobaltous chloride as a typical cobalt salt: soluble.
[a]Hazardous Substance Data Bank (HSDB), 2012, National Library of Medicine, on line.
[b]Baes, C.F., R.D. Sharp, H. Sjoreen, and R.W. Shor, ***A Review and Analysis for Assessing Transport of Environmentally Released Radionuclides through Agriculture, ORNL-5786, Oak Ridge National Laboratory*** .
[c]Budavari, S, Ed., 1989, ***The Merck Index, An Encyclopedia of Chemicals, Drugs, and Biologicals***, Eleventh Edition, Merck & Co., Rahway, NJ.

2.0 Environmental Fate and Transport

Cobalt is released to the environment, particularly to the air, largely from industrial processes that involve grinding or polishing hard metal devices that contain cobalt (HSDB, 2012). Other anthropogenic sources include fossil fuel burning, vehicular and aircraft exhaust, production and use of cobalt-containing alloys and chemicals, copper and nickel smelting and refining, disposal of sewage sludge, and application of fertilizers derived from phosphate rock (ATSDR, 2004). Natural sources include soil and soil dust, seawater spray, and volcanic eruptions. Natural releases to the atmosphere slightly exceed anthropogenic releases.

Ionic cobalt compounds exist in the particulate phase in air and these compounds may be removed from the air by wet and dry deposition (HSDB, 2012).

HSDB (2012) reports that K_d values for cobalt range from 0.2 to 3,800 L/kg. The value of 45 L/kg presented above appears to be a reasonable intermediate point. Soils with higher pH and content of clay, natural organics, and hydrous manganese and iron oxides, bind cobalt to a greater degree; as these factors decrease, the mobility of cobalt increases. Microbial activity may increase the solubility of cobalt in soil. Chelating agents increase the solubility of cobalt and enhance its mobility in soil. Cobalt compounds do not volatilize from moist or dry soil surfaces due to their ionic character.

The transport and speciation of cobalt in natural waters and sediments is complicated by many factors (HSDB, 2012). The presence of sewage-derived organics appears to enhance the solubility of cobalt in freshwater by forming soluble complexes. Cobalt exists in the +2 or +3 oxidation state for the majority of its compounds and complexes. Volatilization from water surfaces is not expected, due to the ionic nature of dissolved cobalt compounds.

A few plant species are known to accumulate cobalt; however, translocation to aerial parts is generally insignificant (ATSDR, 2004; HSDB, 2012). Cobalt is bioaccumulated by aquatic organisms, particularly at the lower trophic levels. Biomagnification, however, does not occur and cobalt localizes in the viscera and on the skin, rather than in edible tissues. Therefore, cobalt is not expected to impact human health through the food-chain pathways and biotransfer factors are not provided.

3.0 Toxicokinetics

Inhaled cobalt particles deposit in the upper or lower respiratory tract, depending largely on particulate size (ATSDR, 2004). Uptake may occur by dissolution or phagocytosis; larger particles are removed by ciliary clearance. The extent of pulmonary uptake depends largely on particle size distribution.

GI absorption of ingested cobalt in humans ranges from 18 to 97 percent, depending on the form and dose, and on the nutritional status of the subjects (ATSDR, 2004). Cobalt is absorbed more efficiently in cases of iron deficiency. Animal studies show that soluble forms such as cobalt chloride are absorbed to a much greater extent (13 to 34 percent) than insoluble cobalt oxide (1 to 3 percent).

Experiments with humans indicate that cobalt in hard metal dust can be absorbed through the skin, although the rate or extent of uptake were not quantified (ATSDR, 2004). Experiments in animals indicate that cobalt is absorbed much more efficiently through abraded than intact skin.

Distribution of cobalt within body tissues depends in large measure on the route of exposure (ATSDR, 2004). Cobalt as a component of cyanocobalamin (vitamin B12) is generally distributed among the body tissues. Highest levels following inhalation exposure are found in the tissues and lymph nodes of the respiratory tract. Lesser but elevated levels are found in liver, spleen and kidney. Highest levels are found in the liver following ingestion exposure.

Elimination also depends on route of exposure (ATSDR, 2004). Inhaled particulates are cleared by mucociliary elevation, phagocytosis and dissolution. Elevated particles are swallowed and subjected to GI absorption or throughput in the feces. Absorbed cobalt is excreted primarily through the urine.

4.0 Dermal Exposure

The provisional chronic oral RfD of 3E-4 for cobalt was derived from a study in which humans were treated orally with cobalt (EPA, 2008). A GAF of 1, as recommended by EPA (2004) is selected for cobalt.

Data were not located regarding the extent of dermal uptake of cobalt from soil, and EPA (2004) provides no estimate of the extent of dermal absorption (ABS). EPA (2004) recommends that dermal uptake from soil should not be quantified for chemicals without ABS recommendations, but that these chemicals should be discussed qualitatively as a source of uncertainty. The EPA (2004) K_p for cobalt of 4E-4 cm/hour is selected for cobalt.

5.0 Noncancer Effects Evaluation

Human health effects following oral exposure to cobalt include decreased iodine uptake by the thyroid, dermatitis in sensitized individuals, increased erythrocyte production and hemoglobin levels, and cardiomyopthy. Related effects to each of these, except dermatitis, are supported by animal studies. Other effects observed in animal studies include neurobehavioral and testicular; these effects were observed only at relatively high doses. Thyroid toxicity was selected as the critical effect for the derivation of provisional oral reference doses.
Cobalt is nutritionally essential as a cofactor in cyanocobalamin ATSDR, 2004). The element is ubiquitous and universally present in the diet. Data from a dietary survey performed in the 1980s indicate that daily U.S. dietary intakes of cobalt are in the range of 3E-3 to 1.1E-2 mg/day (4E-5 to 2E-4 mg/kg-day, assuming an average body weight of 70 kg). Chronic ingestion from the consumption of beer containing high concentrations of cobalt is associated with "beer-cobalt cardiomyopathy," which includes polycythemia and goiter, as well as marked myocardial degeneration and mortality. However, confounding variables were identified and a dose-response could not be derived from the associated studies (EPA, 2008).

A consistently produced effect of exogenously administered cobalt in humans is the erythropoietic effect of stimulating erythrocyte production resulting in increased blood hemoglobin concentration (EPA, 2002). Cobalt chloride has been used therapeutically at dose rates of 1.6E-1 to 3.2E-1 mg cobalt/kg-day in anemic, anephric dialysis patients for 12 to 32 weeks to induce a significant, but reversible, rise in blood hemoglobin concentration. Clinical studies demonstrating this effect identified an effect level of 1.8E-1 mg/kg-day, which EPA (2002) had previously designated a LOAEL. However, EPA (2008) has since identified confounding variables, and has judged the effects of cobalt in some of the patients in pertinent studies as beneficial rather than adverse.
A LOAEL of 1 mg/kg-day for subchronic thyroid toxicity as the critical oral effect was identified by EPA (2008) from a subchronic study by Roche and Layrisse (1956). A provisional subchronic RfD of 3E-3 mg/kg-day was derived assuming a composite UF of 300. This assumes a UF of 10 for LOAEL to NOAEL conversion, and a UF of 10 for inter-individual variability. An additional UF of 3 was added due to a lack of multigenerational studies, since testicular degeneration and sperm function were noted in some animal studies.

The provisional chronic oral RfD of 3E-4 mg/kg-day was derived as described for the subchronic RfD, with an additional UF of 10 added to extrapolate from subchronic to chronic exposure for a composite UF of 3,000 (EPA, 2008). Confidence in the principal study is described as low-to-medium.

The human and animal database indicate that symptoms of inhaled cobalt include respiratory tract irritation and altered pulmonary function. There were identified as the critical effects for exposure to inhaled cobalt for the derivation of RfDs. A NOAEL adjusted for continuous exposure of 1.9 $\mu g/m^3$ was identified by EPA (2008). A subchronic RfC of 2E-5 mg/m^3 was derived by EPA (2008) assuming a composite UF of 100, assuming a UF of 10 for database insufficiencies and a UF of 10 for inter-individual variability. The preliminary subchronic inhalation RfC is equivalent to a preliminary subchronic inhalation RfD of 5.7E-5 mg/kg-day.

A provisional chronic RfC of 6E-6 mg/m3 was derived as described above for the subchronic RfC, but with an additional UF of 3 for the extrapolation from subchronic to chronic exposure

(EPA, 2008). Thus, the composite UF is 300. This provisional RfC equals an inhalation RfD of 1.7E-6 mg/kg-day.

6.0 Carcinogenicity Evaluation

Human or animal studies examining the carcinogenicity of cobalt associated with oral exposure were not located. Therefore, cobalt is classified as having "inadequate information to assess carcinogenic potential" via the oral pathway, thus no cancer slope factor was derived (EPA, 2008).

Cobalt is described as "likely to be carcinogenic to humans by the inhalation route," based on limited evidence of carcinogenicity in humans (occupational studies) and sufficient evidence of carcinogenicity in animals (EPA, 2008). Respiratory tract tumors have been suggested in occupational studies as the result of inhaled cobalt. Statistically increased incidence of respiratory tract tumors have been observed in animal studies. Limited evidence supports genotoxicity and cytotoxicity, followed by cellular regeneration as potential modes of cobalt tumorigenicity. A mutagenic effect may be plausible for inhaled cobalt, but has not been clearly established (EPA, 2008).

Human inhalation studies were not sufficiently detailed to use in the derivation of a URF. Rats and mice exposed via inhalation to cobalt sulfate heptahydrate for 2 years developed alveolar and bronchial lung tumors (neoplasms and adenomas). EPA (2008) identified a benchmark dose level of In the absence of an identified mode of action, EPA developed a provisional URF by linear extrapolation of benchmark dose level of 0.011 mg/m^3. Using a benchmark response of 10 percent in extra risk, a provisional URF of 9E-3$(\mu g/m^3)^{-1}$ was derived for cobalt sulfate. This equals an inhalation SF of 3.2E+1 $(mg/kg\text{-}day)^{-1}$.

7.0 Toxicity Summary

Toxicity values for cobalt are summarized as follows:

Noncancer Effects						Carcinogenicity				
Oral Exposure			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
3E-3	3E-4	Thyroid	2E-5/5.7E-5	6E-6/ 1.7E-6	RT	ND	ND	B	9E-3	3.2E+1

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.
Target organ or critical effect abbreviations: RT = respiratory tract.

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IRON (7439-89-6)

1.0 Introduction and Physical Properties

Iron is a very abundant, ubiquitous, naturally occurring **metal** that constitutes approximately 5 percent of the earth's crust (Spivey Fox and Rader, 1988). It is the second most prevalent metal in the earth's crust following aluminum (HSDB, 2012). Its primary use is in making steels and other metals that have a wide range of application. Less than one percent of iron is used to make iron compounds that have application in dyes and pigments, water treatment, organic chemical synthesis, and medicinal preparations. Relevant physical properties are compiled below:

MW	log K_{ow}	H	K_d	D_a	D_w	VP	S
55.85[a] (Element)	NA	NA	25[b]	NA	NA	ND	Note 1[a]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; K_d = soil/water partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; NA = not applicable; ND = no data.
Note 1: Ferrous sulfate as a typical iron salt: soluble.
[a]Hazardous Substance Data Bank (HSDB), 2012, National Library of Medicine, on line.
[b] Baes, C.F., R.D. Sharp, H. Sjoreen, and R.W. Shor, ***A Review and Analysis for Assessing Transport of Environmentally Released Radionuclides through Agriculture, ORNL-5786, Oak Ridge National Laboratory*** .

2.0 Environmental Fate and Transport

There is little information available regarding the anthropogenic release of iron and its fate in the environmental, probably because of its prevalence in nature. Clearly, however, mining and handling of iron ores releases dust containing iron oxides (HSDB, 2012). Presumably the manufacture and use of iron compounds may result in release to the environment, but data were not located.

Insoluble iron compounds are most likely to occur in air as particulates, and are expected to deposit to soil and surface water (HSDB, 2012). Although data are unavailable, soluble compounds are expected to leach to groundwater, and to remain in solution in both groundwater and surface water. The extent of partitioning to sediment is expected to depend on water pH, organic matter and reduction-oxidation potential of the water system.

Biouptake of iron is known to occur, because the element is a nutritionally required trace element that is a structural component of heme proteins and some enzymes, which are common to mammals and several other orders of living organisms (Spivey Fox and Rader, 1988). However, there is no evidence that iron bioconcentrates in either aquatic or terrestrial food chain pathways. Therefore, biotransfer factors for iron are not presented.

3.0 Toxicokinetics

The GI absorption of iron is regulated by homeostatic mechanisms sited largely in the intestinal mucosa (Goyer, 1991; EPA, 2006). Approximately 2 to 15 percent of dietary iron is ordinarily absorbed; however, several dietary factors may increase or decrease absorption (HSDB, 2012). Dietary iron from animal sources is absorbed more readily (10 to 25 percent) than iron from

vegetables and grains (1 to 10 percent) (Elinder, 1986). Absorption is greatly increased at times of unusual need (rapid growth of childhood, pregnancy, blood loss). Divalent (ferrous) iron is absorbed into the intestinal mucosal cells and released to the blood plasma where it is oxidized to the trivalent (ferric) form, which binds with a specific protein, transferrin, for transport to storage sites.

Approximately 67 percent of iron in the body is associated with hemoglobin in the erythrocytes, 10 percent is associated with myoglobin and various iron-containing enzymes, and the remainder is bound to ferritin or hemosiderin, which are intracellular storage forms (Goyer, 1991). Ferritin and hemosiderin bind iron in a manner that renders it inactive for beneficial use (e.g., hemoglobin synthesis) and inactive as a toxicant. Some of the iron taken up by the cells of the reticuloendothelial system remains stored and some enters a labile pool that is available for erythropoiesis.

Excess iron is generally excreted, in part in shed intestinal epithelial cells, or in the bile or urine (Goyer, 1991). In cases of very high iron intake, excretion may be unable to remove iron as quickly as it is absorbed. Iron overload results, which stimulates increased synthesis of ferritin and increased iron storage, particularly in the liver, pancreas, spleen, various endocrine organs and the heart.

4.0 Dermal Exposure

As noted above, the GI absorption of iron appears to be under homeostatic control in normal humans (EPA, 2006), which suggests that GI absorption could vary widely between individuals depending on nutritional status. Given the uncertainty about the GI absorption of iron, a default GAF of 1 (EPA, 2004) is chosen for this evaluation.

Data were not located regarding the extent of dermal uptake of iron from soil, and EPA (2004) provides no estimate of the extent of dermal absorption (ABS). EPA (2004) recommends that dermal uptake from soil should not be quantified for chemicals without ABS recommendations, but that these chemicals should be discussed qualitatively as a source of uncertainty. Empirical data regarding the uptake of soluble forms of iron from water were not located. The EPA (2004) default K_p for inorganic chemicals of 1E-3 cm/hour is selected for iron.

5.0 Noncancer Effects Evaluation

Iron is a nutritionally required trace element that forms an integral part of hemoglobin, myoglobin and several enzymes (Spivey Fox and Rader, 1988). The NAS (1989) Recommended Daily Allowance (RDA) for iron is 10 mg/day (0.13 mg/kg-day) for adult males; 15 mg/day (0.24 to 0.33 mg/kg-day) for females aged 11 to 50 years; 30 mg/day (0.443 mg/kg-day) for pregnant females; and 10 mg/day (0.36 to 1.11 mg/kg-day) for children aged 6 months to 10 years.

Both acute and chronic toxicity syndromes are associated with ingestion exposure to iron. Acute toxicity generally involves children (Goyer, 1991). Acute ingestion of large quantities (e.g., children may ingest several ferrous sulfate tablets with candy-like coating) results in severe GI irritation and, in some cases, liver damage. Liver cirrhosis and blood coagulation defects (indicative of reduced circulating levels of blood clotting factors produced by the liver) are observed as sequellae to severe acute toxicity.

Three chronic toxicity syndromes that result in iron overload have been observed in humans (Goyer et al., 1991). The first chronic syndrome is idiopathic hemochromotosis, which arises from a genetic derangement of the homeostatic mechanisms that control iron absorption. This syndrome involves greatly increased GI absorption of iron, regardless of the level of iron in the diet, which results in massive iron overload.

The second chronic syndrome is iron overload resulting from high dietary intake (Goyer, 1991). Although high dietary intake seldom results in iron overload in humans with normal homeostatic control of iron absorption, rare exceptions occur (EPA, 2006). One such exception is the occurrence of iron overload in Bantus who regularly consumed Kaffir beer, an acid beer brewed in iron vessels. This syndrome is not entirely understood; however, the iron in Kaffir beer appears to have exceptionally high bioavailability – equivalent to that of nutritional iron supplements especially formulated for bioavailability – which may account for the increased absorption and iron overload. Other exceptions include persons who take large amounts of tonics or nutritional supplements containing iron.

The third chronic syndrome involves persons requiring multiple blood transfusions over a period of time (Goyer, 1991). This results in the parenteral administration of large quantities of iron that are released as the transfused erythrocytes expire and are removed from the circulation by the reticuloendothelial system. As noted above, excretion cannot keep up with unusually high circulating levels of iron, such as results from multiple blood transfusions. Clearly, the third syndrome has no relevance to environmental exposure.

Regardless of the chronic syndrome that produces it, the effects of iron overload involve the same pathogenesis (Goyer, 1991). Iron stores in the body increase from the normal level of 3 to 5 g, to levels of 20 to 40 g. The cells are induced to increase production of ferritin, which binds the iron cation inactivating its toxicity. Increasingly larger proportions of iron are located in hemosiderin than in ferritin. Hemosiderin is a larger storage protein, probably formed primarily from ferritin. The iron in hemosiderin is essentially completely unavailable and nontoxic. Hemosiderosis is the term given to large accumulations of hemosiderin that do not result in adverse effects because the iron is unavailable. Extremely large accumulations of hemosiderin that result in impaired cellular function is termed hemochromotosis. Hemochromotosis of the liver, endocrine glands and heart is associated with reduced liver function, eventually liver cirrhosis, pancreatic fibrosis, diabetes mellitus, other endocrine disruption and cardiovascular effects.

Goyer (1991) and EPA (2006) reviewed the available data regarding the toxicity of iron. Neither source located any data clearly associating *environmental* exposure with toxicity. EPA (1996) reviewed a study associating high circulating ferritin levels and high dietary iron intakes with myocardial infarction in Finnish men, but association with other factors (e.g., high levels of red meat consumption) confounds interpretation of this study. Furthermore, attempts to produce an animal model of chronic iron toxicity have failed, presumably because of the efficacy of the homeostatic mechanisms that regulate iron absorption from the GI tract.

EPA (1996) reasoned previously that a NOEL for chronic iron overload could be inferred from the estimates of dietary intake and iron status (circulating ferritin levels) established by the second National Health and Nutrition Examination Survey (NHANES II) data base. The

NHANES II study determined that average dietary iron intakes, which ranged from 0.15 to 0.27 mg/kg-day, were associated with normal iron status. More recently, EPA (2006) has concluded that the assignment of a LOAEL based on iron overload for normal individuals cannot be determined based on existing data because of confounding factors in the studies.

EPA (2006) has determined that gastrointestinal toxicity, commonly associated with therapeutic use of iron supplements, is the critical effect. A provisional subchronic and chronic oral RfD of 0.7 mg/kg-day was derived, based on a LOAEL of 1 mg/kg-day and a UF of 1.5 (EPA, 2006). The same value was derived for both subchronic and chronic exposures because clinical experience with iron supplements indicates that the gastrointestinal irritation is associated with treatment and does not intensify with duration. Further, the effect is reversible once treatment is discontinued. A higher UF was not selected because of the reversibility and the effect is not regarded as serious (EPA, 2006).

Inhalation (occupational) exposure to iron oxide fumes may lead to radiographic densities in the lungs without demonstrable clinical effects (ACGIH, 1991). Inhalation of dusts or mists of ferric salts may irritate the respiratory tract. Inhalation data are insufficient for derivation of an inhalation RfC or RfD (EPA, 2012).

6.0 Carcinogenicity Evaluation

Data regarding the potential carcinogenicity of iron were not located. Neither a cancer weight-of-evidence classification nor cancer potency factors are available (EPA, 2012).

7.0 Toxicity Summary

Toxicity values for iron are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
7E-1	7E-1	GI	ND	ND	NA	ND	ND	ND	ND	ND

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.
Target organ or critical effect abbreviations: GI = gastrointestinal.
[a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.

In most cases, it is inappropriate to apply the toxicity values summarized above to environmental exposure.

8.0 References

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U.S. Environmental Protection Agency (EPA), 2005a, ***Provisional Peer-Reviewed Toxicity Values for Iron and Compounds (CASRN 7439-89-6), Derivation of a Carcinogenicity Assessment***, National Center for Environmental Assessment, Cincinnati, OH, 29 July.

U.S. Environmental Protection Agency (EPA), 2005b, ***Provisional Peer-Reviewed Toxicity Values for Iron and Compounds (CASRN 7439-89-6), Derivation of n Inhalation RfC***, National Center for Environmental Assessment, Cincinnati, OH, 16 June.

U.S. Environmental Protection Agency (EPA), 2006, ***Provisional Peer-Reviewed Toxicity Values for Iron and Compounds (CASRN 7439-89-6), Derivation of Chronic and Subchronic Oral RfDs***, National Center for Environmental Assessment, Cincinnati, OH, 29 July.

U.S. Environmental Protection Agency (EPA), 2012, ***Integrated Risk Information System (IRIS)***, National Center for Environmental Assessment, Cincinnati, OH, on line.

NICKEL 7440-02-0)

1.0 Introduction and Physical Properties

Nickel is a naturally occurring **metal** whose concentration ranks 24th in the crust of the earth (ATSDR, 2003), averaging approximately 180 mg/kg (HSDB, 2012). Its primary use is in metal alloys, to which it imparts many desirable characteristics. Nickel compounds are used for nickel plating, to color ceramics, to make some batteries, and as catalysts that increase the rate of various chemical reactions (ATSDR, 2003). Relevant physical properties are compiled below:

MW	log K_{ow}	H	K_d	D_a	D_w	VP	S
58.69[a] (element)	NA	NA	6.5E+1[b]	NA	NA	ND	Note1[c]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; K_d = soil/water partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; NA = not applicable.
Note 1: Nickel chloride as a typical nickel salt: 6.42E+5 at 20°C.
[a]Hazardous Substance Data Bank (HSDB), 2012, National Library of Medicine, on line.
[b]U.S. Environmental Protection Agency (EPA), 2001, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Peer Review Draft, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, March.
[c]Agency for Toxic Substances and Disease Registry, (ATSDR), 2003, ***Update Toxicological Profile for Nickel***, Draft for Public Comment, U.S. Public Health Service, Atlanta, Georgia, September, on line.

2.0 Environmental Fate and Transport

Natural sources of airborne particles that contain nickel include soil, sea, volcanoes, forest fires, and vegetation (ATSDR, 2003; HSDB, 2012). Meteorites that enter the atmosphere contribute free nickel to the air. Anthropogenic releases of nickel, approximately 1.4 to 5 times as great as natural releases, include combustion of fuel oils (including diesel engine emissions) and coal, nickel refining, municipal waste incineration, and steel and nickel alloy production. Nickel exists in the atmosphere as free metal and as various compounds, all in the form of particulates. Small particles may remain suspended in the air for long periods (half-life up to 30 days) and travel great distances. Removal mechanisms are limited to gravitational settling and wet and dry deposition.

Nickel is deposited on soil from the atmosphere (ATSDR, 2003; HSDB, 2012). Other contributions to soil include direct disposal of nickel-containing waste. Nickel in soil is subject to adsorption, precipitation, coprecipitation and complexation, which tend to immobilize it and reduce leaching. Several soil properties, such as calcium and magnesium content and pH, control the extent to which nickel remains immobile or available for leaching because several nickel salts are quite soluble.

Nickel gains access to surface water bodies by direct deposition from the atmosphere, in waste streams from industries that process or use nickel, from domestic waste water treatment plants, and by erosion and runoff from soil (ATSDR, 2003; HSDB, 2012). Nickel in water is subject to the same processes that occur in soil. These processes transfer nickel to particles that are subject to settling; however, large proportions may remain in solution (e.g., 75 percent in one polluted lake).

Empirical data with voles and rabbits living in sludge-amended land, as well as with aquatic invertebrates and vertebrates, suggest that nickel is not biomagnified in either aquatic or terrestrial food chain pathways (ATSDR, 2003). Nickel was identified by the EPA (1995) as a metal of no concern to human health from bioconcentration in fish. Therefore, biotransfer factors are not presented for nickel.

3.0 Toxicokinetics

Absorption of inhaled nickel that reaches the lungs (i.e., particles less than 1 micrometer in diameter) approximates 20 to 35 percent, depending on the specific compound involved (ATSDR, 2003). Uptake from the GI tract depends greatly on the specific compound and the mode of administration. In one study with humans uptake of nickel sulfate given in drinking water was much higher (approximately 27 percent) than when given in food (approximately 0.7 percent). Other studies show that the nature of the food items and their time of consumption relative to the time of administration of nickel have a great effect on the extent of uptake. EPA (2004) cited a 1972 study to support the GAF of 4 percent in humans for nickel in food and water.

Nickel has been shown to penetrate the skin. Studies in humans with radioactive nickel sulfate applied to occluded skin indicate that 55 to 77 percent of the dose is absorbed within 24 hours (ATSDR, 2003). A study in guinea pigs indicated that systemic absorption accounts for 0.005 percent to 0.51 percent of the dermally applied dose of radioactive nickel chloride. The extent to which nickel is sequestered in the dermis and the extent to which it passes to the bloodstream is unclear.

Highest levels of nickel are found in the lungs in occupationally exposed humans and animals exposed by the inhalation route (ATSDR, 2003). Highest levels in animals treated *per os* were found in the kidneys and blood. Significant levels were also found in liver, heart, lung and fat. Highest levels in animals following dermal treatment were found in the skin, blood, kidneys and liver.

Nickel metabolism is limited to ligand exchange reactions by which the cation binds to albumin and other serum proteins (ATSDR, 2003). Dogs lack some of the binding sites present in the serum of other species; therefore, more nickel in dog serum remains free and unbound. Some serum nickel binds to nickeloplasmin, which appears to represent a non-exchangeable pool.

Absorbed nickel is excreted in the urine regardless of the route of exposure (ATSDR, 2003). An excretion half-time of approximately 28 hours has been estimated for humans.

4.0 Dermal Exposure

As noted above, EPA (2004) estimated a GAF for nickel of 4 percent.

Data were not located regarding dermal uptake of nickel in soil and EPA (2004) provides no estimate of the extent of dermal absorption (ABS). EPA (2004) recommends that dermal uptake from soil should not be quantified for chemicals without ABS recommendations, but that these chemicals should be discussed qualitatively as a source of uncertainty. EPA (2004) recommends a K_p value 2E-4 cm/hour, which was used in this evaluation.

5.0 Noncancer Effects Evaluation

In a subchronic gavage study with nickel chloride in water, clinical signs of toxicity in rats included lethargy, ataxia, irregular breathing, reduced body temperature, salivation and discolored extremities (EPA, 202). EPA (2012) presented a verified RfD of 2E-2 mg/kg-day for chronic oral exposure to nickel, based on a NOAEL for decreased organ and body weights in a two-year dietary study with nickel sulfate in rats and an uncertainty factor of 300. Confidence in the oral RfD is medium. The critical effect of prolonged oral exposure to low levels of nickel appears to be reduced body and organ weights without histopathological lesions. EPA (1997) adopted the verified chronic oral RfD of 2E-2 mg/kg-day as the provisional subchronic oral RfD. These oral RfDs are appropriate for oral exposure to soluble salts of nickel or unspeciated nickel compounds.

Inhalation exposure is associated with asthma and pulmonary fibrosis in welders using nickel alloys (ACGIH, 1991). Lung effects were observed in laboratory animals exposed by inhalation. Although the lung is clearly the target organ for inhalation exposure, the data are inadequate for derivation of an inhalation RfC or RfD.

6.0 Carcinogenicity Evaluation

Occupational exposure to nickel is associated with increased risk of nasal, laryngeal and lung cancer (ACGIH, 1991; ATSDR, 2003). Inhalation exposure of rats to nickel subsulfide increased the incidence of lung tumors. EPA (2012) presented a cancer weight-of-evidence Group A classification (human carcinogen) for nickel, and an inhalation URF of 2.4E-4 per $\mu g/m^3$ for nickel refinery dust. The URF is equivalent to 8.4E-1 per mg/kg-day. The quantitative estimate was derived from human occupational studies. EPA (2012) also presented a URF of 4.8E-4 per $\mu g/m^3$, which is equivalent to 1.7E+0 per mg/kg-day, for nickel subsulfide, one of the most predominant constituents in nickel refinery dust. The evaluation for nickel refinery dust is ordinarily chosen when the form of nickel in air is unknown. The Group A classification should apply only to inhalation exposure.

7.0 Toxicity Summary

Toxicity values for nickel are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
Nickel, Soluble Salts or Unspeciated										
2E-2	2E-2	BW	ND	ND	NA	Please see below.				
Nickel Refinery Dust										
Please see above						NA	NA	A	2.4E-4	8.4E-1
Nickel Subsulfide										
Please see above.						NA	NA	A	4.8E-4	1.7E+0

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.
Target organ or critical effect abbreviations: BW = reduced body weight.
[a]sRfDo and cRfDo should be adjusted by the GAF of 0.04 when applied to dermal exposure.

8.0 References

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SELENIUM (7782-49-2)

1.0 Introduction and Physical Properties

Selenium is an **INORGANIC ELEMENT** ubiquitously distributed in nature that occurs in most rocks and soils at concentrations of 0.1 to 2.0 mg/kg, or 0.05 to 0.09 mg/kg in the earth□s crust as a whole (ATSDR, 1996, HSDB, 2012). Selenium is used predominantly in the semiconductor industry and in photoelectric applications. Other uses include glass making, pigments, anti-dandruff shampoos, fungicides and medical imaging. Dietary supplements for livestock are the largest agricultural use. Relevant physical properties are compiled below:

MW	log K_{ow}	H	K_d	D_a	D_w	VP	S
78.96[a] (Element)	NA	NA	5.0E+0[b]	NA	NA	ND	Note 1[a, c]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry□s Law constant (atm-m^3/mole) at the reference temperature; K_d = soil/water partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; NA = not applicable; ND = no data.
Note 1: Element insoluble in water; many selenites and selenates are relatively soluble.
[a]Hazardous Substance Data Bank (HSDB), 2012, National Library of Medicine, on line.
U.S. Environmental Protection Agency (EPA), 2002, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Fianl, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, December.
[c]Agency for Toxic Substances and Disease Registry, (ATSDR), 1996, ***Update Toxicological Profile for Selenium***, U.S. Public Health Service, Atlanta, Georgia, August, on line.

2.0 Environmental Fate and Transport

Natural atmospheric releases of selenium result from volatilization, as a result of biomethylation of selenium by plants and bacteria, and from volcanic eruptions (ATSDR, 1996; HSDB, 2012). Leaching and weathering of parent bedrock material may result in release to soil. Anthropogenic selenium releases include mining and milling operations, base metal smelting and refining, selenium refining, the burning of coal, oil and solid waste, and the uses described above. Burning of coal and production of copper account for approximately 62 and 26 percent, respectively, of the total anthropogenic selenium released to the atmosphere. One study showed that approximately 53 percent of the selenium contained in coal is emitted to the atmosphere as volatilized selenium compounds or included with particles of fly ash.

The majority of selenium in the atmosphere is expected to exist in the particulate form (HSDB, 2012). Particulate-phase selenium may be physically removed from the air by wet and dry deposition (ATSDR, 1996; HSDB, 2012). The volatile selenium compounds such as selenium dioxide, hydrogen selenide, dimethyl selenide, and dimethyl diselenide are expected to exist in the gaseous state in the atmosphere. Hydrogen selenide released to the air is unstable and will be oxidized to elemental selenium and water. Selenium dioxide released to the air from the combustion of fossil fuels is expected to be reduced to elemental selenium by sulfur dioxide formed during combustion.

The behavior of selenium in soils is affected by redox conditions, pH, hydrous oxide content, clay content, organic materials and the presence of competing anions (ATSDR, 1996; HSDB, 2012). Heavy metal selenides, which are insoluble, predominate in acidic soils and soils with high amounts of organic matter. Selenium in this form is immobile. Sodium and potassium selenites dominate in neutral, well-drained mineral soils. Selenites are soluble, but can strongly adsorb to soil minerals and organic matter. Iron and manganese oxides adsorb selenite, with iron oxides adsorbing more than manganese. In alkaline, well-oxidized soil environments, selenates predominate. The selenates are very mobile because of their high water solubility and low tendency to sorb to soil particles. Selenite adsorption was observed to decrease with increasing pH in the range 4 to 9, and selenate adsorption was minimal under most pH conditions. In soils, elemental selenium and inorganic selenium compounds can be methylated by microorganisms and subsequently volatilize to the atmosphere. Dimethyl selenide and dimethyl diselenide are the principal methylation products.

Surface water may receive selenium from the atmosphere by wet or dry deposition, from surface runoff or erosion, from subsurface drainage or from various waste streams (ATSDR, 1996; HSDB, 2012). Selenium in surface water forms oxyanions and exhibits anionic chemistry. Volatilization of the ionic forms is not expected to be an important fate process. Which anionic form predominates is determined by the pH and redox potential of the water. Elemental selenium is favored by low pH and reducing conditions. Selenates are stable under alkaline oxidizing conditions. Selenious acid species occur under the intermediate to slightly oxidizing conditions generally encountered in aerobic water. Over the pH range of 3 to 9, the biselenite species predominate; at pH values greater than 9, selenite is the major species. At pH values less than 7 and under mildly reducing conditions, selenites are reduced to elemental selenium. Reducing conditions in surface sediments or ponded laboratory sediment columns promote the progressive reduction of soluble selenate to soluble selenite to insoluble elemental selenium, which tends to accumulate. Reduced selenium adsorbed to sediment will remain relatively immobile unless the sediments are chemically or biologically oxidized. Biological methylation of selenium may occur in aquatic environments; inorganic selenium undergoes biological methylation to dimethyl selenide and dimethyl diselenide, which are subject to volatilization.

Selenium has been identified by the EPA (1995) as a chemical that is not a bioaccumulative chemical of concern in fish; therefore, a BCF is not included for selenium. Other data, however, indicate that selenium has the potential to bioaccumulate and possibly to biomagnify in terrestrial food chain pathways (ATSDR, 1996; HSDB, 2012). Biotransfer factors for selenium are compiled below:

BCF	Bpr	Bpv	Bb	Bm
NA[a]	2.5E-2[b]	2.5E-2[b]	1.5E-2[b]	4.0E-3[b]

BCF = bioconcentration factor, L/kg; Bpr = soil-to-plant (reproductive portions) biotransfer factor, unitless; Bpv = soil-to-plant (vegetative portions) biotransfer factor, unitless; Bb = soil-to-beef biotransfer factor, days/kg; Bm = soil-to-milk biotransfer factor, days/kg; NA = not applicable.
[a]See above.
[b]Baes, C.F., R.D. Sharp, A.L. Sjoreen, R.W. Shor, 1984, ***A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture***, Health and Safety Division, Oak Ridge National Laboratory, ORNL-5786, September.

3.0 Data for Evaluating Dermal Exposure

Selenium appears to be readily absorbed from the GI tract, apparently nearly free from homeostatic control, especially the soluble forms, but the form of selenium administered affects absorption efficiency (ATSDR, 1996; HSDB, 2012). Reported absorption efficiencies range from 30 to 46 percent up to 95 to 97 percent. Reasons for the wide range are unclear. Cats treated with a variety of selenium compounds excreted not more than 20 percent of the dose in the feces, indicating that upwards of 80 percent was absorbed. EPA (2004) recommends that oral toxicity values should not be adjusted to reflect the extent of GI absorption unless GI absorption is significantly less than complete. Therefore, a GAF is not estimated for selenium and the oral toxicity values are used for dermal exposure without adjustment.

The empirical data indicate that selenium is absorbed by the skin, at least by mice. However, data were not located regarding the extent of dermal uptake of selenium from soil, and EPA (2004) provides no estimate of the extent of dermal absorption (ABS). EPA (2004) recommends that dermal uptake from soil should not be quantified for chemicals without ABS recommendations, but that these chemicals should be discussed qualitatively as a source of uncertainty. The EPA (2004) default PC for metals of 1E-3 cm/hour is used for selenium.

4.0 Noncancer Effects Evaluation

Selenium is a nutritionally essential trace element that is an integral part of the enzyme glutathione peroxidase and other proteins (Högberg and Alexander, 1986). NRC (1989) recommended dietary allowances for humans range from 10 to 75 μg/day. Chronic ingestion of 5 mg/day (7.1E-2 mg/kg-day, assuming humans weigh 70 kg) induces clinical selenosis in humans, characterized by the characteristic "garlic odor" of excess selenium excretion in the breath and urine, thickened and brittle nails, hair and nail loss and abnormal re-growth, lowered hemoglobin levels, mottled teeth, skin lesions, and CNS abnormalities (peripheral anesthesia, acroparesthesia and pain in the extremities) (EPA, 2002; Högberg and Alexander, 1986). Effects in domestic grazing animals exposed to high levels of selenium include emaciation, lameness, and loss of hair and hooves. EPA (2002) presents a verified RfD of 5E-3 mg/kg-day for chronic oral exposure to selenium compounds based on effects in humans exposed to selenium in high selenium areas. An uncertainty factor of 3 was used. Confidence in the RfD is high. The target organs for oral exposure to selenium are the skin (including the nails and hair), teeth, erythrocyte and CNS.

EPA (1997) adopted the chronic oral RfD of 5E-3 mg/kg-day as sufficiently protective for subchronic oral exposure as well.

Occupational exposure to selenium fume or various selenium compounds is associated with intense ocular and respiratory tract irritation, chemical pneumonia, skin rashes, garlic odor to the breath, metallic taste in the mouth, and various socio-psychological effects (ACGIH, 1991). Although no verified RfC could be derived (EPA, 2012), an RfC of 2E-3 mg/m^3, derived by the California Environmental Protection Agency (2012), was used in this evaluation. The target organ for this RfC is the eye and the central nervous system.

5.0 Carcinogenicity Evaluation

An impressive body of data indicates that selenium exerts an anticarcinogenic effect (Högberg and Alexander, 1986). In laboratory animals, selenium supplementation decreases the incidence

of chemical-induced cancers. In humans, the incidence of lymphomas and cancers of the breast, digestive tract and lung were lower in geographic areas with high soil selenium levels. Occupational data suggest that selenium may protect against lung cancer. Several animal tests with various deficiencies in design and conduct equivocally associated exposure to selenium with increased incidence of cancer. In a well controlled oral experiment, selenium sulfide was associated with an increase in the incidence of liver tumors in rats, and with liver and lung tumors in mice. On the basis of this study, EPA (2002) classified selenium sulfide a cancer weight-of-evidence Group B2 compound (probable human carcinogen), but declined to derive quantitative risk estimates. Selenium and other selenium compounds were classified in cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans) (EPA, 2002). Quantitative risk estimates are not derived for Group D substances.

6.0 Toxicity Summary

Toxicity values for selenium are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
5E-3	5E-3	S, Te, E, CNS	3E-2/ 7E-2	3E-2/ 7E-2	E, CNS	D	ND	D	ND	ND

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data.
Target organ abbreviations: S = skin; Te = teeth; E = erythrocyte; CNS = central nervous system; NA = not applicable.
[a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.

7.0 References

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U.S. Environmental Protection Agency (EPA), 2012, ***Integrated Risk Information System (IRIS)***, National Center for Environmental Assessment, Cincinnati, OH, on line.

THALLIUM (7440-28-0)

1.0 Introduction and Physical Properties

Thallium is a naturally occurring metal with an abundance of about 0.3-0.6 ppm in the earth□s crust (HSDB, 2012). Thallium compounds are used in a variety of applications, including pharmaceuticals, semiconductors, photoelectric cells, optical systems, ore separation, glass production, and as oxidizing agents in organic synthesis (ATSDR, 1992; HSDB, 2012). An important former use of thallium and its compounds (before 1972) was in pesticide formulations for the control of insects and rodents. Relevant physical properties are compiled below:

MW	log K_{ow}	H	K_d	D_a	D_w	VP	S
204.38[a] (Elemental)	NA	NA	7.1E+1[b,c]	NA	NA	NA	Note 1[a]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; K_d = soil/water partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; NA = not applicable.
Note 1: Thallium sulfate as a typical thallium salt: 4.87E+4 mg/L (20˚ C).
[a]Agency for Toxic Substances and Disease Registry, (ATSDR), 1992, ***Toxicological Profile for Thallium***, U.S. Public Health Service, Atlanta, Georgia, July, on line.
[b]U.S. Environmental Protection Agency (EPA), 2002, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, December.
[c]pH = 6.8.

2.0 Environmental Fate and Transport

Thallium is released to the atmosphere largely from coal-burning power plants, cement factories, and ferrous and nonferrous smelting operations (ATSDR, 1992; HSDB, 2012). Facilities that produce or use thallium or its compounds account for a much smaller part of the total release.

Thallium in air exists as oxide, hydroxide, sulfate or sulfide particles (ATSDR, 1992; HSDB, 2012). The hydroxide and sulfate are water soluble and may partition to water vapor for eventual removal in precipitation. The less soluble particulate forms are probably removed by dry deposition.

Thallium released to surface water usually occurs as the monovalent ion that forms soluble salts with several anions (ATSDR, 1992; HSDB, 2012). Adsorption to suspended particulates may also occur, but the soluble forms remain in the water column.

Although empirical data are sparse, the high solubility of several thallium salts suggests that mobility in soil could be high and the potential for leaching could be significant (ATSDR, 1992).

Thallium has been identified by the EPA (1995) as a chemical that is not a bioaccumulative chemical of concern in fish; therefore, a BCF is not included for thallium. Other data, however, indicate that thallium has the potential to bioaccumulate and possibly to biomagnify in terrestrial food chain pathways (ATSDR, 1992; HSDB, 2012). Biotransfer factors for selenium are compiled below:

BCF	Bpr	Bpv	Bb	Bm
NA[a]	4.0E-4[b]	4.0E-4[b]	4E-2[b]	

BCF = bioconcentration factor, L/kg; Bpr = soil-to-plant (reproductive portions) biotransfer factor, unitless; Bpv = soil-to-plant (vegetative portions) biotransfer factor, unitless; Bb = soil-to-beef biotransfer factor, days/kg; Bm = soil-to-milk biotransfer factor, days/kg; NA = not applicable.
[a]See above.
[b]Baes, C.F., R.D. Sharp, A.L. Sjoreen, R.W. Shor, 1984, ***A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture***, Health and Safety Division, Oak Ridge National Laboratory, ORNL-5786, September.

3.0 Toxicokinetics

Data regarding absorption from the respiratory tract following inhalation exposure were not located; however, small particles are probably absorbed to some extent and larger particles are probably removed by mucocilliary clearance and swallowed, where they become available for GI absorption. Thallium compounds appear to be completely absorbed from the GI tract in humans and laboratory animals (ATSDR, 1992). Quantitative data regarding dermal uptake of thallium were not located, although HSDB (2012) states that absorption through the skin occurs readily.

Tissue levels in acutely poisoned humans appear to be highest in the brain in regions dense with neurons, such as the gray matter (HSDB, 2012). Tissue distribution testing in a single human volunteer cancer patient treated orally with a small dose of radiolabeled thallium indicated that highest concentrations were located in scalp hair followed by kidney, heart, bone, spleen and brain (ATSDR, 1992). Distribution in orally treat laboratory animals is rapid and widespread, with higher levels generally associated with the kidney. The rank of levels in other tissues is more variable (ATSDR, 1992), but high levels are ordinarily found in the testis (HSDB, 2012).

The biological half-life in rats in one study was 3.3 days, indicating that excretion is efficient (ATSDR, 1992). Excretion in humans may be somewhat slower. Excretion appears to be primarily through the urine in humans, and through the urine and feces. However, the data are somewhat confusing because animal studies indicate that the ratio of fecal to urinary excretion increases with time. This suggests that biliary excretion and enterohepatic recirculation may be operative, which could result in underestimation of fecal excretion in the human study.

4.0 Dermal Exposure

As noted above, GI absorption of thallium is essentially complete. EPA (2004) concluded that a GAF should not be estimated for thallium for the purpose of adjusting oral toxicity values for dermal exposure. Therefore, the oral toxicity values described below are used directly without adjustment for evaluating dermal exposure.

Thallium may be readily absorbed by the skin (HSDB, 2012); however, data were not located regarding the extent of dermal uptake of thallium from soil, and EPA (2004) provides no estimate of the extent of dermal absorption (ABS). EPA (2004) recommends that dermal uptake from soil should not be quantified for chemicals without ABS recommendations, but that these chemicals should be discussed qualitatively as a source of uncertainty. Empirical data regarding the uptake of soluble forms of thallium from water were not located. The EPA (2004) default K_p for inorganic chemicals of 1E-3 cm/hour is selected for thallium.

5.0 Noncancer Effects Evaluation

Thallium is highly toxic. Acute oral exposure to thallium and its compounds may cause death preceded by neurological disturbances and effects on the lungs, heart and liver (ATSDR, 1992). Formerly, thallium was used medicinally to induce alopecia to facilitate treatment of ringworm of the scalp, sometimes with disastrous results. The critical effect of chronic oral exposure to low levels of thallium compounds in animals and humans is alopecia (ACGIH, 1992; EPA, 2012). EPA (2012) had previously verified chronic oral RfDs for several thallium salts (thallium acetate, thallium carbonate, thallium chloride, thallium nitrate and thallium sulfate) based on a study with thallium sulfate; these RfDs were removed from IRIS in September 2009.

Currently, IRIS (EPA, 2012) describes a 90-day oral thallium toxicity study in rats (Midwest Research Institute [MRI], 1988) as having been considered a candidate study from which to derive a verifiable RfD. The critical effect of the MRI study is alopecia. Based on this study, a benchmark dose of 0.01 mg/kg-day was developed, and to this a total uncertainty factor of 3,000 was applied to yield candidate RfDs of 3E-6 mg/kg-day (clinical observations) and 1E-5 mg/kg-day (hair follicle atrophy). However, EPA determined that the available toxicity data base contains studies of generally poor quality that are insufficient from which to derive an RfD.

EPA (2010) provides a provisional screening value for thallium in an appendix to the *Provisional Peer-Reviewed Toxicity Values for Thallium and Compounds*, but EPA (as described in IRIS) found the data base insuffient for the derivation of a PPRTV. In this evaluation, EPA (2010) evaluates the same MRI study that was evaluated in IRIS and identifies NOAEL of 0.4 mg/kg-day. To this NOAEL, the total uncertainty factor of 3,000 is applied to derive a screening chronic toxicity value of 1E-5 mg/kg-day for thallium. A subchronic screening toxicity value of 4E-5 was dereived using and a total uncertainty factor of 1,000. Although these provisional screening toxicity values may be used in risk assessments, EPA (2010) cautions that there is considerably more uncertainty associated with such screening values than the PPRTV values that

Inhalation exposure data are very limited. An occupational study suggests that neurological effects may develop following prolonged inhalation exposure (ATSDR, 1992). The nervous system appears to be more sensitive than the skin as a target organ for inhalation exposure. The data are inadequate for estimation of an RfC (EPA, 2012; 2010).

6.0 Carcinogenicity Evaluation

Several thallium compounds (thallium oxide, thallium acetate, thallium carbonate, thallium chloride, thallium nitrate, thallium sulfate) are classified as cancer weight-of-evidence Group D substances (not classifiable as to carcinogenicity to humans) (EPA, 2012). No weight-of-evidence classification was located for thallium alone, but the Group D classification can be applied to thallium. Quantitative cancer risk estimates are not derived for Group D chemicals.

7.0 Toxicity Summary

Toxicity values for thallium are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
4E-5	1E-5	hair	ND	ND	NA	D	NA	D	NA	NA

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.
[a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.

8.0 References

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Polychlorinated Biphenyls (PCBs)

1.0 Introduction and Physical Properties

The nomenclature of the PCBs is somewhat unique, including the terms homologue and congener. The PCB molecule consists of two joined phenyl groups. The carbon atoms are numbered 1 through 6 on one ring and 1′ through 6′ on the other ring. Numbering proceeds consecutively starting with the carbon atom attached to the other ring. The term homologue refers to the degree of chlorination. Since one carbon atom in each phenyl group is bonded to the other ring, five carbon atoms on each phenyl group – a total of 10 carbon atoms – are available for bonding to chlorine atoms. Consequently, there are ten possible *homologues* of PCBs – monochlorinate biphenyls, dichlorinated biphenyls, through decachlorinated biphenyls. Congener refers to the exact placement of each chlorine atom. For example, there are three congeners of monochlorinated biphenyls: 2-PCB, 3-PCB and 4-PCB. The term isomer is often incorrectly used instead of congener with the PCBs. Free rotation around the C-C bond, however, precludes stereoisomerism, which limits the number of theoretically possible congeners.

The PCBs are a class of chemicals generally considered to be **SVOC**s including 209 possible individual congeners (ATSDR, 2000). The PCBs formerly manufactured and used in the U.S. are called Aroclors. The Aroclors are mixtures of several PCB congeners and related compounds. Many individual PCB congeners are common to all or many of the different Aroclors. The Aroclors differ from one another primarily in the relative proportions of the different congeners. ATSDR (2000) provides a summary of the proportion of each homologue in commercial mixtures of the various Aroclors. Of interest to this evaluation is the observation that Aroclor-1016 and Aroclor-1221 contain no homologues with 5 or more chlorines. Most Aroclors occur as oily or viscous liquids at room temperatures, although Aroclor-1260 occurs as a sticky resin. Aroclors were used as dielectric and heat exchange agents in several open and closed systems, but since the middle 1970s, use has been restricted largely to electrical transformers and capacitors.

Analysis of PCBs in environmental media is often performed using EPA Method SW8082. Method SW8082 is usually performed as a "finger printing" procedure and the results are reported as the commercial Aroclor(s) that most closely reflect the fingerprint(s) (ATSDR, 2000). Recently, however, concern has arisen that some individual PCB congeners may behave toxicologically in the same manner as the polychlorinated dibenzo-p-dioxins (PCDD), and that they may have greater toxic potency than is reflected in the toxicity assessment of the commercial Aroclors. This problem may be exacerbated by weathering, which may preferentially remove the less toxic (generally less highly chlorinated) congeners, leading to a relative concentration of the more highly chlorinated congeners. The more highly chlorinated congeners are generally the more persistent and the more toxic (ATSDR, 2000; EPA, 2012). For this reason, Method SW8082 has been expanded so that the analytical results can be reported in terms of selected specific congeners. In addition, EPA Method E1668 is a very high-resolution protocol (highly sensitive and highly selective) that reports individual congeners as well as totals for each of the homologues. Method E1668 is seldom used for environmental media, with the exception of incinerator emissions testing, because of its unusually high cost.

EPA (2000) identified 12 individual PCB congeners with dioxin-like activity. The PCB mixtures and dioxin-like congeners analyzed by the EPA methods mentioned above are compiled below:

PCB Mixture or Congener	CASRN	IUPAC No.	Method 8082	Method 1668
Aroclor-1016	12674-11-2	NA	Yes	No
Aroclor-1221	11104-28-2	NA	Yes	No
Aroclor-1232	11141-16-5	NA	Yes	No
Aroclor-1242	53469-21-9	NA	Yes	No
Aroclor-1248	12672-29-6	NA	Yes	No
Aroclor-1254	11097-69-1	NA	Yes	No
Aroclor-1260	11096-82-5	NA	Yes	No
3,3′,4,4′-Tetrachlorobiphenyl	**32598-13-3**	**77**	**Probably[a]**	**Yes**
3,4,4′,5-Tetrachlorobiphenyl	**70362-50-4**	**81**	**Probably[a]**	**Yes**
2,3,3′,4,4′-Pentachlorobiphenyl	**32598-14-4**	**105**	**Probably[a]**	**Yes**
2,3,4,4′,5-Pentachlorobiphenyl	**74472-37-0**	**114**	**Probably[a]**	**Yes**
2,3′,4,4′,5-Pentachlorobiphenyl	**31508-00-6**	**118**	**Probably[a]**	**Yes**
2′,3,4,4′,5-Pentachlorobiphenyl 2,3′,4,4′,5′-Pentachlorobiphenyl)	**65510-44-3**	**123**	**Probably[a]**	**Yes**
3,3′,4,4′,5-Pentachlorobiphenyl	**57465-28-8**	**126**	**Probably[a]**	**Yes**
2,3,3′,4,4′,5-Hexachlorobiphenyl	**38380-08-4**	**156**	**Probably[a]**	**Yes**
2,3,3′,4,4′,5′-Hexachlorobiphenyl	**69782-90-7**	**157**	**Probably[a]**	**Yes**
2,3′,4,4′,5,5′-Hexachlorobiphenyl	**52663-72-6**	**167**	**Probably[a]**	**Yes**
3,3′,4,4′,5,5′-Hexachlorobiphenyl	**32774-16-6**	**169**	**Probably[a]**	**Yes**
2,3,3′,4,4′,5,5′-Heptachlorobiphenyl	**39635-31-9**	**189**	**Probably[a]**	**Yes**
Total Monochlorobiphenyls	NA	NA	No	Yes
Total Dichlorobiphenyls	NA	NA	No	Yes
Total Trichlorobiphenyls	NA	NA	No	Yes
Total Tetrachlorobiphenyls	NA	NA	No	Yes
Total Pentachlorobiphenyls	NA	NA	No	Yes
Total Hexachlorobiphenyls	NA	NA	No	Yes
Total Heptachlorobiphenyls	NA	NA	No	Yes
Total Octachlorobiphenyls	NA	NA	No	Yes
Total Nonachlorobiphenyls	NA	NA	No	Yes
Total Decachlorobiphenyls	NA	NA	No	Yes

PCB = polychlorinated biphenyl; CASRN = Chemical Abstract Service Registry Number; IUPAC No. = congener-specific identification number assigned by the International Union of Pure and Applied Chemists. The specific congeners are sometimes called PCB-77, PCB-81, etc., and are sometimes *inappropriately* called Aroclor-77, Aroclor-81, etc. Technically, the term Aroclor should be reserved for chemical mixtures, where the name Aroclor is followed by a four-digit identifier code.
Dioxin-like congeners are bolded.
[a]Although the congeners listed have not been tested by Method 8082, it is likely that they could be quantified by the method. Other non-dioxin-like congeners can routinely be analyzed by this method.

Data regarding the physical properties of the individual PCB congeners are very limited. The physical characteristics of the Aroclor mixtures have been much more thoroughly evaluated. Although the Aroclors described below are classified as SVOCs, largely on the basis of MW, their H values suggest that volatilization could be important. Furthermore, the MW values provided are proportional averages based on the composition of the various Aroclor mixtures. Several individual PCB congeners have MW values below the limit of 200 g/mole ordinarily used to distinguish VOCs from SVOCs. For these reasons it is recommended that the Aroclors should be evaluated in exposure pathways (such as vapor intrusion into indoor air) that involve volatilization. Relevant physical properties are compiled below:

MW[a]	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
Aroclor-1016 (12674-11-2)										
257.9[b]	5.6[b]	2.9E-4[b] (25°C)	4.96[c]	4.69E-2[d] (25°C)[e]	6.8E-6[c] (25°C)	5.3E-7[b] (25°C)	4.2E-1[b] (25°C)	340.50[f]	475.22[f]	1.8E+4[f]
Aroclor-1221 (11104-28-2)										
200.7[b]	4.7[b]	7.36E-4[b] (25°C)	2.44[c]	5.54E-2[d] (25°C)[e]	7.5E-6[c] (25°C)	8.8E-6[b] (25°C)	5.9E-1[b] (24°C)	571[b]	ND	ND
Aroclor-1232 (11141-16-5)										
232.2[B]	5.1[B]	8.64E-4[c] (25°C)[e]	2.83[c]	5.03E-2[d] (25°C)[e]	7.2E-6[c] (20°C)	5.34E-6[b] (25°C)	4.5E-1[b] (25°C)	581[b]	ND	ND
Aroclor-1242 (53469-21-9)										
266.5[b]	5.6[b]	5.2E-4[b] (25°C)	4.59[c]	4.59E-2[d] (25°C)[e]	6.1E-6[c] (20°C)	5.34E-7[b] (25°C)	2.4E-1[b] (25°C)	345.5[f]	482.20[f]	1.8E+4[f]
Aroclor-1248 (12672-29-6)										
299.5[g]	6.2[g]	2.8E-3[g] (25°C)	5.64[c]	4.24E-2[d] (25°C)[e]	6.6E-6[c] (20°C)	6.5E-7[g] (25°C)	5.7E-2[g] (24°C)	631[g]	ND	ND
Aroclor-1254 (11097-69-1)										
326.4[h]	6.5[b]	2.83E-4[h] (25°C)	4.67[h]	3.99E-2[d] (25°C)[e]	5.6E-6[c] (20°C)	1.01E-7[b] (25°C)	3.5E-2[b] (24°C)	377.50[f]	512.27[f]	1.9E+4[f]
Aroclor-1260 (11096-82-5)										
375.7[b]	6.8[b]	4.6E-3[b] (25°C)	6.42[c]	3.65E-2[d] (25°C)[e]	5.3E-6[c] (20°C)	5.33E-8[b] (25°C)	8.0E-2[b] (24°C)	402.50[f]	539.37[f]	1.9E+4[f]
Aroclor-1262 (1336-36-3)										
389[b]	ND	ND	ND	3.57E-2[d] (25°C)[e]	4.13E-6[d] (25°C)[e]	ND	5.2E-2[b] (24°C)	680.7[b]	ND	ND
Aroclor-1268 (11100-14-4)										
453[b]	ND	ND	ND	3.22E-2[d] (25°C)[e]	3.73E-6[d] (25°C)[e]	ND	3.0E-1[b] (24°C)	ND	ND	ND

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point of pure liquid compound (°K); T_c = critical temperature (°K); $\Delta H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); I = insoluble; ND = no data.

[a]Average molecular mass for the proportions of individual congeners in the commercial product.

[b]Agency for Toxic Substances and Disease Registry (ATSDR), 2000, ***Update Toxicological Profile for Polychlorinated Biphenyls***, U.S. Department of Health and Human Services, Atlanta, Georgia, November, on line.

[c]Montgomery, J.H., 1996, ***Groundwater Chemicals Desk Reference, Second Edition***, Lewis Publishers, New York.

[d]Calculated as described in Introduction to Toxicological profiles.

[e]Assumed.

[f]U.S. Environmental Protection Agency (EPA), 1997, ***User's Guide for the Johnson and Ettinger (1991) Model for Subsurface Vapor Intrusion into Buildings***, prepared by Environmental Quality Management, Inc. for the Office of Emergency and Remedial Response, Washington, DC, September.

[g]Earlier version (1995 Draft for Public Comment) of ATSDR Toxicological profile.

[h]U.S. Environmental Protection Agency (EPA), 2011, *EPISuite electronic database*.

2.0 Environmental Fate and Transport

Former PCB releases occurred as a result of their manufacture, use, disposal, and leakage from damaged PCB-containing equipment (ATSDR, 2000). Currently the major source of PCB release to the environment is recycling of PCBs previously introduced into the environment, which involves volatilization from ground surfaces (water, soil) into the atmosphere with subsequent removal from the atmosphere via wet/dry deposition, followed by volatilization (HSDB, 2012). PCBs are also currently released to the environment from landfills containing PCB waste materials and products, incineration of municipal refuse and sewage sludge, and improper (or illegal) disposal of PCB materials, such as waste transformer fluid, to open areas.

Major sources to air include emissions from the overhaul, repair or reuse of PCB-containing items, and the recycling of previously released PCBs described above (ATSDR, 2000; HSDB, 2012). The vapor pressures of the PCBs indicate that they would exist primarily in the vapor-phase in the atmosphere; monitoring data have shown that between 87 and 100% of the PCBs in air are in the vapor-phase. Vapor pressure of the PCBs generally decreases with an increase in the extent of chlorination; therefore, the more highly chlorinated PCBs are more likely to be associated with the particulate phase in air than are the lesser chlorinated PCBs. Physical removal of PCBs in the atmosphere is accomplished by wet and dry deposition; dry deposition occurs only for PCBs in the particulate phase.

Major sources to soil include leaks or discharges from PCB-containing items and deposition from the atmosphere (ATSDR, 2000). PCBs sorb tightly to constituents of soil with adsorption generally increasing with the degree of chlorination. Although the lesser chlorinated biphenyls may exhibit some mobility in soil, PCBs generally will not leach significantly in most aqueous soil systems. In the presence of organic solvents, PCBs may leach quite rapidly through soil. Vapor loss of PCBs from soil surfaces appears to be an important loss mechanism with the rate of volatilization decreasing with increasing chlorination. Although the volatilization rate may be low, the total loss by volatilization over time may be significant because of the persistence and stability of the PCBs. In general, persistence of the PCBs increases with an increase in the degree of chlorination (ATSDR, 2000; HSDB, 2012). Mono-, di- and trichlorinated biphenyls (Aroclors-1221 and -1232) biodegrade relatively rapidly, tetrachlorinated biphenyls (Aroclors-1016 and -1242) biodegrade slowly, and higher chlorinated biphenyls (Aroclors-1248, -1254 and -1260) are quite resistant to biodegradation. The position of chlorination within a given homologue also determines the extent of biodegradation. Although biodegradation of the more highly chlorinated congeners may occur very slowly on an environmental basis, no other degradation mechanisms have been shown to be important in soil systems; therefore, biodegradation may be the ultimate degradation process in soil.

Former sources of PCBs to surface water include waste streams and discharges from waste water treatment plants (ATSDR, 2000). Currently, direct deposition, runoff and erosion probably predominate. Removal from water involves sorption to particles and sedimentation, as well as volatilization.

The PCBs are among the compounds that bioaccumulate in food chain pathways and are of special concern for biomagnification from sediment in benthic fish. Biotransfer factors for the PCBs are compiled below:

BSAF	Bpr[a,b]	Bpv[a,b]	Bb[a]	Bm[a]
Aroclor-1016				
See below	2.24E-2	2.24E-2	1.00E-2	3.16E-3
Aroclor-1221				
See below	7.44E-2	7.44E-2	1.26E-3	3.98E-4
Aroclor-1232				
See below	4.37E-2	4.37E-2	3.16E-3	1.00E-3
Aroclor-1242				
See below	2.24E-2	2.24E-2	1.00E-2	3.16E-3
Aroclor-1248				
See below	1.01E-2	1.01E-2	3.98E-2	1.26E-2
Aroclor-1254				
See below	6.78E-3	6.78E-3	7.94E-2	2.51E-2
Aroclor-1260				
See below	4.55E-3	4.55E-3	1.58E-1	5.01E-2
Aroclor-1262				
See below	ND	ND	ND	ND
Aroclor-1268				
See below	ND	ND	ND	ND

BSAF = biota-sediment accumulation factor, unitless; Bpr = soil-to-plant (reproductive portions) biotransfer factor, unitless; Bpv = soil-to-plant (vegetative portions) biotransfer factor, unitless; Bb = soil-to-beef biotransfer factor, days/kg; Bm = soil-to-milk biotransfer factor, days/kg; ND = no data.
[a]Calculated as described in Introduction to the Toxicological profiles.
[b]The methodology for estimating biotransfer of organic chemicals to plants does not differentiate vegetative and reproductive portions.

EPA (1995) reported a biota/sediment absorption factor (BSAF) for total PCBs of 1.85 for trout in the Great Lakes ecosystem. The BSAF of 1.85 is applied to all PCBs in this evaluation.

3.0 Data for Evaluating Dermal Exposure

Toxicokinetic data from laboratory animals suggest that the efficiency of GI absorption is roughly inversely related to the degree of chlorination (ATSDR, 2000). The GI absorption of mono- to hexachlorinated biphenyls exceeds 90 percent. Dichlorobiphenyl GI absorption efficiency is approximately 95 percent, but the absorption efficiency of octachlorobiphenyl approximates only 75 percent. GI absorption efficiency of Aroclor-1254 approximates 85.4 percent in ferrets and greater than 90 percent in monkeys. EPA (2004) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. Therefore, no GAF is developed for the PCBs and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

The PCBs appear to be readily absorbed by the skin when applied as neat compound or mixed with a suitable vehicle (ATSDR, 2000), but efficiency falls when soil is the medium of exchange. The EPA (2004) recommended ABS of 0.14 for PCBs is used in this evaluation. EPA (2004) provides values for K_p, τ, FA and B for 4-chlorobiphenyl and hexachlorobiphenyl. Generally, the more highly chlorinated PCB congeners are the more persistent in the environment; therefore, the values for hexachlorobiphenyl provided below are applied to all PCBs in this evaluation.

Chemical	K_p	τ	FA	B
Hexachlorobiphenyl	4.3E-1	1.13E+1	0.5	3.2
K_p = permeability coefficient (cm/hour); τ= lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).				

4.0 Noncancer Effects Evaluation

The acute oral toxicity of the PCBs is low to moderate, as indicated by LD_{50} values in laboratory animals ranging from 750 mg/kg (mink) to 4250 mg/kg (rats) (ATSDR, 2000). Mink appear to be unusually sensitive, which is also true for prolonged oral exposure. Death appears to be due to respiratory depression and dehydration from diarrhea.

The best known incident involving oral exposure of humans to PCBs is the "Yusho" incident in Japan, in which persistent chloracne, gastrointestinal irritation and central nervous symptoms followed ingestion of cooking oil contaminated with PCBs (Gaffey, 1983). Further investigation, however, revealed that concentrations of polychlorinated dibenzofurans (PCDF) and polychlorinated quaterphenyls in the cooking oil were similar to those of PCBs, which confounds interpretation of the reported observations and symptoms.

Prolonged oral exposure of laboratory animals to various Aroclors leads to liver damage, signs of chloracne, immunological effects, and neurological impairment, particularly of the young (EPA, 2012). A verified oral RfD for Aroclor-1254 of 2E-5 mg/kg-day for chronic oral exposure is based on a LOAEL of 5E-3 mg/kg-day associated with chloracne and related signs and immunological effects in monkeys treated with the test material in gelatin capsules for over five years. An uncertainty factor of 300 was applied. Confidence in the RfD is medium. The immune system and skin are considered the target organs for prolonged oral exposure to Aroclor-1254.

EPA (1997) derived a provisional RfD for subchronic oral exposure to Aroclor-1254 of 5E-5 by applying an uncertainty factor of 100 to the LOAEL from the monkey study described above.

A verified oral RfD of 7E-5 mg/kg-day for Aroclor-1016 is based on a NOAEL of 7E-3 mg/kg-day in a perinatal and neurobehavioral toxicity study in monkeys (EPA, 2012). An uncertainty factor of 100 was applied to the NOAEL. The uncertainty factor of 100 consists of factors of 3 each to extrapolate from monkeys to humans, to provide greater protection for more sensitive humans, to account for deficiencies in the database, and to expand from a subchronic study to chronic exposure. The LOAEL (2.8E-2 mg/kg-day) was associated with low birth weights. The

fetus is considered to be the most sensitive member of the population. The fetus and nervous system are selected as "target organs" for prolonged oral exposure to Aroclor-1016. Confidence in the oral RfD is medium.

There is no EPA-derived subchronic oral RfD for exposure to Aroclor-1016. However, a preliminary RfD can be derived from the NOAEL of 7E-3 mg/kg-day in the monkey study described above by application of an uncertainty factor of 30. The uncertainty factor of 30 includes all the factors described above except the factor of 3 to expand from subchronic to chronic exposure. The preliminary subchronic oral RfD so derived is 2.3E-4 mg/kg-day, which is expressed as 2E-4 mg/kg-day when rounded to one significant figure.

The similarities in the nature of the adverse effects and the thresholds for these effects for various Aroclors suggest that the adverse effects and thresholds across all the Aroclors may be similar. That this may be true is supported by the fact that many of the same PCB congeners are present in the different Aroclors, which differ from one another primarily only in the relative proportions of the individual congeners. Therefore, it is reasonable to apply the RfDs described above to any of the Aroclor mixtures, or to total PCBs. The chronic and subchronic oral RfDs developed for Aroclor-1016 rather than those developed for Aroclor-1254 are selected as surrogates for evaluating the adverse effects of the other Aroclors or total PCBs. The RfDs developed for Aroclor-1016 are preferred because they include less uncertainty than the RfDs developed for Aroclor-1254. Therefore, the verified chronic oral RfD of 7E-5 mg/kg-day and the preliminary subchronic oral RfD of 2E-4 mg/kg-day developed for Aroclor-1016 are applied to the Aroclors other than Aroclor-1254 or to total PCBs.

Occupational exposure to PCBs, which involved both inhalation and dermal exposure, was associated with upper respiratory tract and ocular irritation, loss of appetite, liver enlargement and increased serum concentrations of liver enzymes, skin irritation, rashes and chloracne, and, in heavily exposed female workers, decreased birth weight of their infants (ATSDR, 2000). Concurrent exposure to PCB contaminants, such as polychlorinated dibenzofurans, confounds the interpretation of the occupational exposure studies. Rats, mice, rabbits and guinea pigs intermittently exposed to Aroclor-1254 vapors exhibit moderate liver degeneration, decreased body weight gain and slight renal tubular degeneration; however, the accuracy of the reported exposure concentration is in doubt. Neither verified nor provisional chronic inhalation RfC values are available.

5.0 Carcinogenicity Evaluation

EPA (2012) declined to evaluate the carcinogenicity of the individual Aroclor mixtures. Instead, EPA (2012) classified PCBs in cancer weight-of-evidence Group B2 (probable human carcinogen) based on adequate evidence for liver tumors in laboratory animals and inadequate data in humans. EPA (2012) established a three-tiered approach for estimating the cancer potency of exposure to PCBs.

<u>High-Risk Tier</u> A SF of 2.0E+0 per mg/kg-day is verified as an upper-bound potency factor for exposure to PCBs in the high-risk tier (EPA, 2012). The high-risk tier includes ingestion in the food chain, incidental ingestion of soil or sediment, inhalation of dust or aerosol, or dermal contact with soil or sediment if a dermal absorption factor is applied. The high-risk SF of 2.0E+0 per mg/kg-day is used for mixtures containing any congeners considered to be persistent

or acting in a dioxin-like manner, and for any early life exposures (e.g., residential scenario, which includes both adults and children). In this context, persistent congeners are those with five or more chlorines. The 12 PCB congeners considered to act in a dioxin-like manner were identified above. The SF of 2.0E+0 per mg/kg-day is equivalent to a URF (for dust or aerosol inhalation) of 5.7E-4 per $\mu g/m^3$.

The high-risk tier SF for central tendency (CT) assessment is 1.0E+0 per mg/kg-day. The SF of 1.0E+0 per mg/kg-day is equivalent to a URF (for dust or aerosol inhalation) of 2.9E-4 per $\mu g/m^3$.

Low-Risk Tier EPA (2012) verified an upper-bound SF of 4E-1 per mg/kg-day for the low-risk tier, which includes ingestion of water-soluble congeners (assumed to be PCBs detected in drinking water), inhalation of evaporated congeners, and dermal exposure if no absorption factor is applied. The SF of 4E-1 per mg/kg-day is equivalent to a URF for vapor inhalation of 1E-4 per $\mu g/m^3$. A SF of 3E-1 per mg/kg-day is recommended for the low-risk CT evaluation. The SF of 3E-1 per mg/kg-day is equivalent to a URF (for vapor inhalation) of 9E-5 per $\mu g/m^3$.

Lowest-Risk Tier EPA (2012) verified an upper-bound SF of 7E-2 per mg/kg-day for the lowest-risk tier, which is restricted to data sets for which homologue-or congener-specific data verify that congeners containing 5 or more chlorines constitute less than 0.5 percent of the total PCBs. The SF of 7E-2 per mg/kg-day is equivalent to a URF for inhalation of 2E-5 per $\mu g/m^3$. These values are used in for Aroclor 1016. An SF of 4E-2 per mg/kg-day is recommended for the low-risk CT evaluation. The SF of 4E-2 per mg/kg-day is equivalent to a URF for vapor inhalation of 1E-5 per $\mu g/m^3$.

An alternative method of PCB cancer risk assessment was proposed by EPA (2000, 2012) for sites where congener-specific analytical results are available. This method involves application of toxicity equivalency factors (TEF) adopted by EPA (2000) to the 12 dioxin-like congeners identified above. TEFs are factors that express the toxicity of the dioxin-like congeners relative to 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD or "dioxin"), the reference compound. EPA (1997) presented a provisional oral and inhalation SF for 2,3,7,8-TCDD of 1.5E+5 per mg/kg-day. As explained in the toxicological profile for polychlorinated dibenzo-p-dioxins and dibenzofurans, the inhalation SF is more accurately expressed as 1.1E+5 per mg/kg-day, which is equivalent to 3.3E+1 per $\mu g/m^3$, or 3.3E+4 per mg/m^3. Application of the EPA (2000) TEFs to the dioxin-like PCB congeners yields the cancer potency factors presented below:

Dioxin-Like PCB Congener	IUPAC No.	TEF	SFo	URFi	SFi
3,3′,4,4′-Tetrachlorobiphenyl	77	0.0001	1.5E+1	3.3E+0	1.1E+1
3,4,4′,5-Tetrachlorobiphenyl	81	0.0001	1.5E+1	3.3E+0	1.1E+1
2,3,3′,4,4′-Pentachlorobiphenyl	105	0.0001	1.5E+1	3.3E+0	1.1E+1
2,3,4,4′,5-Pentachlorobiphenyl	114	0.0005	7.5E+1	1.7E+1	5.5E+1
2,3′,4,4′,5-Pentachlorobiphenyl	118	0.0001	1.5E+1	3.3E+0	1.1E+1
2′,3,4,4′,5-Pentachlorobiphenyl 2,3′,4,4′,5′-Pentachlorobiphenyl)	123	0.0001	1.5E+1	3.3E+0	1.1E+1
3,3′,4,4′,5-Pentachlorobiphenyl	126	0.1	1.5E+4	3.3E+3	1.1E+4
2,3,3′,4,4′,5-Hexachlorobiphenyl	156	0.0005	7.5E+1	1.7E+1	5.5E+1
2,3,3′,4,4′,5′-Hexachlorobiphenyl	157	0.0005	7.5E+1	1.7E+1	5.5E+1
2,3′,4,4′,5,5′-Hexachlorobiphenyl	167	0.00001	1.5E+0	3.3E-1	1.1E+0
3,3′,4,4′,5,5′-Hexachlorobiphenyl	169	0.01	1.5E+3	3.3E+2	1.1E+3

Dioxin-Like PCB Congener	IUPAC No.	TEF	SFo	URFi	SFi
2,3,3′,4,4′,5,5′-Heptachlorobiphenyl	189	0.0001	1.5E+1	3.3E+0	1.1E+1

IUPAC No. = unique sequentially numbered congener identifier proposed by the International Union of Pure and Applied Chemists; TEF = toxicity equivalency factor (EPA, 2000); SFo = oral slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per milligram per cubic meter); SFi = inhalation slope factor (risk per milligram per kilogram-day).

6.0 Toxicity Summary

Cancer potency factors for the dioxin-like congeners are summarized above. Toxicity values for PCBs other than the dioxin-like congeners, are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
Aroclor-1016[b]										
2E-4	7E-5	F	ND	ND	NA	Please see below.				
Aroclor-1254										
5E-5	2E-5	Is, S	ND	ND	NA	Please see below.				
PCBs, High-Risk, Upper Bound (Reasonable Maximum Exposure) Assumptions										
Please see above, including footnote “b.”						B2	2.0E+0	B2	5.7E-1[c]	2.0E+0[c]
PCBs, High-Risk, Central Tendency Exposure Assumptions										
Please see above, including footnote “b.”						B2	1.0E+0	B2	2.9E-1[c]	1.0E+0[c]
PCBs, Low-Risk, Upper Bound (Reasonable Maximum Exposure) Assumptions										
Please see above, including footnote “b.”						B2	4E-1	B2	1E-1[d]	4E-1[d]
PCBs, Low-Risk, Central Tendency Exposure Assumptions										
Please see above, including footnote “b.”						B2	3E-1	B2	9E-2[d]	3E-1[d]
PCBs, Lowest-Risk, Upper Bound (Reasonable Maximum Exposure) Assumptions										
Please see above, including footnote “b.”						B2	7E-2	B2	2E-2	7E-2
PCBs, Lowest-Risk, Central Tendency Exposure Assumptions										
Please see above, including footnote “b.”						B2	4E-2	B2	1E-2	4E-2

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per milligram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data.
Target organ abbreviations: F = unborn child; Is = immune system; S = skin; NA = not applicable.
[a]sRfDo, cRfDo and SFo should be used for dermal exposure without adjustment for GI absorption.
[b]sRfDo and cRfDo derived for Aroclor-1016 should be applied to all other Aroclor mixtures except Aroclor-1254. They should also be applied to total PCBs, but not to specific PCB homologues congeners.

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
[c]Reasonable maximum exposure evaluation of inhalation pathways including dusts or aerosols. [d]Reasonable maximum exposure evaluation of inhalation pathways limited to vapors, excluding dusts or aerosols.										

7.0 PCB Risk Assessment

The approach to risk assessment of PCB-contaminated sites depends on the analytical data available. Typically, PCB analysis is limited to Method 8082 for the seven commonly encountered Aroclors. When this is the case, the hazard associated with noncancer effects is evaluated with the oral RfDs provided in the table above. Cancer risk is evaluated with the upper bound (reasonable maximum exposure) SFo and URFi or SFi from the "High-Risk" or "Low-Risk" scenarios, depending on the Aroclors identified, and the receptors and exposure pathways evaluated.

If homologue-specific analytical results are available in addition to results for the seven common Aroclors, it will be necessary to decide which is the better data set. This decision will depend, at least in part, on the samples included in each data set. Generally, the data set that better represents contamination across the area of investigation or a given exposure unit should be used in the risk assessment. If the same samples were analyzed for both Aroclors and specific homologues so that representativeness is not an issue, EPA (2012) generally considers that the homologue data are preferable because they are based on greater sensitivity (lower reporting limits) and are more likely to reflect selective removal of the more labile and mobile congeners due to weathering. Homologue-specific analytical results in the absence of data for the seven common Aroclors can be evaluated directly in the risk assessment.

The homologues should not be evaluated individually for noncancer hazard using the oral RfDs provided above. However, their sum (total PCBs) can be evaluated with the oral RfD for Aroclor-1016, assuming that the total PCBs reflect the characteristics of a mixture not unlike one or more of the Aroclors. If this assumption is not reasonable, the reason should be clearly stated, total PCBs should not be evaluated for noncancer hazard, and the uncertainty imparted to the risk assessment (probably a non-conservative bias) should be discussed. For example, it might be that only the most highly chlorinated homologues persist and are identified from an "old" release.

Cancer risk is estimated for total PCBs rather than the individual homologues. If the penta-, hexa-, hepta-, octa-, nona- and deca-chlorinated homologues together constitute not more than 0.5 percent of the total PCB, the SFo and URFi or SFi for the "Lowest-Risk" scenario should be used. If the penta-, hexa-, hepta-, nona- and deca-chlorinated homologues together constitute more than 0.5 percent of the total PCB, the SFo and URFi or SFi for the "High-Risk" or "Low-Risk" scenario should be used, depending on the receptors and exposure pathways evaluated.

It is unlikely that congener-specific data will be the only PCB data available. Should that be the case, however, the noncancer hazard can be estimated for total PCBs as described in the previous paragraph. For cancer risk assessment, the dioxin-like congeners should be assessed as

explained below. The non-dioxin-like congeners should be summed. If the penta-, hexa-, hepta-, nona- and deca-chlorinated congeners together constitute not more than 0.5 percent of the total PCB, the SFo and URFi or SFi for the "Lowest-Risk" scenario should be used. If the penta-, hexa-, hepta-, nona- and deca-chlorinated congeners together constitute more than 0.5 percent of the total PCB, the SFo and URFi or SFi for the "High-Risk" or "Low-Risk" scenario should be used, depending on the receptors and exposure pathways evaluated. The cancer risks from the non-dioxin-like and the dioxin-like congeners (see next paragraph) should be summed.

It is more likely that limited congener-specific data will be available *in addition to* data for the Aroclors or homologues. (Limited in the number of congeners analyzed and/or the number of samples analyzed for individual congeners.) For cancer risk assessment, EPA (2012) recommends evaluating the Aroclors or homologues as described above, after reducing their exposure-point concentrations by the contribution from the dioxin-like congeners. In most cases the concentrations of the dioxin-like congeners will be so much lower than the concentrations of the Aroclors or homologues that their subtraction would make little difference. The cancer risk for the dioxin-like congeners is assessed by using the TEF-based SFo and URFi or SFi values presented above. The two sets of risk estimates are then summed.

The newer trends in PCB analysis and risk assessment introduce additional sources of uncertainty to the assessment. PCBs tend to be somewhat ubiquitous because of their once-common use, potential for widespread dispersion, and persistence in environmental media (ATSDR, 2000). Method 1668 is a high-resolution method that is likely to identify very low "anthropogenic background" levels of PCBs that may not be reflected in the results of Aroclor analysis using Method 8082. This may impart an overly conservative bias to the risk assessment. Another source of uncertainty may arise from analyzing only a limited number or proportion of PCB-bearing samples for individual congeners. The limited analysis could impart either a conservative or non-conservative bias to the risk assessment, depending on the relative level of contamination in the samples selected for analysis of individual congeners.

8.0 References

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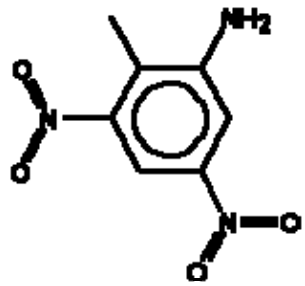
Explosives

AMINODINITROTOLUENES (ADNT) and DIAMINONITROTOLUENES (DANT)



2-Amino-4-6-dinitrotoluene

1.0 Introduction and Physical Properties

The ADNTs, 2-amino-4,6-dinitrotoluene (2-ADNT) (35572-78-2) and 4-amino-2,6-dinitrotoluene (4-ADNT) (19406-51-0) are **SVOCs** that are present in environmental media presumably as microbial reduction products of 2,4,6-trinitrotoluene (TNT) (ATSDR, 1995; HSDB, 2012). Based on the melting point for 2-amino-4,6-dinitrotoluene of 129.14 EC (RAIS, 2005), it is assumed that the ADNTs occur as solids at ambient temperatures in the pure state. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
2-Amino-4,6-Dinitrotoluene										
197.15[a]	1.84[a]	1.61E-10[a] (25°C)[b]	2.36[d]	5.61E-2[c] (25°C)[b]	6.49E-6[c] (25°C)[b]	1.41E-8[a] (25°C)[b]	1.22E+3[a] (25°C)[b]	625.2[a]	ND	ND

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point of pure liquid compound (°K); T_c = critical temperature (°K);.$H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); ND = no data.
[a]Risk Assessment Information System (RAIS), 2005, "Chemical-Specific Factors," Oak Ridge National Laboratory, on line, accessed 6 December.
[b]Assumed.
[c]Calculated as described in Introduction to Toxicity Profiles.
[d] Estimated with the U.S. Environmental Protection Agency (EPA), 2011, ***EPI Suite Version 4.10*** Software for estimating physical properties.

The physical properties presented above for 2-ADNT should be applied also to 4-ADNT, for which chemical-specific data were not located.

Physical properties were not located for the DANTs, 2,4-diamino-6-nitrotoluene (2,4-DANT) (6629-29-4) and 2,6-diamino-4-nitrotoluene (2,6-DANT) (59229-75-3). However, some properties can be estimated, as follows:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
2,4-Diamino-6-nitrotoluene										
167.17[a]	0.55[b]	2.77E-10[b] (25°C)[c]	2.15[b]	6.26E-2[d] (25°C)[c]	7.25E-6[d] (25°C)[c]	3.55E-8[b] (25°C)	1.27E+3[b,e] (25°C)[c]	ND	ND	ND

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point of pure liquid compound (°K); T_c = critical temperature (°K);.$H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); ND = no data.
[a]Estimated from molecular formula and periodic table.
[b]Estimated with the U.S. Environmental Protection Agency (EPA), 2011, ***EPI Suite Version 4.10*** Software for estimating physical properties.
[c]Assumed.

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
[d]Calculated as described in Introduction to Toxicity Profiles. [e]Based on molecular fragments method.										

The physical properties presented above for 2-DANT should be applied also to 4-DANT. The value for H classifies the DANTs as SVOCs. The estimated melting point for 2-DANT of at least 121.14 EC suggests that these compounds would occur as solids at ambient temperatures in the pure state.

2.0 Environmental Fate and Transport

The ADNTs may be released to the environment as degradation products of TNT or similar compounds (HSDB, 2012). ATSDR (1995) shows the DANTs as mammalian metabolic nitroreduction products of the ADNTs, which are nitroreduction products of TNT metabolism. The DANTs have been identified as major metabolites in the urine of rats treated with a single oral dose of TNT. Environmental degradation and mammalian biotransformation of organic compounds frequently parallel; therefore, it is expected that DANTs occur in the environment as nitroreduction products of TNT and the ADNTs.

Data regarding the environmental fate of the ADNTs and the DANTs were not located in the available literature. It is assumed, however, that the ADNTs and DANTs may behave similarly to TNT because of the structural similarity of these compounds. Under this assumption, the ADNTs and DANTs are likely to persist in soil; hydrolysis and volatilization are unlikely to be significant (HSDB, 2012). They are likely to occur almost entirely in the vapor phase in the atmosphere, and may be subject to direct photolysis and photochemical degradation.

The capability of microorganisms to biotransform TNT under anaerobic conditions in soil and water is well established; however, reduction rates under aerobic conditions are very slow (HSDB, 2012). It is unclear the extent to which the ADNTs or DANTs may be subject to further microbial reduction. Photolysis, which is the most important removal process for TNT in surface water, may also be significant for the ADNTs and DANTs. Hydrolysis and volatilization are not significant for TNT and also are not expected to be significant for the ADNTs or DANTs. The extent of adsorption to suspended or benthic sediment is expected to be moderate.

Generally TNT is not expected to bioconcentrate in aquatic systems or to participate significantly in food chain pathways under normal environmental conditions (ATSDR, 1995; HSDB, 2012). It is assumed that the ADNTs and DANTs will not bioconcentrate significantly and biotransfer factors are not estimated. This is supported by the observation that metabolites of TNT, including the ADNTs and DANTs, are rapidly cleared from the body, primarily through the urine and also through the feces (ATSDR, 1995).

3.0 Toxicokinetics

EPA (2003) states that 2- and 4-ADNT appear to be well absorbed and rapidly excreted in the urine and bile of mammals. This is consistent with TNT, for which the data indicate that a minimum of 60 to 75 percent of a single oral dose is absorbed from the GI tract (ATSDR, 1995). Studies with bile-duct-cannulated rats, however, suggest that biliary excretion is significant, and that enterohepatic recirculation may have resulted in artificially low estimates of GI absorption in the TNT studies. It is assumed that the ADNTs and DANTs (as well as TNT) are readily and extensively absorbed from the GI tract.

ATSDR (1995) identifies 2-ADNT and 4-ADNT as metabolites of TNT in mammals. The ADNTs are subject to further nitroreduction to form the DANTs, oxidation of the methyl group to form the corresponding benzyl alcohol or benzoic acid derivatives, and oxidation of the aromatic ring to for the corresponding amino-dinitrocresols. Metabolites are rapidly excreted; however, marked differences in the color or urine from different species suggests that the metabolites produced, or at least their relative proportions, are species dependent.

4.0 Dermal Exposure

EPA (2004) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. Therefore, no GAF is developed for the ADNTs and the DANTs, and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

Data regarding the extent of dermal uptake of the ADNTs or DANTs from soil were not located. Therefore, the EPA (2004) default ABS of 0.1 for SVOCs is used in this evaluation. From the MW and log K_{ow} values given above and the EPA (2004) method, t*, K_p, τ, FA and B values are estimated as follows:

Chemical	t*	K_p	τ	FA	B
Aminodinitrotoluenes	3.20	2.04E-3	1.33	1[a]	0[b]
Diaminonitrotoluenes	2.18	4.23E-4	0.91	1[a]	0[b]

t* = Time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).
[a]Assumed.
[b]Sufficiently small to be rounded to zero.

5.0 Noncancer Effects Evaluation

Data were not located regarding the chronic oral toxicity of the ADNTs, and the ADNTs are not listed on IRIS (EPA, 2012). EPA (2003) evaluated the toxicity of TNT, 2,4-dinitrotoluene and 2,6-dinitrotoluene in the context of the ADNTs, and previously posited, based on structural similarities alone, that TNT is the most appropriate surrogate for the ADNTs. EPA reviewed the toxicity data available for the ADNTs and concluded that they were insufficient for estimation of peer-reviewed oral RfDs (EPA, 2005a) or inhalation RfCs (EPA, 2005b). EPA (2011) has more recently taken the approach of using the oral chronic RfD for 2,4-DNT of 2E-3 mg/kg-day as a surrogate values for both ADNTs. This approach has been adopted in the current human health risk evaluation. This value is also extrapolated for the DANTs

Data are not available regarding the toxicity of inhalation exposure to the ADNTs or DANTs; therefore, inhalation RfCs cannot be estimated.

6.0 Carcinogenicity Evaluation

EPA (1993) classified the ADNTs in EPA cancer weight-of-evidence Group D, not classifiable as to carcinogenicity in humans, to reflect a total lack of human or animal data. Cancer potency factors are unavailable. Data were not located regarding the carcinogenicity of the DANTs. It

should be noted that EPA (2005c) reviewed the toxicity data available for the ADNTs and concluded that they were *inadequate for an assessment of human carcinogenic potential*. This conclusion is consistent with the EPA (1993) review, which is continued herein and applied also to both the ADNTs and DANTs.

7.0 Toxicity Summary

Toxicity values for the ADNTs are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfc/ sRfD	cRfC/ cRfD	TO	WOE	SFo	WOE	URFi	SFi
2E-3	2E-3	L, E	ND	ND		D	NA	D	NA	NA

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.
Target organ abbreviations: L = liver; E = erythrocyte.
[a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.

The toxicity values presented above for the ADNTs apply also to the DANTs.

8.0 References

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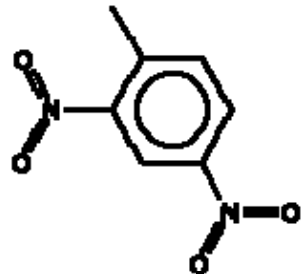
U.S. Environmental Protection Agency (EPA), 2012, ***Integrated Risk Information System (IRIS)***, National Center for Environmental Assessment, Cincinnati, OH, on line.

DINITROTOLUENES (DNT)



(2,4-Dinitrotoluene)

1.0 Introduction and Physical Properties

The dinitrotoluenes (DNT) are **SVOCs** that occur as yellow to orange to red needles or crystals at ambient temperatures (HSDB, 2012). They are used predominantly as intermediates in the production of polyurethanes, dyes, rubber, plastics, toluidines, toluenediisocyanates, flexible and rigid foams, surface coatings, and other organic chemicals (ATSDR, 1998; HSDB, 2012). The DNTs are also used as gelatinizing and waterproofing agents in the production of explosives. The DNTs may appear in environmental media as break down products of 2,4,6-trinitrotoluene (TNT). Isomers include 2,3-, 2,4-, 2,5-, 2,6-, 3,4- and 3,5-DNT. Analysis of technical grade DNT yielded the following results: 76.49 percent 2,4-DNT, 18.83 percent 2,6-DNT, 0.65 percent 2,5-DNT, 2.43 percent 3,4-DNT, 1.54 percent 2,3-DNT, 0.040 percent 3,5-DNT, 0.050 percent trinitrotoluene, 0.005 percent cresols, 0.003 percent mononitrobenzene, and 0.003 percent, 0.0005 percent, and 0.006 percent ortho-, meta-, and para-, mononitrotoluenes, respectively. The compounds of most interest in environmental exposure are limited to 2,4- and 2,6-DNT. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
2,3-Dinitrotoluene (602-01-7)										
182.14[a]	2.2[a]	9.3E-8[a] (25°C)[b]	2.57[a]	5.91E-2[c] (25°C)[b]	6.85E-6[c] (25°C)[b]	5.26E-7[a] (25°C)	2.2E+2[d] (25°C)[b]	ND	ND	ND
2,4-Dinitrotoluene (121-14-2)										
182.1[e]	1.98[e]	8.40E-8[i] (25°C)	2.46[i]	2.03E-1[f] (25°C)	7.06E-6[f] (25°C)	1.93E-7[a] (22°C)	2.70E+2[f] (20-25°C)	590.0[g]	814.0[g]	1.35E+4[g]
2,5-Dinitrotoluene (619-15-8)										
182.14[a]	2.2[a]	9.3E-8[a] (25°C)[b]	2.56[a]	5.91E-2[c] (25°C)[b]	6.85E-6[c] (25°C)[b]	5.26E-7[a] (25°C)	2.2E+2[d] (25°C)[b]	ND	ND	ND
2,6-Dinitrotoluene (606-20-2)										
182.1[e]	1.72[e]	7.47E-8[i] (25°C)[b]	2.46[i]	5.91E-2[c] (25°C)[b]	6.85E-6[c] (25°C)[b]	7.46E-7[a] (25°C)	1.82E+2[h] (20-25°C)	558.0[g]	770.0[g]	1.29E+4[g]
3,4-Dinitrotoluene (610-39-9)										
182.14[a]	2.08[a]	9.3E-8[a] (25°C)[b]	2.56[a]	5.91E-2[c] (25°C)[b]	6.85E-6[c] (25°C)[b]	5.26E-7[a] (25°C)	1.00E+2[a] (25°C)	ND	ND	ND
3,5-Dinitrotoluene (618-85-9)										
182.14[a]	2.2[a]	9.3E-8[a] (25°C)[b]	2.56[a]	5.91E-2[c] (25°C)[b]	6.85E-6[c] (25°C)[b]	2.50E-6[a] (25°C)	ND	ND	ND	ND

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K);.$H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); ND = no data.

[a]Hazardous Substance Data Bank (HSDB), 2012, National Library of Medicine, on line.

[b]Assumed.

[c]Calculated as described in Introduction to Toxicity Profiles.

[d]Syracuse Research Corporation (SRC), 2004, *CHEMFATE Data Base*, on line.

[e]U.S. Environmental Protection Agency (EPA), 2004 *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final*, Office of Emergency and Remedial Response, EPA/540/R/99/005, OSWER 9285.7-02EP July.

[f]U.S. Environmental Protection Agency (EPA), 2002, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*, Final, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, December.

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$

[g]U.S. Environmental Protection Agency (EPA), 2003, *Users Guide for Evaluating Subsurface Vapor Intrusion into Buildings*, Office of Emergency and Remedial Response, Washington, DC, 19 June.
[h]U.S. Environmental Protection Agency (EPA), 1996, *Soil Screening Guidance: Technical Background Document*, Office of Emergency and Remedial Response, Washington, DC, EPA/540/R-95/128, Publication 9355.4-17A, PB96-963502, May.
[i]U.S. Environmental Protection Agency (EPA), 2011, *EPISuite electronic database*.
[j]Conservatively assumed to be based on the same Kow as 2,4-DNT.

The physical properties of 2,4-DNT can be used for the DNT mixture (25321-14-6) because the 2,4-isomer predominates in the technical grade product.

2.0 Environmental Fate and Transport

The DNTs are released into the environment in waste streams from processes in which they are manufactured or used (ATSDR, 1998; HSDB, 2012). Also, they may form from degradation of TNT in gunpowder or explosives, particularly at TNT manufacturing or military sites. DNTs released to soil are expected to exhibit moderate mobility and may leach to groundwater. No information on biodegradation in soil was found; however, biodegradation may be an important fate process in soil based on the observation that all DNT isomers in surface water to which yeast extract was added were metabolized. DNTs are not expected to hydrolyze in soils.

DNTs released to water, may exhibit weak to moderate adsorption to sediment (ATSDR, 1998; HSDB, 2012). Evaporation from water is not expected to be an important removal process, based on the low Henry's Law constants for these compounds. Biodegradation may be an important fate process in water, as indicated above. DNTs in water may be susceptible to photolysis, based on the behavior of 2,4-DNT, which had photolytic half-lives ranging from 2.7 to 9.6 hours in natural water environments and 43 hours in distilled water.

DNTs released to the atmosphere are expected to exist solely in the vapor phase (HSDB, 2012). They may be susceptible to direct and indirect photolysis. The half-life for reaction with photochemically produced hydroxyl radicals is 84 days.

Bioconcentration of the DNTs is expected to be negligible (ATSDR, 1998; EPA, 1995; HSDB, 2012); therefore, biotransfer factors are not estimated.

3.0 Toxicokinetics

The rapid disappearance of radioactivity from the small intestine of rats following oral administration of radiolabeled 2,4- or 2,6-DNT suggests that absorption from the GI tract is rapid and essentially complete (ATSDR, 1998; EPA, 1992). Species differences in the excretion of the DNTs, however, confound quantification of the extent of GI absorption. Fecal excretion and the GI tract (tissue + contents) accounted for 9.2 to 17.3 percent of the dose of radioactivity 24 hours after oral administration of radiolabeled 2,4-DNT to rats, rabbits, dogs and monkeys (EPA, 1992). Fecal excretion and the GI tract accounted for 83.1 to 85 percent of an oral dose in mice in the same study. Biliary excretion appears to be more important in mice than in the other species tested. Together, the data for the 2,4-isomer suggest that the GI absorption of the DNTs is practically complete.

Body distribution of radioactivity was followed after administration of a ^{14}C-labeled oral dose of 2,4-DNT in male and female rats (ATSDR, 1998). Levels of radioactivity in the liver and kidneys exceeded levels in the plasma or erythrocytes by 5- to 10-fold; levels in other tissues

were lower than those in blood. The greater concentrations in the liver and kidneys probably represent metabolites rather than parent compound.

Metabolism of the DNTs involves both oxidative and reductive reactions as well as alkylation (ATSDR, 1998). Oxidative reactions occur primarily in the liver and involve stepwise enzymatic oxidation of the methyl group to the corresponding dinitrobenzyl alcohol, dinitrobenzylaldehyde and dinitrobenzoic acid. Dinitrobenzyl alcohol is subject to conjugation, particularly with gluconuric acid, before excretion via the urine or bile. Acetylation of one of the nitro groups of the dinitrobenzoic acid may also occur, yielding the corresponding (n-acetyl)amino nitrobenzoic acid, which is observed as a minor urinary metabolite.

Two types of reduction reactions involving metabolites excreted via the bile or GI tract are accomplished anaerobically by intestinal microflora (ATSDR, 1998). The first reaction involves lysis of the glucuronide conjugate described above to release the corresponding benzyl alcohol. The second reaction involves nitroreduction, resulting in transforming one or both of the nitro groups to amine groups, probably through nitroso and hydroxylamino intermediates. The amino and hydroxylamino benzyl alcohols are reabsorbed, completing the enterohepatic cycle.

The amine group on the reabsorbed benzyl alcohol is subject to partial oxidation in the liver to yield the corresponding hydroxylamino compound, potentially providing a second pathway for formation of these compounds (ATSDR, 1998). The hydroxylamino compounds may conjugate with sulfate, forming an unstable product that decomposes to yield carbonium or nitrenium ions that bond covalently with hepatic macromolecules, giving rise to the first stages of hepatic carcinogenesis. From the foregoing, it appears that microbial transformation and hepatic recirculation are involved in the carcinogenicity observed in laboratory rodents (Section 6.0).

4.0 Dermal Exposure

EPA (2004) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. Therefore, no GAF is developed for the DNTs and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

Urinary excretion data obtained from workers exposed to the DNTs indicates that dermal absorption occurs (ATSDR, 1998) but multiple exposure routes were involved and the extent of dermal uptake cannot be quantified. Empirical data regarding dermal uptake from soil were not located. ABS values of 0.102 and 0.099 were used for 2,4-DNT and 2,6-DNT, respectively (EPA, 2011) t*, K_p, τ, FA and B values are provided by EPA (2004) or estimated by the EPA (2004) methods as follows:

Chemical	t*	K_p	τ	FA	B
2,3-Dinitrotoluene[a]	2.64	4.29E-3	1.10	1	0.0
2,4-Dinitrotoluene[b]	2.69	3.1E-3	1.12	1	0.0
2,5-Dinitrotoluene[a]	2.64	4.29E-3	1.10	1	0.0
2,6-Dinitrotoluene[b]	2.69	2.1E-3	1.12	1	0.0
3,4-Dinitrotoluene[a]	2.64	3.57E-3	1.10	1	0.0
3,5-Dinitrotoluene[a]	2.64	4.84E-3	1.10	1	0.0
t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); τ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability					

Chemical	t*	K_p	τ	FA	B
coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless). [a]Estimated as described in Introduction to Toxicity Profiles. [b]U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Emergency and Remedial Response, EPA/540/R/99/005, OSWER 9285.7-02EP, July.					

The estimated values for K_p for all the DNTs fell within the effective prediction domain.

5.0 Noncancer Effects Evaluation

Data regarding the toxicity of oral exposure to 2,3-DNT are limited to the statement that the 2,4-, 2,6- and 3,4-isomers are more toxic to rats than the 2,3- or 2,5-isomers (HSDB, 2012).

Acute oral exposure to 2,4-DNT induces methemoglobinemia; dogs appear to be more sensitive than rats, which are more sensitive than mice (ATSDR, 1998). Oral LD_{50} values include 270 mg/kg for rats, 1630 mg/kg for mice and 1300 mg/kg for guinea pigs (ATSDR, 1998; HSDB, 2012), establishing the rat as the species most sensitive to acute oral exposure. Subchronic or chronic oral exposure to 2,4-DNT in rats is associated with depressed weight gain, reticulocytosis and splenic hemosiderosis, and decreased spermatogenesis (HSDB, 2012). Some rats had widespread and stiff-legged gaits and demyelination in the cerebellum and brain stem. A verified chronic oral RfD of 2E-3 mg/kg-day for 2,4-DNT is based on neurotoxicity, hematologic effects and biliary tract hyperplasia in dogs given capsules containing the test substance for 2 years (EPA, 2012). Progressive paralysis, accompanied by degenerative lesions in the central nervous system, were observed in dogs treated with 10 mg/kg-day. Hematologic effects, including methemoglobinemia and its sequelae, were observed in dogs treated with 1.5 mg/kg-day, which is the LOAEL for this study. No adverse effects were observed in dogs treated with 0.2 mg/kg-day. Application of an uncertainty factor of 100 to the NOAEL of 0.2 mg/kg-day yields an RfD of 2E-3 mg/kg-day. Confidence in the RfD is high. The CNS, erythrocyte and liver appear to be the target organs for prolonged oral exposure, at least in dogs. EPA (1997) adopted the verified chronic oral RfD as the preliminary RfD for subchronic oral exposure.

HSDB (2012) reports oral LD_{50} values for 2,5-DNT of 707 mg/kg for rats and 1231 mg/kg for mice. Data regarding the effects of prolonged oral exposure were not reported.

Oral LD_{50} values for 2,6-DNT for rats (177 to 665 mg/kg) are similar to those for mice (621 to 714 mg/kg) (ATSDR, 1998; HSDB, 2012). Dogs, however, appear to be more sensitive than rodents in subchronic studies. A provisional chronic oral RfD of 1E-3 mg/kg-day for 2,6-DNT is based on a 13-week dietary study with 2,6-DNT in dogs (EPA, 2005). The NOAEL in this study was 4 mg/kg-day, somewhat higher than the LOAEL for 2,4-DNT. An uncertainty factor of 3000 was applied. The CNS, erythrocyte, and liver appear to be the target organs for prolonged oral exposure to 2,6-DNT. The oral data in dogs suggest that the 2,6-isomer is somewhat less toxic than the 2,4-isomer for prolonged oral exposure. The oral RfD for the 2,6-isomer, however, is less than the oral RfD for the 2,4-isomer. This apparent contradiction is an artifact of the lesser quality data base for 2,6-DNT and, consequently, the higher uncertainty factor used to derive the RfD for the 2,6-isomer. EPA (1997) derived a provisional subchronic oral RfD of 1E-2 mg/kg-day by applying an uncertainty factor of 300 to the NOAEL of 4 mg/kg-day in the 13-week dog study.

The verified chronic oral RfD of 2E-3 mg/kg-day and the provisional subchronic oral RfD of 2E-3 mg/kg-day for 2,4-DNT can be used for DNT mixtures and the other DNT isomers for which oral exposure data sufficient for RfD derivation are not available. The RfD for 2,4-DNT is chosen over the 2,6-DNT RfD for other isomers because the 2,4-isomer predominates in the technical product and because the RfD for the 2,4-isomer is compromised by much less uncertainty.

Occupational studies indicate that acute exposure to the DNTs produces methemoglobinemia, which causes headache, irritability, dizziness, weakness, nausea, vomiting, dyspnea, drowsiness, unconsciousness and, in extreme cases, death (ACGIH, 1991). Occupational exposure may lead to increased risk of ischemic heart disease, possibly arising from decreased oxygen-carrying capacity of the blood. The data are insufficient to develop inhalation RfCs for the DNT isomers.

6.0 Carcinogenicity Evaluation

Carcinogenicity data for the DNTs are somewhat confusing. Treatment of rats and mice with purified 2,4-DNT generally yields no increased incidence of neoplasia, but treatment with technical grade DNT, 2,4-DNT containing as little as 2 percent 2,6-DNT, or with 2,6-DNT itself generally yields a positive neoplastic response (EPA, 2012). Initiation/promotion tests suggest that 2,6-DNT may be a complete carcinogen and 2,4-DNT may be a promoter.

EPA (2012) classified the 2,4-/2,6-DNT mixture in EPA cancer weight-of-evidence Group B2 (probable human carcinogen) on the basis of multiple tumor types in male and female rats and renal tumors in male mice in several dietary studies. Occupational data provide no evidence of carcinogenicity in humans, but the studies reviewed lack the power to reveal small differences in cancer risk (ACGIH, 1991). EPA (2012) verified an oral SF of 6.8E-1 per mg/kg-day for exposure to the 2,4-/2,6-DNT mixture based on an increased incidence of a variety of tumors in female rats. The test material contained approximately 98 percent 2,4-DNT and 2 percent 2,6-DNT. The B2 classification and the oral SF of 6.8E-1 per mg/kg-day are used in this evaluation for 2,6-DNT and the 2,4-/2,6-DNT mixture. Given the uncertainty about to potential carcinogenicity of the 2,4-isomer alone, and the likelihood that small amounts of the 2,6-isomer may be present, it is deemed prudent to apply the B2 classification and the oral SF of 6.8E-1 per mg/kg-day to the 2,4-isomer as well. The data are insufficient for development of potency factors for inhalation exposure. Data regarding the carcinogenicity of the other DNT isomers were not located.

7.0 Toxicity Summary

Toxicity values for the DNTs are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a, b]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
2,4-Dinitrotoluene										
2E-3	2E-3	E, CNS, L	ND	ND	NA	B2	6.8E-1	ND	ND	ND
2,6-Dinitrotoluene										
1E-2	1E-3	E, CNS, L	ND	ND	NA	B2	6.8E-1	ND	ND	ND

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a, b]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.
Target organ abbreviations: E = erythrocyte; CNS = central nervous system; L = liver.
[a]sRfDo, cRfDo and SFo should be used for dermal exposure without adjustment for GI absorption.
[b]The cancer evaluation for the 2,4-/2,6-DNT mixture is applied to any DNT mixture containing 2,4- and 2,6-DNT (e.g., the technical grade material) as well as the individual 2,4- and 2,6-isomers.

The oral RfD values for 2,4-DNT should be applied to the technical grade material, any 2,4-/2,6 mixture, and any isomers other than pure 2,6-DNT. The cancer weight-of-evidence group and the verified oral SF for the 2,4-/2,6-DNT mixture should not be applied to isomers other than 2,4- and 2,6-DNT because the potential for the other isomers to cause cancer has not been evaluated.

8.0 References

Agency for Toxic Substances and Disease Registry, (ATSDR), 1998, ***Update Toxicological Profile for 2,4-Dinitrotoluene and 2,6-Dinitrotoluene***, U.S. Department of Health and Human Services, Atlanta, Georgia, December, PB/99/122004, December.

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2,4,6-TRINITROTOLUENE (TNT) (118-96-7)

1.0 Introduction and Physical Properties

TNT is an SVOC that occurs as a pale yellow solid, crystal or flake at ambient temperatures (HSDB, 2012). It is classified as a high explosive and is used as a military explosive in bombs and grenades (ATSDR, 1995; HSDB, 2012). It has found wide use in filling shells and airborne detonation bombs because it can withstand the shock of ejection from a gun barrel but can be exploded on impact with a detonator mechanism. It is used as a pure compound or combined with other explosive chemicals for military application. Small amounts are used in industrial explosives. Minor applications include use as a chemical intermediate in the manufacture of dyestuffs and photographic chemicals. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
227.13	1.60	2.08E-8 (25°C)	2.25	5.10E-2[a] (25°C)[b]	5.91E-6[a] (25°C)[b]	1.06E-8 (20°C)	5.52E+2 (25°C)	NA	NA	NA

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point of pure liquid compound (°K); T_c = critical temperature (°K); $\Delta H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); NA = not applicable.
Note: All values are from [h]U.S. Environmental Protection Agency (EPA), 2011, *EPISuite electronic database*, unless otherwise noted.
[a]Estimated as described in Introduction to Toxicity Profiles.
[b]Assumed.

2.0 Environmental Fate and Transport

TNT may be released to the environment in wastewater and air effluents from its production and use as a military explosive and propellant, and during the disposal or open detonation of outdated or unwanted munitions (ATSDR, 1995; HSDB, 2012). The behavior of TNT in the environment is expected to be controlled largely by its relatively high water solubility and relatively low vapor pressure. In addition, direct and indirect photolysis yields a large number of degradation products, many of which are persistent in environmental media. Photolysis products include dinitroanthrils, trinitrobenzaldehyde, trinitrobenzyl alcohol, various nitroanilines, condensed azo and axoxy derivatives, and 1,3,5-trinitrobenzene.

Although low, the vapor pressure of TNT is sufficient to suggest that the compound will exist largely in the vapor phase in the atmosphere, where it is expected to be subject to photolysis (HSDB, 2012). The photolysis half-life has been estimated at approximately 110 days. The solubility of TNT in water suggests that wet deposition may be a significant removal process.

TNT on the surface of soil is subject to photolysis (ATSDR, 1995; HSDB, 2012). Mobility in soil is expected to be low to moderate. Large quantities released to soil (e.g., from former munitions production works) may result in substantial concentrations in groundwater. TNT in soil is subject to degradation to a number of nitro reduction products (amino compounds, mono- and dinitro compounds).

TNT in surface water is subject to photolysis; volatilization and hydrolysis are not expected to be significant (ATSDR, 1995; HSDB, 2012). Photolysis gives rise to the persistent red or pink water condition frequently observed with TNT contamination. Biodegradation occurs too slowly to be an important removal process. TNT and some of its degradation products will partition moderately to sediment or suspended particles in water.

Bioconcentration or bioaccumulation are not expected to be significant for TNT (ATSDR, 1995; HSDB, 2012); therefore, biotransfer factors are not developed.

3.0 Data for Evaluating Dermal Exposure

Pharmacokinetic data are limited to studies of oral administration of radiolabeled compound to several species followed by collection and measurement of radioactivity in urine, gastrointestinal tract (including contents) and feces (ATSDR, 1995). Total recovery from these compartments ranged from 92 to 104 percent, suggesting little metabolism to radioactive metabolites that were exhaled. The percent of the dose recovered in the urine may be considered a minimal estimate of GI absorption, because the extent of biliary excretion and enterohepatic recirculation has not been investigated. Urinary recovery averaged 60 percent in rats, mice and dogs, and approximately 74 percent in rabbits.

EPA (2004) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. Therefore, no GAF is developed for TNT and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

Studies indicate that TNT is rapidly absorbed through the skin of occupationally exposed humans, but quantitative data were not located (ATSDR, 1995). Dermal absorption ranged from 17 to 68 percent of a single dose of radioactivity in studies using laboratory animals exposed for 24 hours to radiolabeled compound. Absorption appeared to be more complete in rabbits and mice than in rats and dogs, suggesting that species differences are significant. Data were not located regarding the dermal uptake of TNT from soil, which would account for the matrix effect, or the ability of soil to bind the chemical and retard its dermal uptake. An ABS of 0.032 (EPA, 2011) is adopted for this evaluation. K_p, τ, FA and B values are estimated by the EPA (2004) method as follows:

Chemical	K_p	τ	FA	B
2,4,6-Trinitrotoluene	9.64E-4	1.96E+0	1.0[a]	0[b]

K_p = permeability coefficient (cm/hour); τ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).
[a]Assumed based on the value used for similar compounds.
[b]Sufficiently small to be rounded to zero.

4.0 Noncancer Effects Evaluation

Single-dose oral LD50 values for TNT include 1010 to 1320 mg/kg for male rats, 795 to 820 mg/kg for female rats, and 660 to 1014 mg/kg in mice (ATSDR, 1995; EPA, 1993; HSDB, 2012). Female rats appear to be slightly more sensitive than males, but no significant gender differences appear in mice. Acutely poisoned animals exhibit tremors and convulsions. The radicals produced during intracellular nitroreduction of TNT inflict damage on several organelles across many different cell and tissue types.

The critical effect of prolonged oral exposure of animals to TNT is liver damage (EPA, 2012). Dogs appear to be more sensitive than rats or mice. A verified RfD for chronic oral exposure of

5E-4 mg/kg-day was derived from a LOAEL of 0.5 mg/kg-day associated with hepatic swelling and hepatocytomegaly in a 26-week feeding study in dogs. An uncertainty factor of 1000 was applied. The UF of 1000 allows for uncertainties in laboratory animal-to-man dose extrapolation, interindividual sensitivity, subchronic-to-chronic extrapolation, and LOAEL-to-NOAEL extrapolation, although the individual uncertainty factors for each category were not given. Hemosiderosis, evidence of erythrocyte destruction, was observed in dogs treated at a dose rate as low as 2 mg/kg-day (ATSDR, 1995). Confidence in the oral RfD is medium. EPA (1997) adopted the verified chronic oral RfD as the provisional oral RfD for subchronic exposure.

Although the key study is described as a comprehensive and well designed subchronic study, only effects on the liver were reported by EPA (2012), presumably because the liver effects were the critical effects upon which the oral RfD is based. Specifically, observations regarding clinical chemistry, hematology, urinalyses, periodic electrocardiography and ophthalmic examinations were not reported. Additional information from other sources, however, indicates that anemia is one of the major signs of TNT toxicity consistently observed in rats, mice and dogs (ATSDR, 1995). TNT and/or its metabolites induce the oxidation of intracellular hemoglobin to methemoglobin, which results in erythrocytic hemolysis. Hemolytic anemia is followed by a compensatory response manifested primarily as reticulocytosis. Effects on the testes, including irreversible atrophy and decreased reproductive performance, apparently secondary to altered zinc and copper nutrition, are observed in rats treated with much higher dose rates (e.g., 125 mg/kg-day).

Target organs at or near the threshold for toxicity include the erythrocyte and liver. Effects on the erythrocyte arise from the oxidation of hemoglobin to methemoglobin, which is consistently observed with exposure to inorganic nitrates and nitrites, as well as with many other nitroaromatic compounds (HSDB, 2012). Mild effects on the liver occur at slightly lower doses; the mechanism of hepatotoxicity has not been elucidated. Effects on the testes at higher levels probably arise from reduced levels of circulating ceruloplasmin, which is necessary for proper zinc nutrition at the cellular level.

Information regarding the inhalation toxicity of TNT are limited to occupational studies, which probably also include dermal exposure, generally associated with the manufacture of explosives for World War I and World War II (ATSDR, 1995). Effects attributed to occupational exposure include deaths from liver disease and aplastic anemia, anemia, dermatitis and cataracts. The data are insufficient to derive an RfC for inhalation exposure to TNT.

5.0 Carcinogenicity Evaluation

TNT is classified in EPA weight-of-evidence Group C (possible human carcinogen) on the basis of positive mutagenicity studies and dietary studies that showed an increased incidence of urinary bladder tumors in rats (EPA, 2012). Human data are inadequate. An oral SF of 3.0E-2 per mg/kg-day is based on the incidence of bladder tumors in female rats in a 24-month dietary study. The data are inadequate for potency estimation for inhalation exposure.

6.0 Toxicity Summary

Toxicity values for TNT are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
5E-4	5E-4	L, E	ND	ND	NA	C	3.0E-2	C	ND	ND

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per microgram per kilogram-day); ND = no data; NA = not applicable.
Target organ abbreviations: L = liver; E = erythrocyte.
[a]sRfDo, cRfDo and SFo should be used for dermal exposure without adjustment for GI absorption.

7.0 References:

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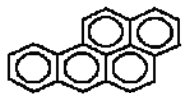
Semivolatile Organic Compounds

POLYNUCLEAR AROMATIC HYDROCARBONS a.k.a. POLYCYCLIC AROMATIC HYDROCARBONS a.k.a. POLYAROMATIC HYDROCARBONS (PAH) (130498-29-2)



Benzo(a)Pyrene
(A representative and the most studied member of this class of compounds.)

1.0 Introduction and Physical Properties

The PAHs regularly observed in environmental media and addressed in this profile include acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene and pyrene. All exist as solids at room temperature. Classification as **SVOC** or **VOC** is made in the following table. PAHs are the products of incomplete combustion of fossil fuels or other organic matter, hence include both natural and anthropogenic sources (ATSDR, 1995a; HSDB, 2012). Several are also components of crude oil. Naphthalene is used in the synthesis of phthalic anhydride, the insecticide carbaryl, leather tanning agents and surface active agents, and is a component of diesel and other fuels (ATSDR, 1995b). Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
Acenaphthene (83-32-9) **(VOC)**										
154.21[a]	3.92[a]	1.55E-4[b] (25°C)	3.85[b]	4.21E-2[b] (25°C)	7.69E-6[b] (25°C)	3.29E-6[a] (25°C)	4.24E+0[b] (20-25°C)	550.54[c]	803.15[c]	1.22E+4[c]
Acenaphthylene (208-96-8) **(VOC)**										
152.20[a]	4.07[a]	1.13E-5[a] (25°C)	3.42[a]	6.67E-2[d] (25°C)[e]	7.72E-6[d] (25°C)[e]	1.20E-6[a] (25°C)	3.93E+0[a] (25°C)	543.2[a]	797[f]	1.1E+4[g]
Anthracene (120-12-7) **VOC)**										
178.23[a]	4.45[a]	6.51E-5[b] (25°C)	4.47[b]	3.24E-2[b] (25°C)	7.74E-6[b] (25°C)	3.51E-9[a] (25°C)	4.34E-2[b] (20-25°C)	615.18[c]	873.00[c]	1.31E+4[c]
Benzo(a)anthracene (56-55-3) **(SVOC)**										
228.3[h]	5.66[h]	3.34E-6[b] (25°C)	5.60[b]	5.10E-2[b] (25°C)	9.00E-6[b] (25°C)	2.50E-9[a] (25°C)	9.40E-3[b] (20-25°C)	708.15[c]	1004.8[c]	1.60E+4[c]
Benzo(a)pyrene (50-32-8) **(SVOC)**										
252.3[a]	6.10[h]	4.57E-7[k] (25°C)	6.01[b]	4.30E-2[b] (25°C)	9.00E-6[b] (25°C)	7.22E-12[a] (25°C)	1.62E-3[b] (20-25°C)	715.90[c]	969.27[c]	1.90+4[c]
Benzo(b)fluoranthene (205-99-2) **(VOC)**										
252.3[h]	6.12[h]	6.57E-7[k] (25°C)	6.09[b]	2.26E-2[b] (25°C)	5.56E-6[b] (25°C)	6.58E-10[a] (20°C)	1.50E-3[b] (20-25°C)	715.90[c]	969.27[c]	1.70+4[c]
Benzo(k)fluoranthene (207-08-9) **(SVOC)**										
252.32[a]	6.84[a]	8.29E-7[b] (25°C)	6.09[b]	2.26E-2[b] (25°C)	5.56E-6[b] (25°C)	1.28E-12[a] (25°C)	8.00E-4[b] (20-25°C)	753.15[c]	1019.7[c]	1.80E+4[c]
Benzo(g,h,i)perylene (191-24-2) **(SVOC)**										
276.34[a]	6.63[a]	2.66E-7[a] (20°C)	4.98[a]	4.48E-2[d] (25°C)[e]	5.19E-6[d] (25°C)[e]	1.3E-13[a] (25°C)	2.6E-4[a] (25°C)	823[a]	1097[f]	1.96E+4[g]
Chrysene (218-01-9) **(VOC)**										
228.3[h]	5.66[h]	9.46E-5[b] (25°C)	5.60[b]	2.48E-2[b] (25°C)	6.21E-6[b] (25°C)	8.20E-12[a] (25°C)	1.60E-3[b] (20-25°C)	714.15[c]	979.0[c]	1.65E+4[c]
Dibenz(a,h)anthracene (53-70-3) **(SVOC)**										
278.4[h]	6.84[h]	4.89E-7[k] (25°C)	5.68[k]	2.02E-2[b] (25°C)	5.18E-6[b] (25°C)	1.32E-13[a] (20°C)	2.49E-3[b] (20-25°C)	743.24[c]	990.41[c]	3.00E+4[c]
Fluoranthene (206-44-0) **(VOC)**										
		1.61E-5[b]		3.02E-2[b]	6.35E-6[b]	1.21E-8[a]	2.06E-1[b]			

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
202.3[h]	4.95[h]	(25°C)	5.03[b]	(25°C)	(25°C)	(25°C)	(20-25°C)	655.95[c]	905.0[c]	1.38E+4[c]
Fluorene (86-73-7) **(VOC)**										
166.21[a]	4.18[i]	6.37E-5[b] (25°C)	4.14[b]	3.63E-2[b] (25°C)	7.88E-6[b] (25°C)	4.21E-7[a] (20°C)	1.98E+0[b] (20-25°C)	570.44[c]	870.0[c]	1.27E+4[c]
Indeno(1,2,3-cd)pyrene (193-39-5) **(SVOC)**										
276.3[h]	6.58[h]	1.60E-6[b] (25°C)	6.54[b]	1.90E-2[b] (25°C)	5.66E-6[b] (25°C)	1.71E-13[a] (25°C)	2.20E-5[b] (20-25°C)	809.15[c]	1078.2[c]	1.90E+4[c]
Naphthalene (91-20-3) **(VOC)**										
128.2[h]	3.30[h]	4.40E-4[k] (25°C)	3.30[b]	5.90E-2[b] (25°C)	7.50E-6[b] (25°C)	1.12E-4[a] (25°C)	3.10E+1[b] (20-25°C)	491.14[c]	748.40[c]	1.04E+4[c]
Phenanthrene (85-01-8) **(VOC)**										
178.2[h]	4.46[h]	1.24E-4[a] (25°C)	4.36[a]	6.00E-2[d] (25°C)[e]	6.95E-6[d] (25°C)[e]	8.95E-7[a] (25°C)	1.29E+0[a] (25°C)	613.2[a]	869.2[j]	1.42E+4[a]
Pyrene (129-00-0) **(VOC)**										
202.26[a]	4.88[a]	1.1E-5[b] (25°C)	5.02[b]	2.72E-2[b] (25°C)	7.24E-6[b] (25°C)	1.17E-7[a] (25°C)	1.35E-1[b] (20-25°C)	667.95[c]	936.0[c]	1.44E+4[c]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K); $H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); ND = no data.

[a]Hazardous Substance Data Bank (HSDB), 2012, National Library of Medicine, on line.

[b]U.S. Environmental Protection Agency (EPA), 2002, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Office of Solid Waste and Emergency Response, Washington, D.C., 9355.4-24, December.

[c]U.S. Environmental Protection Agency (EPA), 2000, ***User's Guide for the Johnson and Ettinger (1991) Model for Subsurface Vapor Intrusion into Buildings, Revised***, Office of Emergency and Remedial Response, Washington, DC, December.

[d]Calculated as described in Introduction to Toxicological profiles.

[e]Assumed.

[f]Estimated from Equation 12-4 in Lyman, W.J., W.F. Reehl and D.H. Rosenblatt, 1990, ***Handbook of Chemical Property Estimation Methods***, American Chemical Society, Washington, DC.

[g]Estimated from Equation 13-5 in Lyman, W.J., W.F. Reehl and D.H. Rosenblatt, 1990, ***Handbook of Chemical Property Estimation Methods***, American Chemical Society, Washington, DC.

[h]U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part E - Supplemental Guidance for Dermal Risk Assessment)***, Final, Office of Superfund Remediation and Technology Innovation, Washington, D.C., EPA/540/R-99/005, July.

[i]Syracuse Research Corporation (SRC), 2004, ***CHEMFATE Search Results***, on line, accessed 23 April.

[j]National Institute of Standards and Technology (NIST), 2004, Standard Reference Data Program, Online Data Bases, accessed 23 April.

[k]U.S. Environmental Protection Agency (EPA), 2011, *EPISuite electronic database*.

2.0 Environmental Fate and Transport

The PAHs are ubiquitous products of incomplete combustion; natural sources include volcanoes and forest fires (ATSDR, 1995a,b; HSDB, 2012). There is some evidence for biosynthesis by plants, bacteria and algae. Some of the PAHs occur naturally in fossil fuels. Anthropogenic releases to the environment, primarily to the atmosphere, greatly outweigh the natural sources and include any processes that involve incomplete combustion of fossil fuels and organic matter, including wood-burning for home heat (the predominant source), cigarette smoke, internal combustion engine exhaust, and fuel oil emissions. Industrial sources include coal mining, processing and storing, wood treatment (creosote), manufactured gas plants (coal tar), power generation, production of coal tar, coke and asphalt, petroleum cracking and industrial and municipal incineration. Other sources include various crude oils, fresh and used motor oils, gasolines, charcoal-broiled foods, processed foods, various oils, margarine, butter and fats, fruits, vegetables, and cereals, roasted coffee and tea. Indoor sources include unvented kerosene heaters and gas cooking and heating appliances. Naphthalene is released during its manufacture and processes that involve its use (e.g., vaporization from moth balls).

Although PAHs generally occur in mixtures, certain chemicals tend to predominate in different sources so that the PAH pattern observed in a given medium may provide a clue to the source. The following compilation relates individual PAHs and sources:

Source[a]	Individual PAHs
Residential wood burning	Acenaphthylene
Auto emissions	Benzo(g,h,i)perylene, pyrene
Diesel exhaust particulates	Fluoranthene, phenanthrene, pyrene

Source[a]	Individual PAHs
Diesel exhaust vapors	Phenanthrene, anthracene
Diesel total emissions	Acenaphthene, fluorene, phenanthrene
Fly ash & bottom ash from U.S. municipal waste incinerators	Phenanthrene
Fly ash from U.K. municipal waste incinerators	Benzo(g,h,i)perylene
Particulate emissions from municipal waste incinerator	Benzo(a)fluoranthene, benzo(g,h,i)perylene, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene
Municipal/medical waste incinerator	Benzo(a)anthracene, benzo(g,h,i)perylene
Rotary kiln incinerator charged with polyethylene, no afterburner	Fluoranthene, phenanthrene, pyrene (see next entry)
Rotary kiln incinerator charged with polyethylene with afterburner	Benzo(a)anthracene, phenanthrene (total PAH emissions reduced 100-fold compared with no afterburner)
Coal tar pitch emissions	Phenanthrene and pyrene 20 to 80 X > benzo(a)pyrene, benzo(g,h,i)perylene
Natural gas home appliances – fine particulate emissions	Chrysene, fluoranthene, pyrene, triphenylene
Groundwater near coal & oil gasification plant	Acenaphthylene, acenaphthene, fluorene, phenanthrene, fluoranthene, pyrene, chrysene
Groundwater near wood treatment facilities	Benzo(a)pyrene, phenanthrene
[a]Agency for Toxic Substances and Disease Registry, (ATSDR), 1995, ***Update Toxicological Profile for Polycyclic Aromatic Hydrocarbons (PAHs)***, U.S. Public Health Service, Atlanta, Georgia, August, on line.	

Data compiled for soils are not included in the table above because the lists are long and the variation from one site to another is great, so that the information is not useful for identifying sources. Similarly, sediment is a sink for PAHs from all sources including atmospheric deposition from far distant locations, and the patterns observed in sediment do not necessarily reflect a nearby source (ATSDR, 1995a). Generally, PAHs associated with combustion exhibit highly condensed ring structures and little alkylation (i.e., benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, benzo(a)pyrene, benzo(e)pyrene, chrysene, fluoranthene, pyrene).

Crude petroleum and products made from crude petroleum (e.g., asphalts, fuels, oils) contain PAHs, but the patterns observed depend on the location of the source (ATSDR, 1995a; Potter and Simmons, 1998). Phenanthrene and alkylated forms of PAHs, particularly the methylnaphthalenes, often predominate in petroleum products.

The partitioning and fate of the PAHs in environmental media depend largely on VP (tendency to exist in air as a vapor), H (indicator of partitioning between air and water) and K_{oc} (indicator of affinity to bind to organic matter in soil and sediment). ATSDR (1995a) noted that H and K_{oc} are roughly directly related to MW, and that VP is roughly inversely related to MW. Therefore, they grouped the PAHs into the following categories to facilitate understanding their behavior in the environment:

- Low MW (152 to 178 g/mole) – acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, phenanthrene

- Medium MW (approximately 202 g/mole) – fluoranthene, pyrene

- High MW (228 to 278 g/mole) – benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene.

PAHs exist in the atmosphere as vapors or adsorbed to particulates, the proportion depending on the vapor pressure of the individual chemical and atmospheric conditions such as temperature and humidity (ATSDR, 1995a, b; HSDB, 2012). Generally, the two- and three-ring compounds (low and medium MW except pyrene) exist predominantly as vapors; the four-ring compounds exist in both the vapor and particulate phase, and compounds with 5 or more rings (benzo[a]pyrene, benzo[g,h,i]perylene exist predominantly as particulates. Increasing atmospheric temperature and relative humidity favors existence in the vapor phase. PAHs may travel short or long distances before removal from the air. Vapor forms are subject to chemical oxidation processes in the air, which reduces the distance they may travel. Residence time and transport distance is inversely related to the size of the particles on which the PAHs are adsorbed. Small particles may have residence times of weeks, permitting transport for hundreds or upwards of a thousand miles. Wet and dry deposition accounts for removal of the particulates.

The predominant sources of PAHs in surface water are deposition from the atmosphere, industrial and sewage effluent and oil spills (ATSDR, 1995a,b). Runoff and erosion can also contribute PAHs to surface water bodies. Volatilization is a significant fate process for PAHs with H values of 1E-5 atm-m^3/mole or greater (generally the low and medium MW compounds). Volatilization is a very limited removal process for most of the high MW compounds. Volatilization is enhanced by high temperature, turbulence and high wind. Sorption to benthic or suspended sediment and biodegradation are competing removal processes. Generally, volatilization and biodegradation are the predominant removal processes for the low MW compounds, and volatilization and sorption are the predominant removal processes for medium and high MW compounds. Naphthalene is relatively water soluble and may remain largely in solution. PAHs in sediment may biodegrade, recycle back to the water column (lower MW compounds) or accumulate in the lower trophic levels of living organisms.

Deposition from the atmosphere is the principal source of PAHs in soil (ATSDR, 1995a,b). Other sources include industrial activities, disposal of sewage sludge, and leaching from coal storage sites. Most PAHs sorb to soil constituents because of their low solubility and high affinity for organic matter. Volatilization is an important removal process for the low molecular weight compounds. Some of the low molecular weight compounds, particularly naphthalene, may leach fairly rapidly to groundwater.

The high lipophilicity of many PAHs evidenced by high log K_{ow} values suggest that the PAHs might cross biologic membranes and participate significantly in food-chain pathways involving fish, fruit and vegetable, and meat and milk consumption. This, however, is not the case. For example, the PAHs are efficiently metabolized and excreted by fin fish, greatly reducing the likelihood of bioconcentration from water or bioaccumulation from sediment (ATSDR, 1995a). Consequently, there are often great discrepancies between modeled BCF values and empirical BCF values, where care was taken to identify the parent compound rather than PAH metabolites in fish tissue. This distinction is necessary because aromatic fragments from PAH metabolism are readily assimilated as normal endogenous components of biological tissue. PAH concentrations in aquatic food-chain systems usually decrease with increasing trophic level, reflecting the generally greater efficiency of metabolism in the higher trophic organisms.

Approximate tissue-to-sediment PAH concentration ratios were reported to be 0.6 to 1.2 for amphipods, 0.1 for clams, and 0.05 for fin fish and shrimp.

It has been reported that terrestrial plants can accumulate PAHs from soil by uptake through the roots (ATSDR, 1995a). More careful investigation, however, reveals that root uptake is quite low, and there is no evidence of bioconcentration or biomagnification. For example, PAH ratios in vegetation to soil in one survey ranged from 0.001 to 0.18 for total PAHs, and from 0.002 to 0.33 for benzo(a)pyrene. It is likely that most of the PAH contamination on the vegetation resulted from atmospheric deposition. Increased concentrations in vegetation have not been observed when soil PAH concentrations were greatly increased by amendment with sewage sludge. Data from carrots (*Daucus carotu*) showed that PAHs adhere to the outer skin of the root but show little tendency to penetrate to deeper layers, and even less tendency to translocate to aerial parts.

The inability of plants to bioconcentrate PAHs from soil reduces concern for bioconcentration in agricultural products such as meat and milk. It should be noted, however, that measurable concentrations of PAHs may accumulate on the aerial parts of plants because of deposition from the atmosphere (ATSDR, 1995a). Also, food-producing animals ingest a substantial amount of soil while grazing or consuming mechanically harvested forage crops. Mammals, however, efficiently metabolize the PAHs to polar compounds that are readily excreted, reducing concern for bioconcentration.

In summary, the PAHs are highly lipophilic, which implies significance in food-chain exposure pathways. Empirical data, however, show that fish and mammals efficiently metabolize and eliminate these compounds. Furthermore, bioconcentration in plants because of uptake from soil is not significant. Therefore, it is unlikely that the PAHs would participate significantly in food-chain pathways, and biotransfer factors are not estimated.

3.0 Toxicokinetics

The PAHs are absorbed by all routes of exposure, but the rate and extent depends on the compound, the species of animal and the vehicle (or nature of the particulates) (ATSDR, 1995a). PAHs are readily absorbed during inhalation exposure; however, intratracheal instillation studies indicate that particle size is the most important determiner of the extent of pulmonary uptake.

Toxicokinetic studies of several PAHs summarized by ATSDR (1995a) provide limited quantitative information regarding the extent of GI absorption. Limitations arise largely because biliary excretion complicates quantification of uptake from the GI tract. A study of benzo(a)pyrene in rats suggests that GI absorption ranges from 38 to 58 percent. A study in rats reported absorption efficiency for anthracene ranging from 53 to 74 percent. GI absorption of pyrene, chrysene and dibenzo(a,h)anthracene is described as high. Administration of the test compound in oil or in a high-fat diet appears to increase the extent of GI absorption.

Empirical data with pure compound dissolved or suspended in various vehicles suggest that dermal uptake of benzo(a)pyrene is extensive (ATSDR, 1995a). One occupational study reported that approximately 75 percent of systemically absorbed pyrene entered the body through dermal uptake rather than through inhalation exposure. Combining PAHs with soil appears to significantly reduce the extent of dermal uptake compared with oleaginous or acetone vehicles.

Anecdotal evidence from using cloth diapers stored in contact with naphthalene indicates that naphthalene is absorbed by the skin, but quantitative data are not available (ATSDR, 1995b).

Distribution of absorbed PAHs is generally widespread, with highest levels located initially in lipid-rich tissues (ATSDR, 1995a). Highest levels of metabolites (radioactivity following administration of radiolabeled compounds) are located in the liver and GI tract, even after inhalation exposure, probably reflecting extensive metabolism in the liver followed by biliary excretion. Ciliary clearance and deglutition probably contribute to levels associated with the GI tract. Concentrations of radioactivity following administration of radiolabeled compound reveal fetal levels approximately 2- to 10-fold lower than maternal levels, although this depends on the specific compound administered.

Metabolism of the PAHs, particularly benzo(a)pyrene, has been extensively studied (ATSDR, 1995a). Metabolism proceeds rapidly, yielding products that are more water soluble and readily excreted than the parent compound. All tissues have the ability to metabolize the PAHs, potentially to carcinogenic intermediates, which probably accounts for the observation that cancers occur at the point of contact. There is considerable variability in tissue metabolic activity; however, the liver is probably the most active in most cases.

ATSDR (1995a) distinguishes between “alternant” and “nonalternant” PAHs, based on the nature of the electron density associated with the molecule, which influences how that compound is metabolized to its ultimate carcinogen. Alternant PAHs (e.g., benzo[a]pyrene, benzo[a]anthracene, chrysene, dibenz[a,h]anthracene) exhibit a uniformly distributed electron density. Nonalternant PAHs (e.g., fluoranthene, benzo[k]fluoranthene, indeno[1,2,3-cd]pyrene) behave more like two separate molecules because of uneven electron distribution.

Alternant PAHs (based on data for benzo[a]pyrene) are initially metabolized by the microsomal cytochrome P-450 system to several arene oxides (ATSDR, 1995a). These may re-arrange spontaneously to phenols or undergo hydration to form the corresponding trans-dihydrodiols. Further oxidation of the dihydrodiols results in formation of quinones, phenol diols and dihydrodiol epoxides. Phenols may be formed by direct insertion of oxygen into a ring. Many of the metabolites resulting from the reactions described above are subject to conjugation with various substrates followed rapidly by excretion. The dihydrodiol epoxides that form in the “bay” region (the three-sided concave region formed by the fusion of three benzene rings) are most likely the ultimate carcinogens that covalently bind to macromolecules such as DNA, resulting in alkylation or other adducts that yield genetic errors.

Metabolism of the nonalternant PAHs differs from the alternant PAHs in that more extensive oxidation to hydroxy-epoxy-diols may be important to achieve genotoxicity (ATSDR, 1995a). Dihydrodiol epoxide formation in the bay region is associated with carcinogenicity of the PAHs generally; however, some of the nonalternant PAHs yield reactive metabolites that deviate from the classical bay region model.

PAH metabolites are readily excreted, largely through the bile, although some metabolites are excreted by the kidney (ATSDR, 1995a). The extent of elimination is species specific. In one inhalation study rats excreted metabolites much more efficiently than dogs or monkeys.

4.0 Dermal Exposure

EPA (2004) recommends that oral toxicity values for the PAHs should not be adjusted when applied to dermal exposure because GI absorption probably exceeds 50 percent. Therefore, no GAF is estimated and the oral toxicity values described below should be used for dermal exposure without adjustment.

Empirical data with pure compound dissolved or suspended in various vehicles suggest that dermal uptake of benzo(a)pyrene is extensive (ATSDR, 1995a). Anecdotal evidence from using cloth diapers stored in contact with naphthalene indicates that naphthalene is absorbed by the skin, but quantitative data are not available (ATSDR, 1995b). EPA (2004) reviewed empirical data regarding dermal uptake of benzo(a)pyrene and recommended an ABS of 0.13 for the PAHs. However, EPA (2004) also notes that VOCs tend to volatilize from soil when applied to the skin, reducing dermal uptake to toxicologically insignificant levels. Therefore, the ABS of 0.13 is applied to all the PAHs identified above as SVOCs. Dermal uptake of the PAHs identified as VOCs is not quantified.

Values for t*, K_p, τ, FA and B are provided or estimated as follows:

Chemical	t*	K_p	τ	FA	B
Acenaphthene[a]	1.84	8.39E-2	7.67E-1	1	0.4
Acenaphthylene[a]	1.79	1.08E-1	7.47E-1	1	0.5
Anthracene[a]	4.06	1.38E-1	1.05E+0	1	0.7
Benzo(a)anthracene[b]	8.53	4.7E-1	2.03E+0	1.0	2.8
Benzo(a)pyrene[b]	11.67	7.0E-1	2.69E+0	1.0	4.3
Benzo(b)fluoranthene[b]	12.03	7.0E-1	2.77E+0	1.0	4.3
Benzo(k)fluoranthene[a]	12.40	2.00E+0	2.72E+0	0.4	12
Benzo(g,h,i)perylene[a]	8.89	1.07E+0	3.70E+0	0.7	6.8
Chrysene[b]	8.53	4.7E-1	2.03E+0	1.0	2.8
Dibenz(a,h)anthracene[b]	17.57	1.5E+0	3.88E+0	0.6	9.7
Fluoranthene[b]	5.68	2.2E-1	1.45E+0	1.0	1.2
Fluorene[a]	2.15	1.07E-1	8.95E-1	1	0.5
Indeno(1,2,3-cd)pyrene[b]	16.83	1.0E+0	3.78E+0	0.6	6.7
Naphthalene[b]	1.34	4.7E-2	5.6E-1	1	0.2
Phenanthrene[b]	4.11	1.4E-1	1.06E+0	1	0.7
Pyrene[a]	3.42	1.94E-1	1.43E+0	1	1.1

t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); τ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).
[a]Estimated as described in Introduction to Toxicological profiles.
[b]Provided by U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part E - Supplemental Guidance for Dermal Risk Assessment)***, Final, Office of Superfund Remediation and Technology Innovation, Washington, D.C., EPA/540/R-99/005, July.

5.0 Noncancer Effects Evaluation

The PAHs are generally divided into two EPA cancer weight-of-evidence groups: Group D – not classifiable as to carcinogenicity to humans, and Group B2 – probable human carcinogens. The Group D PAHs have not been evaluated for carcinogenicity by toxicity testing; therefore, cancer SFs or URFs cannot be estimated for these compounds (EPA, 1986, 2012). Risk evaluation of these compounds is limited to noncancer effects. It is theoretically possible that cancer risk could be the "driver" for some of these compounds. However, the mechanism of carcinogenicity of the PAHs is fairly well understood to be correlated with molecular morphology and the propensity to

form certain active metabolites (ATSDR, 1995a). The Group D PAHs either do not fit the morphologic mold or have been shown empirically to be unlikely to cause cancer, reducing greatly the uncertainty that significant cancer risk is being overlooked.

Cancer SFs and URFs are available for the Group B2 compounds, but noncancer RfDs or RfCs are not. Therefore, risk evaluation of these compounds is limited to cancer risk. These compounds have the morphologic requirements for carcinogenicity; therefore, it has been thought that cancer risk is the driver, and that noncancer effects are relatively insignificant, although empirical data were lacking until recently.

Recent data support this assumption. De Jong et al. (2008) reported a study in which male rats were treated by gavage with benzo(a)pyrene 5 days per week for 35 days at dose rates of 0 (control), 3, 10, 30 or 90 mg/kg. Significantly reduced rate of body weight gain and altered organ weights were observed in the 90 mg/kg group. Fore stomach lesions were found in the 30 and 90 mg/kg groups. Decreased thymus weights and hematological evidence of erythrocyte toxicity were observed in a dose-related manner in rats treated with 10 mg/kg and above. Subtle alterations in measures of immune function were also observed in these groups, establishing 10 mg/kg as the LOAEL and 3 mg/kg as the NOAEL for this study. The 3 mg/kg dose is equivalent to a NOAEL of 2.1 mg/kg-day when adjusted for continuous exposure. Application of an uncertainty factor of 1000 (factor of 10 to expand from subchronic to chronic exposure, and factors of 10 each to provide additional protection for intra- and interspecies variation) allows development of a preliminary oral RfD of 2E-3 mg/kg-day. Uncertainty surrounding the preliminary oral RfD is very high because the data base for the noncancer effects of benzo(a)pyrene is essentially limited to one study and several toxicological endpoints (e.g., developmental, reproductive, neurological) were not investigated.

The sole purpose for developing this oral RfD is to evaluate the potential for noncancer effects to be the driver for the Group B2 PAHs. The RfD was not developed with sufficient rigor to be used in the risk assessment of the noncancer effects of benzo(a)pyrene. The oral SF for benzo(a)pyrene is 7.3 per mg/kg-day (please see below), from which it is estimated that the oral RfD is equivalent to a cancer risk of 1.5E-2. This cancer risk is orders of magnitude above the EPA (1990) risk management range of 1E-6 to 1E-4, strengthening the position that noncancer effects are unlikely to be the driver for the Group B2 PAHs.

Data regarding the toxicity of acute oral exposure to the PAHs are generally scarce. Prolonged oral exposure to the Group D PAHs is associated with a number of renal, hematologic and other effects, depending on the compound.

Subchronic (90 day) gavage treatment of mice with acenaphthene is associated with histopathologic evidence of liver hypertrophy. A verified RfD of 6E-2 mg/kg-day for chronic oral exposure was derived from the NOAEL of 175 mg/kg-day and an uncertainty factor of 3000 (EPA, 2012). The LOAEL in this study was 350 mg/kg-day. Confidence in the RfD is low. The liver is considered the target organ for prolonged oral exposure to acenaphthene. EPA (1997) derived a provisional subchronic oral RfD for acenaphthene of 6E-1 mg/kg-day from the same mouse study using an uncertainty factor of 300.

A verified RfD of 3E-1 mg/kg-day for chronic oral exposure to anthracene was derived from a NOEL of 1000 mg/kg-day, the highest dose tested, in a 90-day gavage study in mice (EPA,

2012). An uncertainty factor of 3000 was applied. Confidence in the RfD is low. The data are inadequate to identify a target organ for prolonged oral exposure to anthracene. EPA (1997) derived a provisional subchronic oral RfD for anthracene of 3E+0 mg/kg-day from the same mouse study using an uncertainty factor of 300.

Subchronic exposure to fluoranthene induces liver and kidney effects and hematologic alterations in orally treated mice (EPA, 2012). A verified RfD of 4E-2 mg/kg-day for chronic oral exposure was derived from a NOAEL of 125 mg/kg-day in a 13-week gavage study. The LOAEL was 250 mg/kg-day in this study. An uncertainty factor of 3000 was applied. Confidence in the oral RfD is low. The kidney, liver and blood cells are chosen as the target organs for prolonged oral exposure to fluoranthene. EPA (1997) derived a provisional subchronic oral RfD for fluoranthene of 4E-1 mg/kg-day from the same mouse study using an uncertainty factor of 300.

Subchronic exposure to fluorene induces hemolytic anemia in orally treated mice (EPA, 2012). A verified RfD of 4E-2 mg/kg-day for chronic oral exposure was derived from a NOAEL of 125 mg/kg-day in a 13-week gavage study. The LOAEL was 250 mg/kg-day in this study. An uncertainty factor of 3000 was applied. Confidence in the oral RfD is low. The erythrocyte is the target organ for prolonged oral exposure to fluorene. EPA (1997) derived a provisional subchronic oral RfD for fluorene of 4E-1 mg/kg-day from the same mouse study using an uncertainty factor of 300.

Single-dose LD_{50} values for naphthalene include 533 to 710 mg/kg for mice and 2200 to 2400 mg/kg for rats, establishing the mouse as more sensitive to the lethal effects of acute oral exposure (ATSDR, 1995b). Decreased terminal body weights, accompanied by a remarkable absence of hematological and histopathological effects, were observed in rats treated by gavage for 13 weeks (EPA, 2012). The LOAEL in this study was 142 mg/kg-day associated with greater than 10 percent reduction in terminal body weights. The NOAEL was 71 mg/kg-day. The high dose rate, 286 mg/kg-day was a FEL associated with increased mortality. Application of an uncertainty factor of 3000 (10 to extrapolate from rats to humans, 10 to protect sensitive humans, 10 to extrapolate from subchronic to chronic exposure, and 3 for database deficiencies) to the NOAEL of 71 mg/kg-day yields the verified chronic oral RfD of 2E-2 mg/kg-day. Confidence in the RfD is low. A preliminary subchronic oral RfD can be derived for naphthalene by applying an uncertainty factor of 300 to the NOAEL of 71 mg/kg-day described above. The uncertainty factor of 300 reflects the chronic uncertainty factor of 3000 without the factor of 10 to expand from subchronic to chronic exposure. The preliminary subchronic oral RfD so derived is 2E-1 mg/kg-day.

The key study described above is not sufficient to identify target organs for prolonged oral exposure to naphthalene. Adults, children and neonates exposed to moth balls exhibit hemolytic anemia, evidence of liver disease and neurological deficits (EPA, 1993a, 1998). The liver effects and neurological deficits may be secondary to hemolytic anemia and reduced oxygen-carrying capacity of the blood. Hemolytic anemia and cataract formation have been seen also in orally exposed humans (EPA, 1998). The data suggest that the erythrocyte may be the most sensitive tissue in humans. Among common species of laboratory mammals, hemolytic anemia is seen only in dogs (EPA, 1998). Cataracts are seen in several laboratory mammals, but only at relatively high doses. The key study identifies reduced body weight as the critical effect in rats. Rats, however, do not exhibit hemolytic anemia, and exhibit cataracts only at very high doses,

suggesting that rats may not be a totally acceptable model for the toxicity of naphthalene to humans. Therefore, based on the effects observed in humans, the erythrocyte and eye are selected as target organs for prolonged oral exposure to naphthalene. Reduced body weight is also included as a critical effect because this was the only endpoint observed in rats in the key study.

EPA (1993a, 2012) reported a 2-year study in which mice were exposed to naphthalene vapors for 6 hours/day on 5 days/week. Inflammation of the nasal and olfactory epithelium was the most consistently observed sign; granulomatous lesions in the lungs were also observed. There was equivocal evidence of hematologic involvement. The lowest exposure concentration, 10 ppm, was a LOAEL for the nasal effects, which are considered the critical effects of inhalation exposure. The LOAEL is equivalent to a human equivalent concentration of 9.3 mg/m^3 (EPA, 2012). Application of an uncertainty factor of 3000 yields a verified chronic inhalation RfC of 3E-3 mg/m^3, which is equivalent to a chronic inhalation RfD of 8.6E-4 mg/kg-day. The nasal and olfactory epithelia are the target organs for inhalation exposure to naphthalene. Confidence in the RfC is medium. The chronic inhalation RfC of 3E-3 mg/m^3, equivalent to an inhalation RfD of 8.6E-4 mg/kg-day, is adopted as sufficiently protective for subchronic inhalation exposure as well.

Subchronic exposure to pyrene induces mild renal tubular degeneration and reduced kidney weight in orally treated mice (EPA, 2012). A verified RfD of 3E-2 mg/kg-day for chronic oral exposure was derived from a NOAEL of 75 mg/kg-day in a 13-week gavage study. The LOAEL was 125 mg/kg-day in this study. An uncertainty factor of 3000 was applied. Confidence in the oral RfD is low. The kidney tubule is chosen as the target organ for chronic oral exposure to pyrene. EPA (1997) derived a provisional subchronic oral RfD for pyrene of 3E-1 mg/kg-day from the same mouse study using an uncertainty factor of 300.

Data regarding prolonged oral exposure are not available for several of the Group D PAHs, which hinders estimation of an RfD or RfC and compromises evaluation of the potential for noncancer effects. Therefore, surrogates are used to develop toxicity values for the noncancer effects.

Generally surrogates are chosen on the basis of the following hierarchy:

- Toxicological similarity (effects and dose-response relationship).
- Toxicokinetic similarity, assuming that likeness in absorption, distribution and especially products of biotransformation suggests toxicological similarity.
- Structural similarity, assuming that likeness in structure suggests similarity in toxicokinetics.

Selection of defensible surrogates for the PAHs is compromised because toxicological and toxicokinetic data are virtually non-existent (except for benzo[a]pyrene), and the structural similarities often are not very convincing, which imparts a great deal of uncertainty to the effort. Therefore, the most defensible approach for some of the PAHs is to select the most conservative surrogate; i.e., the PAH with the smallest verified oral RfD, which happens to be pyrene.

Data regarding the effects of chronic or subchronic exposure to acenaphthylene were not located in the available literature. Acenaphthene is adopted as a reasonable surrogate for acenaphthylene based on structural similarity, since the surrogate differs from the principal chemical only in the presence of two hydrogen atoms and the absence of a double bond. Therefore, the verified chronic oral RfD of 6E-2 mg/kg-day for acenaphthene is adopted as the RfD for chronic oral exposure to acenaphthylene. The liver, which is the target organ for acenaphthene, is adopted for oral exposure to acenaphthylene. Similarly, the provisional subchronic oral RfD of 6E-1 mg/kg-day for acenaphthene is adopted as the RfD for subchronic oral exposure to acenaphthylene.

Data regarding the effects of chronic or subchronic exposure to benzo(g,h,i)perylene were not located in the available literature. Pyrene is adopted as a reasonable surrogate for benzo(g,h,i)perylene based somewhat on structural similarity, but more on the selection of a conservative approach as justified above. Therefore, the verified oral RfD of 3E-2 mg/kg-day for pyrene is adopted as the oral RfD for chronic exposure to benzo(g,h,i)perylene. Similarly, the provisional subchronic oral RfD of 3E-1 mg/kg-day for pyrene is adopted as the RfD for subchronic oral exposure to benzo(g,h,i)perylene. The kidney tubule, which is the target organ for pyrene, is adopted for oral exposure to benzo(g,h,i)perylene.

Relevant data regarding chronic or subchronic exposure to phenanthrene were not located. Potential surrogates based on similarity in chemical structure include anthracene and pyrene. Pyrene is selected as the surrogate only because it is the more conservative choice. Therefore, the verified oral RfD of 3E-2 mg/kg-day for pyrene is adopted as the oral RfD for chronic exposure to phenanthrene. Similarly, the provisional subchronic oral RfD of 3E-1 mg/kg-day for pyrene is adopted as the RfD for subchronic oral exposure to phenanthrene. The kidney tubule, which is the target organ for pyrene, is adopted for oral exposure to phenanthrene.

Data regarding inhalation exposure sufficient for development of inhalation RfCs were not located for any of the PAHs with the exception of naphthalene as noted above.

6.0 Carcinogenicity Evaluation

Acenaphthylene, anthracene, benzo(g,h,i)perylene, fluoranthene, fluorene, phenanthrene and pyrene are classified in EPA cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans) because of a lack of human data and inadequate animal data (EPA, 2012). Data regarding the carcinogenicity of acenaphthene were not located. Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene are classified in EPA weight-of-evidence Group B2 (probable human carcinogens) (EPA, 1997, 2012). Benzo(a)pyrene is the most extensively studied member of the class, inducing tumors in tissues at the point of contact of practically all laboratory species tested by all routes of exposure.

Although epidemiology studies suggested that complex mixtures that contain PAHs (coal tar, soots, coke oven emissions, cigarette smoke) are carcinogenic to humans, the carcinogenicity cannot be attributed to PAHs alone because of the presence of other potentially carcinogenic substances in these mixtures (ATSDR, 1995a). In addition, recent investigations showed that the PAH fraction of roofing tar, cigarette smoke and coke oven emissions accounted for only 0.1-8% of the total mutagenic activity in *Salmonella* of the unfractionated complex mixture (Lewtas, 1988). Aromatic amines, nitrogen heterocyclic compounds, highly oxygenated quinones, diones,

and nitrooxygenated compounds, none of which would be expected to arise from in vivo metabolism of PAHs, probably accounts for the majority of the mutagenicity of coke oven emissions and cigarette smoke. Furthermore, coal tar, which contains a mixture of many PAHs, has a long history of use in the clinical treatment of a variety of skin disorders in humans (ATSDR, 1995a).

Because of the lack of human cancer data, assignment of individual PAHs to EPA cancer weight-of-evidence groups is based largely on the results of animal studies with large doses of purified compound (EPA, 2012). Frequently, unnatural routes of exposure, including implants of the test chemical in beeswax and trioctanoin in the lungs of female rats, intratracheal instillation, and subcutaneous or intraperitoneal injection, were used. Although the carcinogenicity of benzo(a)pyrene in animals managed in an unnatural manner in laboratory conditions has been well established, the potential for carcinogenicity to humans in environmental settings involving exposure to low concentrations remains unclear.

EPA (2012) verified a SF for oral exposure to benzo(a)pyrene of 7.3E+0 per mg/kg-day, based on several dietary studies in mice and rats. Recent reevaluations of the carcinogenicity and mutagenicity of the Group B2 PAHs suggest that there are large differences between individual PAHs in cancer potency (Krewski et al., 1989). Based on the available cancer and mutagenicity data, and assuming that there is a constant relative potency between different potential carcinogens across different bioassay systems and that the PAHs under consideration have similar dose-response curves, EPA (1993b) adopted relative potency values for several PAHs. These values and the corresponding oral SFs, based on a relative potency for benzo(a)pyrene of 1.0, are presented below:

Relative Potency Estimates for PAHs				
			Inhalation	
PAH	Relative Potency	Oral Slope Factor (per mg/kg-day)	Unit Risk Factor (per µg/m^3)	Slope Factor (per mg/kg-day)
Benzo(a)pyrene	1.0	7.3E+0	8.8E-4	3.1E+0
Benzo(a)anthracene	0.1	7.3E-1	8.8E-5	3.1E-1
Benzo(b)fluoranthene	0.1	7.3E-1	8.8E-5	3.1E-1
Benzo(k)fluoranthene	0.01	7.3E-2	8.8E-6	3.1E-2
Chrysene	0.001	7.3E-3	8.8E-7	3.1E-3
Dibenz(a,h)anthracene	1.0	7.3E+0	8.8E-4	3.1E+0
Indeno(1,2,3-cd)pyrene	0.1	7.3E-1	8.8E-5	3.1E-1

Although the EPA has not verified SFs for Group B2 PAHs other than benzo(a)pyrene, the SFs above represent reasonable estimates based on the data available. The relative potency approach employed here meets criteria considered to be desirable for this type of analysis (Lewtas, 1988). For example, the chemicals compared have similar chemical structures and would be expected to have similar toxicokinetic fate in mammalian systems. In addition, the available data suggest that the Group B2 PAHs have a similar mechanism of action, inducing frameshift mutations in *Salmonella* and tumor initiation in the mouse skin painting assay. Similar noncancer effects (minor changes in the blood, liver, kidneys) of the Group D PAHs support the hypothesis of a common mechanism of toxicity. Finally, the same endpoints of toxicity, i.e., potency in various cancer assays, and related data, were used to derive the relative potency values (Krewski et al., 1989). The oral SF for benzo(a)pyrene of 7.3E+0 per mg/kg-day, and the SFs presented above for the other Group B2 PAHs are adopted for the purposes of this evaluation.

An EPA (1994) evaluation of the inhalation cancer data suggests adoption of an inhalation SF for benzo(a)pyrene of 3.1E+0 per mg/kg-day, based on the incidence of upper respiratory and digestive tract tumors in hamsters. Applying the relative potency estimates presented above yield the inhalation URFs and SFs for the other Group B2 PAHs presented above.

EPA (2012) classified naphthalene in EPA cancer weight-of-evidence group C – possible human carcinogen – based on benign respiratory tumors and one carcinoma in female mice exposed to naphthalene by inhalation. Cancer potency factors are not available on IRIS because the data were regarded as insufficient based on a 1998 review (EPA, 2012). The EPA (2012) review included an NTP (1992) inhalation study in mice that yielded equivocal data for carcinogenicity of the upper respiratory tract. A well executed National Toxicology Program (NTP) (2000) two-year intermittent exposure inhalation study was conducted to clarify the potential for carcinogenicity by the inhalation route..

The California Environmental Protection Agency (Cal EPA) (2012) derived an inhalation unit risk factor (URF) of 3.4E-5 per $\mu g/m^3$. This URF is as the basis of the Regional Screening Level for naphthalene in soil, air and groundwater (EPA, 2011). The URF is based on the incidence of nasal tumors in male rats described in the NTP (2000) study. The Cal EPA derivation was performed in 2004 using dose-response extrapolation similar to the EPA (2012) methodology. The Cal EPA URF for naphthalene qualifies as a Tier 3 derivation under the EPA (2003) hierarchy for selecting toxicity values for use in risk characterization and from which to estimate cleanup levels.

7.0 Toxicity Summary

Toxicity values for the PAHs are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
Acenaphthene										
6E-1	6E-2	L	ND	ND	NA	ND	NA	ND	NA	NA
Acenaphthylene										
6E-1	6E-2	L	ND	ND	NA	D	NA	D	NA	NA
Anthracene										
3E+0	3E-1	ND	ND	ND	NA	D	NA	D	NA	NA
Benzo(a)anthracene										
ND	ND	NA	ND	ND	NA	B2	7.3E-1	B2	8.8E-5	3.1E-1
Benzo(a)pyrene										
ND	ND	NA	ND	ND	NA	B2	7.3E+0	B2	8.8E-4	3.1E+0
Benzo(b)fluoranthene										
ND	ND	NA	ND	ND	NA	B2	7.3E-1	B2	8.8E-5	3.1E-1
Benzo(k)fluoranthene										
ND	ND	NA	ND	ND	NA	B2	7.3E-2	B2	8.8E-6	3.1E-2
Benzo(g,h,i)perylene										
3E-1	3E-2	K	ND	ND	NA	D	NA	D	NA	NA
Chrysene										
ND	ND	NA	ND	ND	NA	B2	7.3E-3	B2	8.8E-7	3.1E-3
Dibenz(a,h)anthracene										
ND	ND	NA	ND	ND	NA	B2	7.3E+0	B2	8.8E-4	3.1E+0
Fluoranthene										
4E-1	4E-2	L,K,B	ND	ND	NA	D	NA	D	NA	NA
Fluorene										

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
4E-1	4E-2	E	ND	ND	NA	D	NA	D	NA	NA
Indeno(1,2,3-cd)pyrene										
ND	ND	NA	ND	ND	NA	B2	7.3E-1	B2	8.8E-5	3.1E-1
Naphthalene										
2E-1	2E-2	E, Ey, BW	3E-3/ 8.6E-4	3E-3/ 8.6E-4	Ne, Oe	C	ND	C	3.4E-5	1.2E-1
Phenanthrene										
3E-1	3E-2	K	ND	ND	NA	D	NA	D	NA	NA
Pyrene										
3E-1	3E-2	K	ND	ND	NA	D	NA	D	NA	NA

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.
Target organ or critical effect abbreviations: B = blood cells; BW = reduced body weight; E = erythrocyte; Ey = eye; L = liver; K = kidney; Ne = nasal epithelium; Oe = olfactory epithelium.
[a]sRfDo, cRfDo and SFo should be used for dermal exposure without adjustment for GI absorption.

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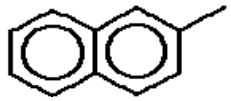
METHYLNAPHTHALENES



2-Methylnaphthalene

1.0 Introduction and Physical Properties

The methylnaphthalenes are the simplest alkylated polyaromatic hydrocarbons (PAH). Two monomethylnaphthalene isomers are possible: 1-methylnaphthalene (occasionally incorrectly called 4-methylnaphthalene) (90-12-0) and 2-methylnaphthalene (91-57-6). A commercial preparation of mixed isomers (1321-94-4) is mentioned (ATSDR, 2005; HSDB, 2012), but the proportion of the individual isomers was not reported. Both 1- and 2-methylnaphthalene are **VOCs**. 1-Methylnaphthalene occurs as a colorless liquid in the pure form at ambient temperatures (HSDB, 2012). 2-Methylnaphthalene reportedly occurs as a solid, but the melting point is 34.6 °C (approximately 94 °F), indicating that at high ambient temperatures the compound would occur as a liquid.

1-Methylnaphthalene is a component of petroleum and a product of incomplete combustion (HSDB, 2012). The compound is also used as a chemical intermediate and a general solvent. 2-Methylnaphthalene is used as an intermediate in organic chemical synthesis, as a dye carrier, in the manufacture of pesticides, as an adjuvant in pesticide formulations, and, in its pure form, in the manufacture of vitamin K. 2-Methylnaphthalene also is a component of crude oil and a product of combustion, which is produced and released to the environment during natural fires. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
1-Methylnaphthalene (90-12-0)										
142.19[a]	3.87[a]	5.14E-4[a] (25°C)	3.36[a]	6.97E-2[b] (25°C)[c]	8.08E-6[b] (25°C)[c]	8.82E-5[a] (25°C)	2.58E+1[a] (25°C)	515[d]	772[d]	1.37E+4[d]
2-Methylnaphthalene (91-57-6)										
142.20[a]	3.86[e]	5.18E-4[e] (25°C)[c]	3.60[ae]	6.97E-2[b] (25°C)[c]	8.08E-6[b] (25°C)[c]	7.24E-5[a] (25°C)	41.4E+1[e] (25°C)	514[d]	761[d]	1.08E+4[d]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K);. $H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); ND = no data.

[a]Hazard Substances Data Bank (HSDB), 2012, National Library of Medicine.
[b]Calculated as described in Introduction to Toxicity Profiles.
[c]Assumed.
[d]National Institute of Standards and Technology (NIST), 2011, *NIST Chemistry WebBook*, on line.
[e] U.S. Environmental Protection Agency (EPA), 2011, *EPISuite electronic database*.

2.0 Environmental Fate and Transport

Emissions from petroleum refining, coal tar distillation, and gasoline and diesel fueled engines are major contributors of methylnaphthalenes to the environment (HSDB, 2012). Because of the widespread use of the methylnaphthalenes in a variety of products, they are also released to the environment in manufacturing effluents, the disposal of waste byproducts, through landfills,

municipal waste water treatment facilities and waste incinerators. Forest fires and uncontrolled combustion are relatively insignificant contributors (ATSDR, 2005).

Based upon their relatively high vapor pressure, the methylnaphthalenes are expected to exist entirely in the vapor phase in ambient air (HSDB, 2012). Direct photolysis of the methylnaphthalenes is likely to occur; however, only aqueous photolysis data are available. Reactions of the methylnaphthalenes with photochemically produced hydroxyl radicals (half-life = 7.4 hours) and ozone (half-life = 29 to 88 days) are likely to be important removal processes in ambient air. The formation of nitro derivatives in night-time air is also likely to be an important removal process for these compounds.

Data regarding the biodegradation of the methylnaphthalenes in soil were not available (HSDB, 2012). However, based upon aqueous screening test data and die-away tests for ground and marine water, the methylnaphthalenes are expected to biodegrade fairly rapidly in soils acclimated to PAHs and at a moderate rate in unacclimated soils. The methylnaphthalenes are not expected to undergo hydrolysis in soils; however, they are expected to undergo direct photolysis in sunlit surface soils. Mobility in soil is likely to be very low. Volatilization from moist soils may be a significant removal mechanism, although it will be attenuated by adsorption.

The methylnaphthalenes will partition from the water column to organic matter contained in sediments and suspended solids (HSDB, 2012). Volatilization is likely to be an important removal process for these compounds. Volatilization half-lives for a model river and model lake were estimated to be 5.5 hours and 5.3 days, respectively. The methylnaphthalenes are expected to degrade rapidly in marine water and waters acclimated to PAHs. Degradation is expected to be less rapid in unacclimated aquatic systems. The methylnaphthalenes are not expected to undergo hydrolysis in water; however, direct photolysis in sunlit waters is likely to be a significant removal process. The direct photolysis half-life for midday, midsummer sunlight at 40˚ N latitude was predicted to be 22 and 54 hours for 1- and 2-methylnaphthalene, respectively, in water solution.

The methylnaphthalenes are not expected to participate significantly in food-chain pathways (ATSDR, 2005; HSDB, 2012); therefore, biotransfer factors are not provided.

3.0 Toxicokinetics

Data regarding the toxicokinetics of the methylnaphthalenes are very limited. Data regarding the toxicokinetics of naphthalene, often used as a surrogate for the methylnaphthalenes, is somewhat more complete.

The observation that inhalation exposure to naphthalene leads to adverse effects in humans suggests that the methylnaphthalenes are also absorbed by the respiratory tract (ATSDR, 2005).

An excretion study with radiolabeled 2-methylnaphthalene in guinea pigs suggests that GI absorption is rapid and nearly complete, as 80 percent of the administered dose of radioactivity was recovered from the urine within 24 hours (ATSDR, 2005).

Data were not located regarding dermal uptake of the methylnaphthalenes. However, serious adverse health effects have been observed in humans dermally exposed to naphthalene, and animal studies show that naphthalene is rapidly and extensively absorbed through the skin, although using soil as the vehicle slows dermal absorption (ATSDR, 2005). These observations suggest that dermal uptake of the methylnaphthalenes may be significant.

Limited distribution data following oral administration of radiolabeled 2-methylnaphthalene to guinea pigs revealed the presence of radioactivity in the liver almost immediately after treatment (ATSDR, 2005). Relatively high levels were located in the gall bladder, liver and kidney, all of which represent excretion. Data from orally administered naphthalene suggests that distribution to adipose tissue is probably substantial, and that the methylnaphthalenes will probably cross the placenta and distribute to milk. As stated above, naphthalene is often used as a surrogate for the methylnaphthalenes because of structural similarity. Similarity in structure implies similarity in physical, chemical, toxicokinetic and toxicological characteristics.

The sole initial step in naphthalene metabolism is oxidation at the 1,2-position to form the epoxide, 1,2-naphthalene oxide (ATSDR, 2005). The epoxide may rearrange spontaneously to form 1- and 2-naphthol, or undergo enzymatic conversion to 1,2-dihydroxy, 1,2-dihydronaphthalene. The epoxide formed in the first step is recognized as an intermediate that reacts with tissue macromolecules inducing toxic effects, particularly in the lung. 1-Naphthol may undergo further oxidation to form 1,4-naphthoquinone, which has also been shown to interact with macromolecules, particularly in the liver. 1,2-Dihydroxy, 1,2-dihydronaphthalene may undergo further oxidation to form 1,2-naphthoquinone or 1,2-dihydroxy-3,4-epoxy-1,2,3,4-tetrahydronaphthalene. 1,2-Naphthoquinone may be the ultimate toxicant associated with naphthalene-induced cataracts. The toxicological significance of 1,2-dihydroxy-3,4-epoxy-1,2,3,4-tetrahydronaphthalene is unclear.

The presence of the methyl group on 1- or 2-methylnaphthalene may greatly alter the metabolic scheme for these chemicals compared with naphthalene. Data are available only for 2-methylnaphthalene, but the metabolism of 1-methylnaphthalene may be similar. The predominant pathway of 2-methylnaphthalene metabolism involves stepwise oxidation of the methyl group to form 2-hydroxymethylnaphthalene and 2-naphthoic acid, possibly through the aldehyde intermediate (ATSDR, 2005). This pathway accounts for 50 to 80 percent of 2-methylnaphthalene, depending on the species. The end products of this pathway are conjugated with glycine or glucuronic acid and excreted. Ring epoxidation at the 3,4-, 5,6- or 7,8- positions accounts for 15 to 20 percent of 2-methylnaphthalene. These epoxides may be subject to conjugation or may be further oxidized to form the corresponding dihydrols and other derivatives, which in turn undergo conjugation. Experiments with mice suggest that glutathione conjugation may be an important detoxication mechanism. Although data regarding the biological activity of methylnaphthalene metabolites is not as complete as data regarding the biological activity of the naphthalene metabolites, the differences in the metabolites formed are considerable.

Data regarding excretion of the methylnaphthalenes is limited to a study of 2-methylnaphthalene in guinea pigs. Approximately 80 percent of the radiolabel from a single oral dose was recovered within 24 hours in the urine; approximately 10 percent was recovered from the feces. Conjugated metabolites of the products of methyl group oxidation accounted for approximately 76 percent of

the recovered radioactivity. Approximately 18 percent of the recovered radiolabel represented epoxidation at the 7,8- positions.

4.0 Dermal Exposure

EPA (2004) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly (50 percent) less than complete. Therefore, no GAF is developed for the methylnaphthalenes and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

Data were not located regarding the dermal uptake of the methylnaphthalenes from soil. VOCs tend to volatilize from soil when applied to the skin, reducing dermal uptake to toxicologically insignificant levels (EPA, 2004). Therefore, dermal uptake of the methylnaphthalenes from soil is not evaluated. t*, K_p, τ, FA and B values are estimated by the EPA (2004) method as follows:

Chemical	t*	K_p	τ	FA	B
1-Methylnaphthalene	1.58	9.08E-2	0.657	1	0.42
2-Methylnaphthalene	1.58	8.94E-2	0.657	1	0.41
t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); τ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).					

5.0 Noncancer Effects Evaluation

Data regarding the effects of human exposure to 1-methylnaphthalene were not located. Subchronic and chronic dietary studies with 1-methylnaphthalene in mice suggest that the toxic potency is low. An increased incidence of pulmonary alveolar proteinosis was the only lesion observed in mice treated at a dose rate of 73 mg/kg-day (lowest dose rate tested) in an 81-week study, but not in mice treated at a dose rate of approximately 1200 mg/kg-day (highest dose rate tested) in a 13-week study (EPA, 1998). These observations suggest that duration of exposure is very important in the toxicity of 1-methylnaphthalene. No RfD has been verififed for 1-methylnaphthalene. The ATSDR (2005) derived a chronic minimum risk level (MRL) of 7E-2 mg/kg-day. It is recommended that this MRL be used in risk assessment, but with the uncertainty of this value acknowledged.

Effects in humans from exposure to low levels of 2-methylnaphthalene appear to be limited to skin irritation and photosensitization (HSDB, 2012). Acute exposure to high levels may induce headaches, nausea, vomiting, diarrhea, anemia, jaundice, euphoria, dermatitis, visual disturbances, convulsions and coma.

EPA (2012) has provided a verified RfD of 4E-3 mg/kg-day based on pulmonary alveolar proteinosis in an 81-week oral study in mice (Murata et al., 1997). The 2-methylnaphthalene was administered at various dose levels in food. A statistically significant increase in the critical effect was observed in the lowest dose administered (50.3/54.3 mg/kg-day [female/male]). A benchmark dose level assuming 5 percent extra risk of pulmonary alveolar proteinosis of 4.7 mg/kg-day, with a 95 percent lower confidence limit of 3.5 mg/kg-day. UF values of 10 each were applied for interspecies differences, intraspecies variation, and database deficiencies for a

composite UF of 1,000. Confidence in the RfD is regarded as low (EPA, 2012). No EPA-derived subchronic oral RfD is available for the methylnaphthalenes. However, a preliminary subchronic oral RfD is assumed to be equal to the chronic RfD.

Data regarding chronic inhalation exposure of humans or animals to 1- or 2-methylnaphthalene were not located in the available literature. EPA (2012) concluded that an RfC cannot be calculated for 2-methylnaphthalene due to inadequate data. Neither were any epidemiological studies or case studies located which examined the potential effects of 1-methylnaphthalene or 2-methylnaphthalene (EPA, 2012). Therefore, no RfC is identified for either compound.

6.0 Carcinogenicity Evaluation

Under EPA's guidelines for carcinogen risk assessment, the database regarding the carcinogenicity of 2-methylnaphthalene in mice and the lack of human carcinogenicity data are inadequate to assess human carcinogenic potential (EPA, 2012). Therefore no oral SF has been idenifed. Although Murata et al., (1997) identified an increased incidence of pulmonary tumors in male mice at the lowest dose, the results of the study did not indicate an increased incidence of tumors at the high dose, nor were increased incidences of tumor observed in female mice. No studies were identified that suggest that inhalation exposure to 2-methylnaphthelene may cause cancer. Therefore, no unit risk has been verified (EPA, 2012). Neither was any information located to suggest that 1-methylnaphthalene is carcinogenic.

7.0 Toxicity Summary

Toxicity values for 1- and 2-methylnaphthalene are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
1-Methylnaphthalene										
7E-2	7E-2	Lung	ND	NA	NA	D	NA	D	NA	NA
2-Methylnaphthalene										
4E-3	4E-3	Lung	ND	NA	NA	D	NA	D	NA	NA

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); NA = not applicable.
[a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.

8.0 References

Agency for Toxic Substances and Disease Registry (ATSDR), 2005, ***Update Toxicological Profile for Naphthalene, 1-Methylnaphthalene, and 2-Methylnaphthalene***, U.S. Department of Health and Human Services, Atlanta, GA, August

Hazardous Substance Data Bank (HSDB), 2012, National Library of Medicine, on line,.

Murata, Y., A. Denda, H. Maruyama et al., 1997, "Short Communication: Chronic Toxicity and Carcinogenicity Studies of 2-Methylnapthalene in B6C3F1 Mice," ***Fundamental and Applied Toxicology***, Volume 36, pp. 90-93.

U.S. Environmental Protection Agency (EPA), 1998, ***Toxicological Review of Naphthalene (CAS No. 91-20-3) In Support of Summary Information on the Integrated Risk Information System (IRIS)***, August.

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Volatile Organic Compounds

BENZENE (71-43-2)

1.0 Introduction and Physical Properties

Benzene is a naturally occurring **VOC**, present in low levels in many plants and animals, as well as a synthetic compound derived from petroleum (ATSDR, 1997). It occurs as a colorless or slightly yellow liquid, or as a solid at temperatures below approximately 5.5 EC (HSDB, 2012). Benzene is widely used as a solvent and in the manufacturing of other organic compounds such as styrene, phenol, detergents, pesticides, explosives, polychlorinated biphenyls, flavors, perfumes, paints and coatings, nylon intermediates and photographic chemicals, among others. It is also used in food processing and leather tanning and occurs as a component of gasoline. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
78.1[a]	2.13[a]	5.56E-3[b] (25°C)	1.77[b]	8.80E-2[b] (25°C)	9.80E-6[b] (25°C)	1.25E-1[c] (25°C)	1.75E+3[b] (20-25°C)	353.24[d]	562.16[d]	7.34E+3[d]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K);.$H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole).

[a]U.S. Environmental Protection Agency (EPA), 2004, *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part E - Supplemental Guidance for Dermal Risk Assessment)*, Final, Office of Superfund Remediation and Technology Innovation, Washington, D.C., EPA/540/R-99/005, July.

[b]U.S. Environmental Protection Agency (EPA), 2002, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*, Final, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, December.

[c]Hazardous Substance Data Bank (HSDB), 2012, National Library of Medicine, on line.

[d]U.S. Environmental Protection Agency (EPA), 2003, *Users Guide for Evaluating Subsurface Vapor Intrusion into Buildings*, Office of Emergency and Remedial Response, Washington, DC, 19 June.

2.0 Environmental Fate and Transport

Benzene enters the atmosphere primarily from fugitive emissions and automobile exhaust because of its presence in gasoline (ATSDR, 1997; HSDB, 2012). Other important sources are emissions associated with its production and use as a solvent, as an industrial intermediate in the production of the materials mentioned above, and coke oven blast furnaces and coke by-product recovery plants. In addition, there are discharges into water from industrial effluents and losses during spills. Sources of release to soil include land disposal of benzene-containing wastes, industrial discharge, and leaks from underground storage tanks and associated plumbing.

Benzene released to the atmosphere will exist almost exclusively in the vapor phase (ATSDR, 1997; HSDB, 2012). It is not subject to direct photolysis but it will react with photochemically produced hydroxyl radicals with a half-life of approximately 13 days. The reaction time in polluted atmospheres containing nitrogen oxides or sulfur dioxide is accelerated with the half-life being reported as 4 to 6 hours. Products of photooxidation include phenol, nitrophenols,

nitrobenzene, formic acid, and peroxyacetyl nitrate. Benzene is fairly soluble in water and is removed from the atmosphere in rain.

Benzene released to soil will be subject to rapid volatilization near the surface; that which does not evaporate will be highly to very highly mobile in the soil and may leach to groundwater (ATSDR, 1997; HSDB, 2012). Benzene may be subject to biodegradation under aerobic conditions. Microbial transformation proceeds through formation of cis-dihydrodiols to catechols, which lead to destruction of the aromatic ring.

Benzene may be subject to photooxidation and biodegradation in shallow, aerobic groundwaters, but probably not significantly under deeper or anaerobic conditions (ATSDR, 1997; HSDB, 2012). Benzene released to surface water will be subject to rapid volatilization. It is not expected to sorb to sediment or to hydrolyze significantly. Biodegradation is unlikely to be a significant fate process in sediment.

Benzene is not expected to participate significantly in food-chain pathways (ATSDR, 1997; EPA, 1995; HSDB, 2012); therefore, biotransfer factors are not provided.

3.0 Toxicokinetics

Benzene is rapidly and readily absorbed during inhalation exposures of humans or laboratory animals to vapors (ATSDR, 1997). However, the extent of uptake and retention decrease with increasing concentration or time of exposure, reflecting saturation of the metabolic processes that remove the substance from the blood. Excretion data from laboratory animals show that absorption is rapid and essentially complete following oral administration. Dermal uptake of liquid benzene through intact skin has been demonstrated in humans and may be toxicologically significant. The extent of dermal uptake of benzene vapor has not been quantified in humans, but experiments in laboratory animals suggest this exposure route also may be toxicologically significant.

Benzene is widely distributed following any route of exposure (ATSDR, 1997). Highest levels were located in adipose and other tissues high in fat such as the brain following inhalation exposure. Highest levels following oral administration were located in liver, kidney and bone marrow.

Quantitative aspects of the metabolism of benzene are somewhat species-, exposure route- and dose-dependent (ATSDR, 1997), but certain relevant generalizations pertain. The first metabolic step appears to be cytochrome P-450-catalyzed oxidation of benzene to benzene epoxide in the liver, which rearranges to phenol. Phenol is transformed to hydroxyquinone, which is further oxidized to benzoquinone, considered to be a major toxicant in bone marrow. Alternatively, phenol may be further oxidized to catechol and possibly to trihydroxybenzene. Phenol and all its derivatives except benzoquinone have been shown to undergo detoxication by conjugation with glucuronide or sulfate, followed by excretion.

A second general pathway involves the further oxidation of benzene oxide to benzene dihydrodiol, which leads to ring-opening and the formation of muconic dialdehyde, a known hematotoxin, primarily in the liver (ATSDR, 1997).

Absorbed benzene is excreted through the lungs as unchanged compound, and through the urinary tract as conjugated metabolites (ATSDR, 1997). Urinary excretion predominates.

Nothing in this review of toxicokinetics suggests that laboratory animals would not serve as appropriate models for the toxicity of benzene to humans.

4.0 Dermal Exposure

EPA (2004) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. Therefore, no GAF is developed for benzene and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

As mentioned above, benzene in the liquid and vapor form are absorbed through the skin (ATSDR, 1997). Combining benzene with soil slows dermal uptake. EPA (2004) notes that VOCs tend to volatilize from soil when applied to the skin, reducing dermal uptake to toxicologically insignificant levels. Therefore, dermal uptake of benzene from soil is not evaluated. EPA (2004) provides t*, K_p, τ, B and FA values as follows:

Chemical	t*	K_p	τ	FA	B
Benzene	0.70	1.5E-2	0.29	1	0.1
t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); τ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).					

5.0 Noncancer Effects Evaluation

Short-term exposure to benzene induces central nervous system (CNS) effects such as drowsiness, dizziness and headaches; long-term exposure may induce anemia (ATSDR, 1997). Oral dosing in animals induces hematopoietic and immune effects. EPA (2012) verified a chronic oral RfD of 4E-3 mg/kg-day, based on hematological effects (reduced lymphocyte count) in a cross-sectional occupational study of 44 workers exposed to benzene. The workers were exposed for 0.7 to 16 years, with a mean of 6.3 years. Because the mean fell below 7 years, the minimal length considered to be chronic, the study is judged to be subchronic in duration. The control group consisted of an equal number of age- and gender-matched unexposed workers. The exposed workers were divided into two equal groups of 22: those exposed to airborne concentrations below and those exposed to airborne concentrations above the median concentration for all workers of 99 mg/m^3. An exposure-adjusted benchmark concentration (BMC) for minimal hematologic effects of 8.2 mg/m^3 was estimated. Assuming that uptake from the respiratory tract is approximately 50 percent of that from the GI tract allowed application of inhalation-to-oral extrapolation to estimate a benchmark dose (BMD) of 1.2 mg/kg-day. Application of an uncertainty factor of 300 to the BMD yielded the verified chronic oral RfD of 4E-3 mg/kg-day. The uncertainty factor of 300 consists of factors of 3 each for extrapolation from a BMC for minimal adverse effects to a BMC for no adverse effects, to expand from subchronic to chronic exposure, and to reflect deficiencies in the data base; a factor of 10 was used to provide additional protection for more sensitive human subpopulations. The blood cells (specifically inhibited hematopoiesis) are the target for prolonged oral exposure to benzene. Confidence in the chronic oral RfD is medium.

A preliminary subchronic oral RfD can be developed from the BMD described above. The subchronic oral RfD is derived by applying an uncertainty factor of 100 to the BMD of 1.2 mg/kg-day. The uncertainty factor of 100 reflects the uncertainty factor of 300 developed by EPA (2012) without the factor of 3 to expand from subchronic to chronic exposure. The preliminary subchronic oral RfD so derived is 1.2E-2 mg/kg-day, which is rounded to 1E-2 mg/kg-day.

A verified chronic inhalation RfC of 3E-2 mg/m^3 for benzene was based on the exposure-adjusted BMC of 8.2 mg/m^3 in the occupational exposure study from which the oral RfD values were derived (EPA, 2012). Application of the uncertainty factor of 300 (as described for the verified chronic oral RfD) to the BMC of 8.2 mg/m^3 yielded the chronic RfC of 3E-2 mg/m^3. The RfC is equivalent to an inhalation RfD of 8.6E-3 mg/kg-day. Confidence in the chronic inhalation RfC is medium. The blood cells (specifically inhibited hematopoiesis) are the target for prolonged inhalation exposure to benzene. A preliminary subchronic inhalation RfC can be derived by application of an uncertainty factor of 100 to the BMC of 8.2 mg/m^3 in the same manner as was done to derive the subchronic oral RfD. The subchronic inhalation RfC so derived is 8.2E-2 mg/m^3, rounded to 8E-2 mg/m^3. The preliminary subchronic inhalation RfC is equivalent to an inhalation RfD of 2.3E-2 mg/kg-day.

6.0 Carcinogenicity Evaluation

Benzene is classified as an EPA cancer weight-of-evidence Group A chemical – a known human carcinogen for all routes of exposure based upon convincing human evidence as well as supporting evidence from animal studies (EPA, 2012). Epidemiologic studies and case studies provide clear evidence of a causal association between exposure to benzene and acute nonlymphocytic leukemia, and also provide supportive evidence for chronic nonlymphocytic leukemia and chronic lymphocytic leukemia. Other neoplastic conditions in humans that are associated with benzene exposure include hematologic neoplasms, blood disorders such as preleukemia and aplastic anemia, Hodgkin's lymphoma, and myelodysplastic syndrome. Experimental animal data add to the weight of evidence that exposure to benzene increases the risk of cancer in multiple species at multiple organ sites (hematopoietic, oral and nasal, liver, forestomach, preputial gland, lung, ovary, and mammary gland). A verified URF range for inhalation exposure of 2.2E-6 to 7.8E-6 per µg/m^3 was based on the incidence of leukemia in humans exposed to benzene while employed in the Pliofilm industry (EPA, 2012). A low-dose linearity model utilizing maximum likelihood estimates was used to estimate the URF. The range reflects differences in the exposure assumptions estimated from the study. EPA (2012) concluded that neither any specific URF value nor either end of the range is more defensible than the other. Therefore, the upper end of the range, 7.8E-6 per µg/m^3, is conservatively selected for this evaluation. The URF of 7.8E-6 per µg/m^3 is equivalent to an inhalation SF of 2.7E-2 per mg/kg/day.

The occupational data that serve as the basis for the inhalation URF also serve as the basis for a verified oral SF for benzene (EPA, 2012). The inhalation URF range was mathematically converted to an equivalent oral SF range by applying standard inhalation rate and body weight assumptions, and by adjusting for route-specific differences in absorption as described for the chronic oral RfD derivation. The oral SF range so derived is 1.5E-2 to 5.5E-2 per mg/kg-day.

The upper end of the range, 5.5E-2 per mg/kg-day, is conservatively selected as the oral SF for this evaluation.

7.0 Toxicity Summary

Toxicity values for benzene are summarized as follows:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
1E-2	4E-3	Bc	8E-2/ 2.3E-2	3E-2/ 8.6E-3	Bc	A	5.5E-2	A	7.8E-6	2.7E-2

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day).
Target organ abbreviations: Bc = blood cells.
[a]sRfDo, cRfDo and SFo should be used for dermal exposure without adjustment for GI absorption.

8.0 References

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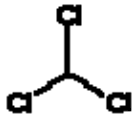
CHLOROFORM (67-66-3)



1.0 Introduction and Physical Properties

Chloroform is a **VOC** that occurs as a clear, colorless, heavy volatile liquid at ambient temperatures (HSDB, 2012). It occurs naturally in the environment, being made by certain forms of algae, seaweed, and the ecological community in peat bogs. Chloroform has been used as a solvent or extraction solvent, dry cleaning fluid, in fire extinguishers, and as an intermediate in the manufacture of dyes and pesticides (ATSDR, 1997). Major current uses include organic synthesis, particularly fluorocarbon-22. It is also formed in the chlorination of drinking water. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
119.4[b]	1.97[a]	3.67E-3[b] (25°C)	1.60[b]	1.04E-1[b] (25°C)	1.00E-5[b] (25°C)	2.59E-1[c] (25°C)	7.92E+3[b] (20-25°C)	334.32[d]	536.40[d]	6.99E+3[d]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point of pure liquid compound (°K); T_c = critical temperature (°K); $\Delta H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole).
data.
[a]U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, EPA/540/R/99/005, OSWER 9285.7-02EP, July.
[b]U.S. Environmental Protection Agency (EPA), 2002, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Final, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, December.
[c]Hazardous Substance Data Bank (HSDB), 2012, National Library of Medicine, on line.
[d]U.S. Environmental Protection Agency (EPA), 2003, ***Users Guide for Evaluating Subsurface Vapor Intrusion into Buildings***, Office of Emergency and Remedial Response, Washington, DC, 19 June.

2.0 Environmental Fate and Transport

Chloroform has been shown to occur naturally in the environment, and its release to the atmosphere from tropical oceans amounts to hundreds of thousands of tons per year (HSDB, 2012). Chloroform also enters the environment associated with its use as an industrial solvent, extractant and chemical intermediate as well as from its inadvertent production in the chlorination of drinking water, municipal sewage and cooling water (ATSDR, 1997; HSDB, 2012). Most environmental releases from industrial uses occur directly to the atmosphere.

Chloroform is expected to exhibit moderate mobility in soil (HSDB, 2012), potentially leaching to groundwater. Volatilization from moist soil surfaces is expected to be an important removal process, given its relatively large Henry's Law constant. Volatilization from dry soil surfaces may also be an important removal process. In one study of chloroform residence time in soils, the compound was found to have a half-life of 0.3 days when applied 1 cm deep into soil, and 1.4 days when applied 10 cm deep. It is classified as a "very short-lived" chemical in soil matrices

primarily due to its high volatility. Under normal environmental conditions, chloroform is not expected to undergo biodegradation in soils, although the compound has been shown to be anaerobically degraded by methanogenic bacteria in the presence of a primary substrate such as acetic acid, and even more readily under sulfate reducing conditions.

Chloroform is not expected to adsorb significantly to sediment or suspended solids in water (HSDB, 2012). Volatilization from water surfaces is expected to be the major process for removing chloroform from surface water. Volatilization half-lives for a model river and model lake have been estimated at 1.3 hours and 4.4 days, respectively. A field study found that the volatilization half-life from the Rhine River was 1.2 days, while in a lake located in the Rhine basin the half-life was 31 days. In another study, chloroform from a municipal treatment plant injected into an estuarine arm of Chesapeake Bay entirely disappeared within 4 km in the spring and within 11 km in the winter under ice. The decrease in concentration could not be attributed entirely to dilution. Based on available experimental data, aquatic degradation is not expected to be a major removal process, although the data are somewhat conflicting. Although base-catalyzed hydrolysis of chloroform is expected to occur, the estimated kinetics predict that this will not be an environmentally important degradation process.

Chloroform is expected to exist solely as a vapor in the ambient atmosphere (HSDB, 2012). Vapor-phase chloroform is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals; the half-life for this reaction in air is estimated to be 151 days. Data regarding the potential for other mechanisms to play an important role in chloroform removal were not located. It is likely that wet deposition or washout may occur, but volatilization would probably readily return the compound to the atmosphere. The tropospheric half-life for chloroform has been estimated at 3 years.

The relatively low log K_{ow} value for chloroform suggests that its participation in food-chain pathways is unlikely to be significant (HSDB, 2012). Measured values for BCF, as well as the observation that the compound is rapidly metabolized confirm this suggestion (ATSDR, 1997; HSDB, 2012; EPA, 1995). Therefore, biotransfer factors are not derived for chloroform.

3.0 Toxicokinetics

Several toxicokinetic studies in animals and humans suggest that chloroform is virtually completely absorbed from the GI tract (ATSDR, 1997). Peak blood levels were higher and attained more quickly from an aqueous vehicle than from an oleaginous vehicle. Although several physiological factors (blood/air partition coefficient, ventilation rate, cardiac output, total body weight and fat content) influence the kinetics of uptake from the respiratory tract, generally arterial blood concentrations are directly proportional to the exposure concentration, suggesting that uptake occurs readily, particularly at concentrations below the saturation point. Experiments with humans indicate that dermal uptake of chloroform in water or ethanol readily occurs.

Absorbed chloroform is rapidly and widely distributed throughout the body, readily crossing the blood-brain and placental barriers (ATSDR, 1997). Highest levels are located in tissues with higher fat content, including adipose tissue, nervous system and liver.

Excretion data suggest that chloroform metabolism is quite species-dependent. Following oral dosing with radiolabeled compound, monkeys excreted most of the dose as unchanged

compound in expired air, mice excreted most of the dose as carbon dioxide, and rats excreted both unchanged compound and carbon dioxide (HSDB, 2012). Urinary metabolites included urea (probably formed from carbon dioxide).

The predominant pathway for chloroform metabolism involves the generation of phosgene in the liver, kidney and other tissues as an intermediate in the formation of carbon dioxide (ATSDR, 1997). Phosgene is a toxicant in its own right, combining covalently with microsomal proteins to disrupt cellular integrity and induce necrosis. Humans appear to be less efficient than laboratory rodents in metabolizing chloroform to phosgene, suggesting that a comparable dose might be less toxic to humans. Trihalomethanes as a group are metabolized to carbon monoxide by most species as a result of reductive dechlorination and hydrolysis (ATSDR, 1997; HSDB, 2012). This, however, represents a relatively minor metabolic pathway, and chloroform is somewhat less efficient in forming carbon monoxide than the other trihalomethanes. Carbon monoxide is also toxic, resulting in the formation of carboxyhemoglobin, which is incapable of releasing oxygen to the tissues and transporting carbon dioxide from the tissues.

The routes and kinetics of chloroform excretion depend on the species, percent of body fat, route of exposure and dose. Excretion occurs primarily as carbon dioxide or unchanged compound via exhaled air; minor metabolites are eliminated through the urine and, to a lesser extent, the feces.

4.0 Dermal Exposure

EPA (2004) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. Therefore, no GAF is developed for chloroform and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

A hypothetical dermal absorption rate of 29.7 mg/minute was modeled for human hands immersed in liquid chloroform, based on absorption data measured in mice (ATSDR, 1997). Data were not located for dermal uptake from soil. VOCs tend to volatilize from soil when applied to the skin, reducing dermal uptake to toxicologically insignificant levels (EPA, 2004). Therefore, dermal uptake of chloroform from soil is not evaluated. t*, K_p, τ, FA and B values are provided by EPA (2004) as follows:

Chemical	t*	K_p	τ	FA	B
Chloroform	1.19	6.8E-3	0.50	1.0	0
t* = Time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); τ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).					

5.0 Noncancer Effects Evaluation

Oral or inhalation exposure of animals to chloroform is associated with liver and kidney damage (ACGIH, 1991; ATSDR, 1997; EPA, 2012). The case for kidney effects associated with prolonged oral exposure in humans, however, is equivocal. In humans, acute inhalation exposure to high levels induces narcosis, ventricular fibrillation and death (ACGIH, 1991). Limited occupational data associate chronic exposure to chloroform with CNS depression, digestive

disturbances and enlarged livers, but not with olfactory epithelial involvement, which has been seen in laboratory animals.

Chloroform has been the subject of continued investigation and reevaluation because of its nearly ubiquitous nature as an anthropogenic chemical and the potential for widespread exposure. An earlier EPA (2003a) evaluation derived a chronic oral RfD of 1E-2 mg/kg-day based on a LOAEL for fatty cyst formation in the livers and biochemical evidence of liver damage in a 1979 study in which dogs were treated orally for 7.5 years. An uncertainty factor of 1000 was applied.

Other studies analyzed in a recent reevaluation include a 1995 drinking water study in mice, a 1995 gavage study in rats, and a 2000 drinking water study in rats. Subtle effects on the kidney appear to be the critical effects of prolonged exposure in rodents. The liver lesions in the 1979 dog study remain the more sensitive endpoint of chloroform exposure and the more appropriate basis for an oral RfD. EPA (2012) developed a benchmark dose limit associated with a 10 percent extra risk for the liver lesions and biochemical evidence described above ($BMDL_{10}$) of 1.2 mg/kg-day. Application of an uncertainty factor of 100 and rounding to one significant figure yields the more recently verified oral RfD of 1E-2 mg/kg-day. The uncertainty factor of 100 consists of factors of 10 each for inter- and intra-species variation. Confidence in the new oral RfD is medium; slightly higher than the level of confidence in the earlier derivation because the BMDL approach is considered somewhat more reliable than the LOAEL/NOAEL approach to RfD development. The rodent studies provide sufficient information to identify both the liver and the kidney as target organs for prolonged oral exposure to chloroform.

Previously, EPA (1997a) adopted the earlier chronic oral RfD of 1E-2 mg/kg-day as the provisional RfD for subchronic oral exposure. As noted above, the earlier chronic oral RfD derivation has been revised, although the value of the RfD remains the same. Therefore, the new verified chronic oral RfD of 1E-2 mg/kg-day is adopted as sufficiently protective for subchronic exposure, but EPA (1997a) is no longer cited as the source.

Prolonged inhalation exposure of rats is associated with atrophy of the ethmoid epithelium at concentrations lower than those associated with liver or kidney effects (EPA, 1997b, 2003a). An earlier provisional subchronic inhalation RfC was derived from a 13-week intermittent exposure study in rats based on effects on the ethmoid epithelium. More recently, EPA (2003a) determined that atrophy of the nasal epithelium in rats is not an appropriate model for human toxicity, in part because this effect has not been observed in humans. The effects on the liver and kidney appear consistently to be the critical effects in humans following inhalation or oral exposure. Subchronic studies in rats and mice showed that mice were somewhat more sensitive than rats to these effects. Therefore, EPA (2003a) estimated a provisional inhalation RfC of 5E-2 mg/m^3 based on an NOAEL for liver and kidney effects in mice. The provisional RfC is equivalent to 1.4E-2 mg/kg-day.

ATSDR (1997) estimated a minimal response level (MRL) for chloroform of 2E-2 parts per million (ppm), equivalent to 9.8E-2 mg/m^3, based on liver effects in 68 workers exposed to chloroform in a pharmaceutical plant for 1 to 4 years. The EPA (2010) selected the ATSDR MRL as the inhalation RfC for RSL development. The key study in the ATSDR evaluation, a 1967 German occupational study, is of limited value because of the small number of workers, the short term of exposure, a wide range of chloroform exposures in air in the breathing zone (2 to

over 200 ppm), and the known presence of other solvents in air. However, the use of human data precludes the uncertainty associated with interspecies extrapolation. Therefore, the ATSDR MRL, equivalent to 2.8E-2 mg/kg-day is selected as the more appropriate toxicity value encumbered with less uncertainty.

6.0 Carcinogenicity Evaluation

The carcinogenicity of chloroform has recent undergone reevaluation and updating on the IRIS record (EPA, 2012). Chloroform was formerly classified as a cancer weight-of-evidence Group B2 compound (probable human carcinogen), based on increased incidence of several tumor types in rats and liver tumors in mice. Human carcinogenicity data are inadequate. A verified oral SF of 6.1E-3 per mg/kg-day was derived from the incidence of kidney tumors in rats treated with chloroform in drinking water for two years. A verified inhalation URF of 2.3E-5 per ug/m^3, developed in 1987, was based on the incidence of hepatocellular carcinomas in mice treated by gavage for 78 weeks. The inhalation URF is equivalent to 8.1E-2 per mg/kg-day.

The more recent cancer evaluation describes chloroform *as likely to be carcinogenic to humans by all routes of exposure under high-exposure conditions that lead to cytotoxicity and regenerative hyperplasia in susceptible tissues (i.e., liver and kidney)* (EPA, 2012). On the other hand, chloroform is unlikely to be carcinogenic to humans by any route of exposure under exposure conditions that do not cause cytotoxicity and cell regeneration. Chloroform appears to exert its carcinogenicity through epigenetic mechanism(s) that are inoperative unless cellular damage in susceptible tissues is sufficient to result in cell regeneration. Since there are thresholds for cytotoxicity, the carcinogenic expression of chloroform is generally assessed as a threshold phenomenon. In other words, the chronic oral RfD of 1E-2 mg/kg-day is considered to be sufficiently protective against carcinogenicity by oral or dermal exposure, and the inhalation RfC of 5E-2 mg/m^3 (1.4E-2 mg/kg-day) is considered to be sufficiently protective against carcinogenicity for inhalation exposure. It should be noted that the previously verified oral SF has been removed from the IRIS record. The previously verified inhalation URF still appears on the IRIS record, but it is preceded by the caveat that it is based on a 1987 evaluation and does not incorporate newer data or reflect updated cancer assessment guidelines. The inhalation carcinogenicity assessment is currently under revision (EPA, 2012).

Because of the foregoing, chloroform should not be evaluated as a potential carcinogen by the application of an oral or inhalation SF or URF. Instead, the verified oral RfD and provisional RfC should be used to evaluate the noncancer hazard associated with oral (and dermal) and inhalation exposure. This approach is more consistent with EPA (2003b) guidance, which places IRIS over other sources of toxicological evaluation for risk assessment and development of cleanup levels.

7.0 Toxicity Summary

Toxicity values for chloroform are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfc/ sRfD	cRfC/ cRfD	TO	WOE	SFo	WOE	URFi	SFi
1E-2	1E-2	L, K	9.8E-2/ 2.8E-2	9.8E-2/ 2.8E-2	L, K	See Section 6	ND[b]	See Section 6	ND[b]	ND[b]

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfc/ sRfD	cRfC/ cRfD	TO	WOE	SFo	WOE	URFi	SFi

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data.
Target organ abbreviations: L = liver; K = kidney.
[a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.
[b]Chloroform is determined to be a threshold carcinogen more appropriately evaluated by the RfD and RfC values derived for protection against threshold phenomena.

8.0 References

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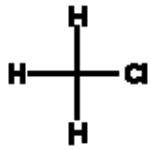
U.S. Environmental Protection Agency (EPA), 2012, ***Integrated Risk Information System (IRIS)***, National Center for Environmental Assessment, Cincinnati, OH, on line.

CHLOROMETHANE (METHYL CHLORIDE) (74-87-3)



1.0 Introduction and Physical Properties

Chloromethane is a **VOC** that exists as a colorless gas at ambient temperatures (HSDB, 2012). It is used largely as a methylating agent in the production of silicones, tetramethyl lead, methyl cellulose, methylene chloride, methyl mercaptan, plastics, pesticides, pharmaceuticals, dyes, perfumes, ethers, resins, agricultural chemicals, quaternary amines and butyl rubber (ACGIH, 1991; ATSDR, 1998; HSDB, 2012). It is also used as an extractant for fats, oils and resins, as a blowing agent and as a refrigerant. It was formerly used as a propellant in various aerosol products. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
50.5[a]	0.91[a]	8.82E-3[b] (25□C)	1.15[b]	1.39E-1[c] (25□C)[d]	1.49E-5[e] (20□C)	5.66E+0[b] (25□C)	5.32E+3[b] (25 □C)	247[f]	416[f]	5.15E+3[f]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K);.$H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole).

[a]U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, EPA/540/R/99/005, OSWER 9285.7-02EP, July.

[b]Hazardous Substance Data Bank (HSDB), 2012, National Library of Medicine, on line.

[c]Calculated as described in Introduction to Toxicological profiles.

[d]Assumed.

[e]Montgomery, J.H., 1996, ***Groundwater Chemicals Desk Reference, Second Edition***, Lewis Publishers, New York, pp. 664-666.

[f]National Institute of Standards and Technology (NIST), 2011, ***NIST Chemistry WebBook***, on line.

2.0 Environmental Fate and Transport

Chloromethane is one of the few halogenated organic chemicals for which natural sources are significant. Natural sources include volcanoes, volatilization from plants, and forest fires (HSDB, 2012). It is produced in seawater by the reaction of methyl iodide with chloride ions. Methyl iodide is produced photosynthetically by several marine organisms, and there may be other oceanic sources as well. The mean air flux of 1.3E-6 g/cm^2-year for the eastern Pacific Ocean, when extrapolated to global waters, provides an adequate source to explain the atmospheric reservoir of chloromethane. Chloromethane is released from brush and forest fires. The estimated 0.6 g of chloromethane released per kg of vegetation burned is believed to make a significant impact on the global burden of the compound.

The production and many uses of chloromethane may result in its release to the environment through various waste streams (HSDB, 2012). It is also released in tobacco smoke and turbine exhaust. Just as forest fires contribute to natural sources, wood burning, field burning, and backyard burning also contribute to atmospheric burdens. Chloromethane is formed in the chlorination of drinking water and sewage effluent, and is found in the effluent of some publically owned treatment works.

Most chloromethane is released to the atmosphere where it is expected to exist solely as a gas (HSDB, 2012). Gas-phase chloromethane is degraded in the atmosphere by reaction with

photochemically-produced hydroxyl radicals; the half-life for this reaction in air is estimated to be 310 days, which provides opportunity for widespread dispersion. The dominant process for removal from the troposphere is upward diffusion, although washout by rain may also be important. From the tropopause to about 30 km, both upward diffusion and reaction with hydroxyl radicals will be of approximately equal importance, and above 30 km in the stratosphere, diffusion, reaction with hydroxyl radicals, and photodissociation will have approximately equal importance. The surface half-life resulting from upward diffusion is approximately 80 days.

Based on its very low estimated K_{oc} value, chloromethane is expected to have very high mobility in soil (HSDB, 2012). Its relatively high water solubility suggests the compound released in sufficient quantity in the liquid phase or dissolved in water could leach readily to groundwater. Volatilization from moist soil surfaces is expected to be an important removal process for small quantities released to the surface. Volatilization from dry soil surfaces may also be important. Field and laboratory studies demonstrate that several halogenated aliphatics may biodegrade slowly under anaerobic conditions, but not under aerobic conditions. Biodegradation is not expected to be a significant removal process.

Chloromethane is not expected to adsorb to suspended solids and sediment in surface water (HSDB, 2012). Volatilization from water surfaces is expected to be a significant removal mechanism; volatilization half-lives for a model river and model lake are 46 minutes and 3 days, respectively. Field and laboratory studies demonstrate that several halogenated aliphatics may biodegrade slowly under anaerobic conditions, but not under aerobic conditions. Biodegradation is not expected to be a significant removal process. Hydrolysis may occur, but very slowly, with a half-life of approximately 2 years (ATSDR, 1998). Hydrolysis will not be a significant removal process for chloromethane in surface water, but may be the only significant removal process for the compound in groundwater, where it has been shown to persist.

Chloromethane is water soluble, volatile and labile, and is not expected to participate significantly in food-chain pathways (ATSDR, 1998; HSDB, 2012). Therefore, biotransfer factors are not estimated for this compound.

3.0 Toxicokinetics

Studies regarding the toxicokinetics of chloromethane are limited to inhalation exposure. Chloromethane is readily absorbed by the respiratory system and equilibrium conditions are reached in approximately one hour in exposed humans and laboratory animals (ATSDR, 1998). Data regarding the extent of respiratory absorption were not located. Although data were not located for GI absorption, it is expected that GI absorption would be rapid and extensive because the compound is a low MW organic substance that is readily absorbed by the respiratory system. HSDB (2012) stated that dermal absorption can occur, but no other information was provided.

Radioactivity is rapidly and extensively distributed throughout the body following inhalation exposure to radiolabeled chloromethane, with highest levels of radioactivity measured in liver, kidney, testis and lung (ATSDR, 1998). Approximately 20 percent of the radiolabel in liver and testis was found to have been metabolically incorporated into the cellular structure, reflecting uptake and utilization from the one-carbon atom pool of the body.

The primary and predominant metabolic pathway of chloromethane involves enzymatic conjugation with glutathione to form S-methylglutathione (ATSDR, 1998). Further metabolism involves deamination to yield S-methylcysteine and other sulfur-containing conjugation derivatives, which are excreted in the urine. Another metabolic pathway involves dehalogenation of chloromethane to form formaldehyde (a toxicant in its own right) and formic acid. These intermediates contribute to the one-carbon atom pool that is available for incorporation into the tissues or for mineralization to carbon dioxide followed by excretion through the lungs.

Studies have shown that adult humans, unlike laboratory animals, may be divided into two groups – fast or slow metabolizers – depending on the activity in their erythrocytes of glutathione-S-transferase, which is responsible for the first conjugation reaction (ATSDR, 1998). Fast metabolizers clear chloromethane from the body more rapidly than slow metabolizers. Whether the unborn, new born or young children exhibit this characteristic is unknown. The implications of glutathione-S-transferase activity regarding population differences in toxic potency are unclear. On the one hand, it may appear that fast metabolizers should be more tolerant of chloromethane because of their enhanced ability to clear the compound from the body. On the other hand, experiments in laboratory animals suggest that a metabolite of S-methylglutathione may be the ultimate toxicant, in which case fast metabolizers may be more sensitive to chloromethane toxicity.

Chloromethane residues are rapidly cleared from the body following the cessation of inhalation exposure (ATSDR, 1998). Clearance in laboratory animals and humans is biphasic, consistent with a linear 2-compartment model. The half-lives for both phases were measured in minutes, indicating the rapidity with which clearance occurs. The exception is that the β-phase in some humans (slow metabolizers) approximated 1.5 hours.

4.0 Dermal Exposure

EPA (2004) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. Chloromethane is assumed to be absorbed readily from the GI tract; therefore, no GAF is developed.

Data regarding the dermal uptake of chloromethane were not located, except that HSDB (2012) stated that dermal absorption could occur. VOCs tend to volatilize from soil when applied to the skin, reducing dermal uptake to toxicologically insignificant levels (EPA, 2004). Therefore, dermal uptake of chloromethane from soil is not quantified. EPA (2004) provides t*, K_p, τ, FA and B values as follows:

Chemical	t*	K_p	τ	FA	B
Chloromethane	0.49	3.3E-3	0.20	1	0
t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); τ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).					

5.0 Noncancer Effects Evaluation

Data regarding the toxicity of oral exposure to chloromethane consist of the statement that liver effects were not observed in rats given a single oral dose of 420 mg/kg (ATSDR, 1998; EPA, no date). EPA (no date) derived a provisional chronic oral RfD of 4E-3 mg/kg-day based on a LOAEL of 69.32 mg/m^3 for subtle neurobehavioral effects from an occupational (inhalation) study. Subsequently, EPA (2012) reviewed the data and determined that ingestion exposure is not applicable because the compound exists as a gas at ambient temperatures. They also noted that the oral exposure data are insufficient to develop an oral RfD. Therefore, the EPA (no date) derivation is considered to be not applicable and no oral RfD is offered herein.

EPA (2012) verified a chronic inhalation RfC of 9E-2 mg/m^3 based on a NOAEL of 50 ppm (103.2 mg/m^3) from an 11-day continuous exposure study in mice. The NOAEL corresponds to a human equivalent concentration (HEC) of 94.6 mg/m^3. The LOAEL in this study, 100 ppm (206.4 mg/m^3 or a HEC of 189.2 mg/m^3) was associated with slight to moderate degenerative changes in the granule cells of the cerebellum. EPA (2012) applied an uncertainty factor of 1000 to the NOAEL HEC of 94.6 mg/m^3 to derive the RfC of 9E-2 mg/m^3. The uncertainty factor consists of factors of 10 each to provide additional protection for unusually sensitive humans and to expand from a short-term to lifetime exposure, and factors of 3 each to extrapolate from mice to humans and to address the uncertainty regarding the potential for CNS effects in the developing young. Confidence in the verified chronic inhalation RfC is medium. The verified inhalation RfC is equivalent to an inhalation RfD of 2.6E-2 mg/kg-day. The CNS is the target organ for prolonged inhalation exposure to chloromethane.

EPA (1996) developed a provisional chronic RfC based on subtle neurobehavioral effects from an occupational (inhalation) study. They adopted the provisional chronic RfC for subchronic application, noting no significant differences in response between chronic and subchronic exposure. However, given the EPA (2012) reevaluation and verification of a more conservative chronic RfC, it is deemed prudent to adopt the verified chronic RfC rather than the provisional chronic RfC as sufficiently protective for subchronic exposure.

6.0 Carcinogenicity Evaluation

Previous EPA (1997, 1998) evaluations classified chloromethane in EPA weight-of-cancer Group C (possible human carcinogen), and developed an oral SF and an inhalation URF. More recently, EPA (2012) reevaluated the data, noting that chloromethane is a naturally occurring compound, and concluded that it is more appropriately classified in Group D (not classifiable as to its human carcinogenicity). Applying more recent cancer assessment guidelines, EPA (2012) concluded that the available data suggest that chloromethane would be classified as an agent whose carcinogenic potential *cannot be determined*. Previously developed potency factors are considered to be not applicable; no potency factors are offered herein for chloromethane.

7.0 Toxicity Summary

Toxicity values for chloromethane are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
			9E-2/	9E-2/						

Noncancer Effects						Carcinogenicity				
Oral Exposure			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
ND	ND	NA	2.6E-2	2.6E-2	CNS	D	NA	D	NA	NA

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.
Target organ or critical effect abbreviations: CNS = central nervous system.

8.0 References

Agency for Toxic Substances and Disease Registry (ATSDR), 1998, ***Update Toxicological Profile for Chloromethane***, U.S. Department of Health and Human Services, Atlanta, GA, December, on line.

American Conference of Governmental Industrial Hygienists (ACGIH), 1991, ***Documentation of the Threshold Limit Values and Biological Exposure Indices***, Sixth Edition, Cincinnati, OH, pp. 953-957.

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U.S. Environmental Protection Agency (EPA), no date, ***Risk Assessment Issue Paper for: Derivation of a Provisional RfD for Chloromethane (CASRN 74-87-3)***, National Center for Environmental Assessment, Cincinnati, OH.

U.S. Environmental Protection Agency (EPA), 1996, ***Risk Assessment Issue Paper for: Derivation of a Provisional Chronic and Subchronic RfC for Chloromethane (CASRN 74-87-3)***, National Center for Environmental Assessment, Cincinnati, OH, 23 July.

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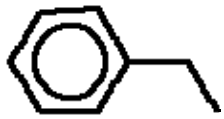
U.S. Environmental Protection Agency (EPA), 2012, ***Integrated Risk Information System (IRIS)***, National Center for Environmental Assessment, Cincinnati, OH, on line.

ETHYLBENZENE (PHENYLETHANE) (100-41-4)



1.0 Introduction and Physical Properties

Ethylbenzene, also known as phenylethane, is a **VOC** that exists in the pure state as a colorless liquid at ambient temperatures (HSDB, 2012). It is used primarily as a precursor in the manufacture of styrene (ATSDR, 1999). It is also used as a solvent and diluent, and as an intermediate in the manufacturing of cellulose acetate, rubber and other organic compounds (ATSDR, 1999; HSDB, 2012). It is also a constituent of asphalt, naphtha, and automotive and aviation fuels. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
106.2[a]	3.15[a]	7.88E-3[b] (25°C)	2.56[b]	7.50E-2[b] (25°C)	7.80E-6[b] (25°C)	1.26E-2[c] (25°C)	1.69E+2[b] (20-25°C)	409.34[d]	617.20[d]	8.50E+3[d]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K);.$H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole).
[a]U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, EPA/540/R/99/005, OSWER 9285.7-02EP, July.
[b]U.S. Environmental Protection Agency (EPA), 2002, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Office of Solid Waste and Emergency Response, Washington, D.C., 9355.4-24, December.
[c]Hazardous Substance Data Bank (HSDB), 2012, National Library of Medicine, on line.
[d]U.S. Environmental Protection Agency (EPA), 2003, ***User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings***, Office of Emergency and Remedial Response, Washington, DC, June 19.

2.0 Environmental Fate and Transport

Ethylbenzene enters the atmosphere primarily from fugitive emissions and exhaust connected with its use in gasoline (ATSDR, 1999; HSDB, 2012). More localized sources to the air and other environmental media include fugitive emissions, waste water and spills from its production and industrial use, leaking underground storage tanks, land disposal of ethylbenzene-containing waste, and municipal and hazardous waste combustion.

Ethylbenzene exists in the air in the vapor phase (ATSDR, 1999; HSDB, 2012). It is somewhat water soluble and may be removed by precipitation; however, it is likely to reenter the air by volatilization. Ethylbenzene is transformed in air by various oxidative processes to yield ethylphenols, benzaldehyde, acetophenone, and m- and p-nitroethylbenzene. Reaction with photolytically generated hydroxyl radicals is probably the most significant reaction, with a half-life estimated to be 55 hours, suggesting that ethylbenzene will not persist in the air or travel long distances.

Ethylbenzene released to soil will volatilize rapidly (ATSDR, 1999; HSDB, 2012). That which infiltrates is expected to be quite mobile in soil and may leach to groundwater because sorption to soil particles is not sufficiently strong to retard movement. Biodegradation in soil in aerobic conditions involves oxidation of the ethyl side chain, ring hydroxylation and ring cleavage, and may be a significant source of removal. Anaerobic degradation is expected to be insignificant.

Ethylbenzene released to surface water will volatilize rapidly to air (ATSDR, 1999; HSDB, 2012). Biodegradation in aerobic conditions will significantly reduce water-borne concentrations. Photolysis and hydrolysis are unlikely to be significant. Ethylbenzene partitions weakly to sediment.

Ethylbenzene is not expected to participate significantly in food-chain pathways (ATSDR, 1999; EPA, 1995; HSDB, 2012); therefore, biotransfer factors are not provided.

3.0 Toxicokinetics

Ethylbenzene is rapidly absorbed during inhalation exposure, with retention near or exceeding 50 percent of the inhaled concentration (ATSDR, 1999). The compound is similarly rapidly absorbed following oral administration. Excretion data in rabbits suggest that a minimum of 72 to 92 of an oral dose is absorbed. Liquid ethylbenzene applied to the skin of humans is rapidly absorbed, but ethylbenzene vapor is poorly absorbed.

Ethylbenzene appears to be efficiently and widely distributed throughout the body following inhalation exposure (ATSDR, 1999). The same is expected following oral and dermal exposure, but data are lacking.

Metabolism in humans of absorbed ethylbenzene following either inhalation or oral exposure predominantly involves successive oxidation of the ethyl side-chain through 1-phenylethanol, acetophenone, ω-hydroxyacetophenone, and 1-phenyl-1,2-ethanediol to form mandelic acid and phenylglyoxylic acid (ATSDR, 1999). Small quantities of the first 4 intermediates are conjugated and excreted in the urine. Mandelic acid and phenylglyoxylic acid are excreted without conjugation and comprise the majority of excreted metabolites. A minor metabolic pathway involves epoxide formation and hydroxylation of the phenyl ring with or without oxidation of the ethyl group to yield small quantities of metabolites that are conjugated and excreted. Experiments with laboratory animals reveal species differences in the predominance of certain metabolites, but the pathways described above appear to hold. There is no evidence that the metabolites are more toxic than the parent compound.

Excretion of metabolites, primarily through the urine, is rapid and extensive in humans and laboratory animals (ATSDR, 1999). Pulmonary excretion of carbon dioxide is a minor pathway.

Nothing in this review of toxicokinetics suggests that laboratory animals would not serve as appropriate models for the toxicity of ethylbenzene to humans.

4.0 Dermal Exposure

EPA (2004) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. GI absorption of ethylbenzene is extensive as discussed in Section 3.0. Therefore, no GAF is developed for ethylbenzene and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

Data were not located for dermal uptake of ethylbenzene from soil. VOCs tend to volatilize from soil when applied to the skin, reducing dermal uptake to toxicologically insignificant levels

(EPA, 2004). Therefore, dermal uptake of ethylbenzene from soil is not evaluated. Values for t*, K_p, τ, FA and B are provided by EPA (2004) as follows:

Chemical	t*	K_p	τ	FA	B
Ethylbenzene	1.01	4.9E-2	0.42	1.0	0.2
t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); τ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).					

5.0 Noncancer Effects Evaluation

An oral LD_{50} in rats of 5.46 g/kg (HSDB, 2012) suggests that the acute toxicity of ingested ethylbenzene is low. Subchronic to chronic oral exposure of laboratory animals to ethylbenzene induces mild liver and kidney lesions (EPA, 2012). EPA (2012) presents a verified chronic oral RfD for ethylbenzene of 1E-1 mg/kg-day based on a NOEL for liver and kidney lesions in female rats of 136 mg/kg-day in a six-month gavage study. The LOAEL in this study was 408 mg/kg-day. An uncertainty factor of 1000 was applied to the NOEL to derive the chronic oral RfD. The uncertainty factor consists of factors of 10 each to extrapolate from animals to humans, to provide additional protection for more sensitive humans, and to expand from subchronic to chronic exposure. Confidence in the oral RfD is low. The liver and kidney are the target organs for prolonged oral exposure to ethylbenzene.

No EPA-derived subchronic oral RfD is available for ethylbenzene. A preliminary subchronic oral RfD can be made, however, by applying an uncertainty factor of 100 to the NOEL of 136 mg/kg-day in the 6-month rat study described above. The uncertainty factor of 100 reflects the chronic uncertainty factor of 1000 without the factor of 10 for expansion from subchronic to chronic exposure. The preliminary subchronic oral RfD so derived is 1E+0 mg/kg-day.

Acute inhalation exposure induces irritation of the mucous membranes in animals and humans (ACGIH, 1991). Prolonged inhalation exposure induces liver enzymes and results in elevated liver and kidney weights; prolonged exposure to relatively high levels is associated with mild histopathological lesions of the liver, kidney and testes (ACGIH, 1991; EPA, 2012). EPA (2012) considered that the effects on the liver at the lower exposure concentrations are adaptive rather than adverse. EPA (2012) presented a verified chronic inhalation RfC of 1E+0 mg/m^3 derived from a human equivalent adjusted NOAEL of 434 mg/m^3 from studies on developmental effects in rats and rabbits. An uncertainty factor of 300 was used. The human equivalent adjusted LOAEL of 4340 mg/m^3 was associated with equivocal evidence of reduced fetal size in rabbits, an increased incidence of extra ribs in rat fetuses, and increased liver, kidney and spleen weights in the rats. The inhalation RfC is equivalent to 2.9E-1 mg/kg-day. Confidence in the RfC is low. The chronic inhalation RfC is adopted as being sufficiently conservative for subchronic as well as chronic inhalation exposure.

The key study from which the inhalation RfC is derived does not clearly identify target organ(s) for inhalation exposure to ethylbenzene. The entire inhalation exposure data base, however, suggests that the liver, kidneys and fetus may be the most significant target organs for prolonged inhalation exposure.

6.0 Carcinogenicity Evaluation

Ethylbenzene is currently verified as a cancer weight-of-evidence Group D compound (not classifiable as carcinogenicity to humans) (EPA, 2012) based on an absence of human or animal cancer studies. Cancer potency factors are not estimated for Group D compounds.

7.0 Toxicity Summary

Toxicity values for ethylbenzene are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
1E+0	1E-1	L, K	1E+0/ 2.9E-1	1E+0/ 2.9E-1	L, K, F	D	NA	D	NA	NA

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); NA = not applicable.
Target organ or critical effect abbreviations: L = liver; K = kidney; F = fetus.
[a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.

8.0 References

Agency for Toxic Substances and Disease Registry, (ATSDR), 1999, ***Update Toxicological Profile for Ethylbenzene***, U.S. Department of Health and Human Services, Atlanta, Georgia, July, on line.

American Conference of Governmental Industrial Hygienists (ACGIH), 1991, ***Documentation of the Threshold Limit Values and Biological Exposure Indices***, Sixth Edition, Cincinnati, OH, p. 581-584.

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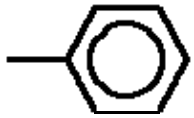
U.S. Environmental Protection Agency (EPA), 2012, ***Integrated Risk Information System (IRIS)***, National Center for Environmental Assessment, Cincinnati, OH, on line.

TOLUENE (METHYLBENZENE) (108-88-3)



1.0 Introduction and Physical Properties

Toluene is a VOC that occurs as a colorless liquid at ambient temperatures (HSDB, 2012). It is back-blended into gasoline to improve octane rating, used to produce benzene, used as a solvent in paints, coatings, adhesives, inks and cleaning agents, and used in the synthesis of a wide range of organic chemicals, particularly benzene and its derivatives (ATSDR, 2000; HSDB, 2012). Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
92.1[a]	2.73[a]	6.64E-3[b] (25°C)	2.26[b]	8.70E-2[b] (25°C)	8.60E-6[b] (25°C)	3.74E-2[c] (25°C)	5.26E+2[b] (20-25°C)	383.78[d]	591.79[d]	7.93E+3[d]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K);.$H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); ND = no data.

[a]U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final,*** Office of Emergency and Remedial Response, EPA/540/R/99/005, OSWER 9285.7-02EP July.

[b]U.S. Environmental Protection Agency (EPA), 2002, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Fianl, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, December.

[c]Hazardous Substance Data Bank (HSDB), 2012, National Library of Medicine, on line.

[d]U.S. Environmental Protection Agency (EPA), 2003, ***Users Guide for Evaluating Subsurface Vapor Intrusion into Buildings***, Office of Emergency and Remedial Response, Washington, DC, 19 June.

2.0 Environmental Fate and Transport

Large amounts of toluene are released into the atmosphere each year, principally from the production, transport and use of gasoline (ATSDR, 2000; HSDB, 2012). Other major sources include volatilization of toluene-based solvents and thinners, and motor vehicle exhaust. Considerable amounts are discharged into waterways or spilled on land during the storage, transport and disposal of fuels and oils. Natural sources include emissions from volcanoes, forest fires and crude oil.

Toluene in the atmosphere will exist predominantly or entirely in the vapor phase, where it is subject to reaction with photochemically produced hydroxyl radicals (ATSDR, 2000; HSDB, 2012). It is also subject to reaction with various oxidizing agents in the atmosphere, but these reactions are far less significant. Wet deposition is another important process for removal of toluene from the atmosphere.

Toluene is expected to be moderately to highly mobile in soil and may leach to groundwater (ATSDR, 2000; HSDB, 2012). Volatilization is an important removal process for toluene near the surface of the soil. Biodegradation may also be significant in soil. Toluene in water will be

lost by both volatilization to the atmosphere and biodegradation. Which process predominates will depend on water temperature, mixing conditions and the existence of acclimated microorganisms at the site. The compound is not expected to sorb significantly to sediment or suspended organic matter in water.

Toluene theoretically may be expected to bioconcentrate because of its lipophilicity, but empirical data show that it is subject to rapid biotransformation, which greatly reduces this tendency (ATSDR, 2000). Overall, biotransfer is not expected to be significant (EPA, 1995) and biotransfer factors are not provided.

3.0 Toxicokinetics

Excretion data from humans and laboratory animals indicate that toluene is rapidly and extensively absorbed during inhalation and following oral administration (ATSDR, 2000). Data from humans suggest that pulmonary retention ranges from 50 to 83 percent of the inhaled concentration. GI absorption is practically complete in humans and animals. Administration of toluene in soil slows the rate but does not reduce the extent of GI absorption. Toluene is absorbed by the skin of humans and laboratory animals when applied as a liquid or as a water solution. Dermal uptake of toluene vapor has been demonstrated in animals. Data were not located regarding dermal uptake from soil.

Absorbed toluene is rapidly and widely distributed throughout the body (ATSDR, 2000). Highest levels are generally found in highly vascular and lipid-rich tissues, including the brain, particularly following inhalation, and the liver, particularly following ingestion. Levels in maternal tissues are generally much higher than those in fetal tissues. The nervous system is an important target for exposure to toluene, particularly following inhalation exposure.

The predominant metabolic pathway for toluene involves oxidation of the methyl group to form benzyl alcohol which is further oxidized to benzoic acid, followed by conjugation with glycine to form hippuric acid, which is recovered as the major urinary metabolite (ATSDR, 2000). A minor pathway involves hydroxylation of the benzene ring to form various cresol isomers, which undergo conjugation and excretion by the kidneys. Another minor pathway involves glutathione conjugation of benzyl alcohol to yield a mercapturic acid urinary metabolite. Quantitative differences in the relevance of these pathways have been shown for different species and different human racial groups.

The liver is the primary site of toluene biotransformation. The enzyme activity involved in toluene metabolism is low in the fetal liver, but reaches adult levels soon after birth. Low levels of detoxication activity in the fetus may increase the likelihood of developmental effects.

Toluene metabolites are rapidly excreted from the body, although excretion appears to be multi-phasic, reflecting release of toluene from adipose depots (ATSDR, 2000).

Nothing in this review of toxicokinetics suggests that laboratory animals would not serve as appropriate models for the toxicity of toluene to humans.

4.0 Dermal Exposure

EPA (2004) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. As noted above, GI absorption is practically complete. Therefore, no GAF is developed for toluene and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

Data were not located for dermal uptake of toluene from soil. VOCs tend to volatilize from soil when applied to the skin, reducing dermal uptake to toxicologically insignificant levels (EPA, 2004). Therefore, dermal uptake of toluene from soil is not evaluated. EPA (2004) provides t*, K_p, τ, B and FA values as follows:

Chemical	t*	K_p	τ	FA	B
Toluene	0.84	3.1E-2	0.35	1.0	0.1
t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); τ= lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).					

5.0 Noncancer Effects Evaluation

Acute inhalation (glue sniffing, solvent abuse, industrial accidents) or ingestion exposure to high levels of toluene induces CNS dysfunction and narcosis (ATSDR, 2000). Acute oral LD_{50} values include 2.6 to 7.5 g/kg in rats (HSDB, 2012), suggesting the acute toxicity is not high. Acute ingestion is associated with lesions in the heart, liver, lungs and kidneys (ATSDR, 2000). Prolonged oral exposure to lower levels is associated with pathological changes in the liver, kidney and brain. Changes in liver and kidney weights were observed in rats treated by gavage for 13 weeks at a dose rate of 446 mg/kg-day (NTP, 1990). Overt kidney effects were observed at higher doses (EPA, 2012). A NOAEL of 223 mg/kg-day was also observed in this NTP study.

EPA (2012) derived a verified chronic RfD for toluene, using the benchmark dose approach and the LOAEL of 446 mg/kg-day. The critical effect of absolute kidney weight was used. This approach derived a benchmark dose level of 238 mg/kg-day as the point of departure. The RfD of 8E-2 mg/kg-day is derived by dividing this value by a composite UF of 3000. This assumes a UF of 10 for each of the following: interspecies variability, intraspecies sensitivity, and subchronic to chronic extrapolation. An additional UF of 3 was added to account for deficiencies in the data base (EPA, 2012). The chronic RfD is also conservatively used for subchronic exposure.

Prolonged occupational (inhalation) exposure to toluene at concentrations near 100 ppm induces upper respiratory tract irritation and CNS dysfunction (EPA, 2012). The CNS effects are selected as the critical endpoint for a verified inhalation RfC of 5 mg/m^3. EPA (2012) considered a plethora of human studies in the derivation of this RfC. It is based on an average adjusted NOAEL from several studies of 46 mg/m^3 (EPA, 2012). An RfC of 5 mg/m^3 is derived from this value by dividing by a UF of 10 to account for inter-individual variability. This value equals an inhalation RfD of 1.4 mg/kg-day.

6.0 Carcinogenicity Evaluation

EPA (2012) verified toluene as a cancer weight-of-evidence Group D compound (not classifiable as to carcinogenicity to humans) based on a lack of human data and inadequate animal testing data. Potency factors are not available for Group D compounds.

7.0 Toxicity Summary

Toxicity values for toluene are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
8E-2	8E-2	K	5/1.4	5/1.4	CNS	D	NA	D	NA	NA

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); NA = not applicable.
Target organ or critical effect abbreviations: K = kidney, CNS = central nervous system.
[a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.

8.0 References

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DICHLOROPROPENES

1,3-Dichloropropene

1.0 Introduction and Physical Properties

This profile addresses 1,1-dichloropropene, 1,2-dichloropropene, 1,3-dichloropropene, and 2,3-dichloropropene. All are **VOCs** and all are liquid at ambient temperatures (ATSDR, 2006; EPA, 2002; HSDB, 2012)

Various mixtures and formulations of dichloropropenes and 1,2-dichloropropane (78-87-5) are used as soil fumigants and nematocides (HSDB, 2012; Meister, 1999). It is generally applied pre-planting by injection equipment at depths of 12 to 18 inches. Compacting the treated soil, covering the treated soil with tarps, or irrigating with water are often done immediately after treatment to retard volatilization loss.

Most soil fumigant mixtures contain predominantly 1,3-dichloropropene (542-75-6), with lesser amounts of 1,2-dichloropropene (563-54-2) and traces of 1,1-dichloropropene (563-58-6) and 2,3-dichloropropene (78-88-6) as well (ATSDR, 2006; HSDB, 2012). The use of 1,3-dichloropropene as a pesticide increased after the EPA phased out the use of ethylene dibromide, and its use is likely to increase further with the planned EPA phase-out of methyl bromide. 1,3-Dichloropropene is also used in much smaller quantities in organic synthesis and as a solvent; small quantities of 2,3-dichloropropene are used in organic synthesis.

Little is known about the physical properties of 1,1-dichloropropene or 2,3-dichloropropene. 1,2-Dichloropropene occurs as a minor constituent in Telone II, one of the more common dichloropropene formulations used as a soil fumigant. There are 2 isomers of 1,3-dichloropropene (542-75-6): cis- (or Z-) 1,3-dichloropropene (10061-01-5) and trans- (or E-) 1,3-dichloropropene (10061-02-6). Many preparations and formulations of 1,3-dichloropropene contain approximately equivalent proportions of the two isomers (HSDB, 2012). Relevant physical properties of the dichloropropenes are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
1,1-Dichloropropene (563-58-6)										
110.97[a]	2.53[a,b]	2.16E-2[a,b] (25°C)	1.83[a,b]	8.23E-2[c] (25°C)[d]	9.53E-6[c] (25°C)[d]	1.19E-1[a,e] (20°C)	1.18E+3[a,b] (25°C)[d]	349.65[f]	551.66[g]	7.15E+3[h]
1,2-Dichloropropene (563-54-2)										
110.97[i]	2.53[a,b]	4.91E-3[a,e] (25°C)	1.83[a,b]	8.23E-2[c] (25°C)[d]	9.53E-6[c] (25°C)[d]	3.16E-2[a,e] (25°C)	2.7E+3[i,e] (25°C)	348[i]	549[g]	7.11E+3[h]
1,3-Dichloropropene (both isomers: 542-75-6)										
111[j]	2.00[i]	3.55E-3[a,b] (25°C)	1.91[a,b]	6.26E-2[k] (25°C)	1.00E-5[k] (25°C)	4.47E-2[a,e] (25°C)	2.80E+3[k] (20-25°C)	381.15[l]	587.38[l]	7.90E+3[l]
2,3-Dichloropropene (78-88-6)										
110.97[a]	2.42[a,b]	4.16E-3[a,e] (25°C)	1.83[a,b]	8.23E-2[c] (25°C)[d]	9.53E-6[c] (25°C)[d]	8.05E-2[i] (25°C)	2.15E+3[a,e] (25°C)	367.2[i]	551.6[i]	8.44E+3[i]

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K);.$H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); ND = no data.

[a]U.S. Environmental Protection Agency (EPA), 2011, *EPI Suite Version 4.10* Software for estimating physical properties, online, 30 November.
[b]Estimated.
[c]Calculated as described in Introduction to Toxicological profiles.
[d]Assumed.
[e]Measured.
[f]Agency for Toxic Substances and Disease Registry (ATSDR), 2006, *Toxicological Profile for Dichloropropenes*, Draft for Public Comment, U.S. Department of Health and Human Services, Atlanta, GA, September, on line.
[g]Estimated by Equation 12-4 of Lyman, W.J., W.F. Reehl and D.H. Rosenblatt, 1990, *Handbook of Chemical Property Estimation Methods*, American Chemical Society, Washington, DC.
[h]Estimated by Equation 13-5 of Lyman, W.J., W.F. Reehl and D.H. Rosenblatt, 1990, *Handbook of Chemical Property Estimation Methods*, American Chemical Society, Washington, DC.
[i]Hazardous Substances Data Bank (HSDB), 2012, National Library of Medicine, on line.
[j]U.S. Environmental U.S. Environmental Protection Agency (EPA), 2004b, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final*, Office of Superfund Remediation and Technology Innovation, Washington, DC, EPA/540/R/99/005, OSWER 9285.7-02EP, NTIS No. PB99-963312, July.
[k]U.S. Environmental Protection Agency (EPA), 2002, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, December.
[l]U.S. Environmental Protection Agency (EPA), 2003, *Users Guide for Evaluating Subsurface Vapor Intrusion into Buildings*, Office of Emergency and Remedial Response, Washington, DC, 19 June.

Considerable discrepancy was noted in the VP values for 1,2-dichloropropene. HSDB (2012) offered a value of 90.8 mm Hg (1.19E-1 atm) at 20 °C from a 1981 report, and EPA (2004) offered a value of 24 mm Hg (3.16E-2 atm) at 25 °C from an experimental data base (not specified). The reason for the discrepancy is not apparent. The value of 24 mm Hg (3.16E-2 atm) at 25 °C from EPA (2004) was selected as the more rigorously reviewed source.

There was also discrepancy between the log K_{ow} values for 1,3-dichloropropene. EPA (2004) offered a value of 1.60, but the source is unclear. HSDB (2012) offered a value of 2.00, and EPA (2004) cited experimental values of 2.03 and 2.06. The value of 2.00 from HSDB (2012) was selected as better documented and more consistent with the experimental values compiled by EPA (2004).

Considerable discrepancy was noted in values for H for 1,3-dichloropropene. EPA (2002) offered a value for H' (unitless) of 7.26E-1, equivalent to 1.77E-2 atm-m^3/mole, from an unclear source. HSDB (2012) offered 9.76E-4 atm-m^3/mole, but the source is unclear. EPA (2004) offered 3.55E-3 atm-m^3/mole from an experimental database. The latter value is chosen because it is surrounded with less uncertainty than the other values. Similar discrepancy was noted in values for K_{oc}. EPA (2002) offered a value for K_{oc} of 45.7 L/kg from an unclear source. HSDB (2012) offered 290 L/kg estimated by a regression equation from the K_{ow}. EPA (2004) offered 80.77 L/kg from an updated regression equation. The value of 80.77 L/kg (log K_{oc} = 1.91) from EPA (2002) is selected as fraught with less uncertainty than the EPA (2002) value and estimated by a more current model than the HSDB (2012) value.

2.0 Environmental Fate and Transport

Dichloropropenes may be released in wastewater or as fugitive emissions during their production and use as chemical intermediates or soil fumigants; however releases of 1,1-, 1,2-, and 3,3-dichloropropene are probably low because no uses were located for these isomers, although they may appear at low levels in other dichloropropene mixtures and formulations. The dichloropropenes may be inadvertently formed by the chlorination of water supplies carrying organic matter (ATSDR, 2006).

Dichloropropenes released to soil are likely to be highly mobile because of their low K_{oc} values (HSDB, 2012). Although the dichloropropenes may leach to groundwater, hydrolysis and biodegradation may attenuate the leaching process (ATSDR, 2006). Also, dichloropropenes will adsorb much more readily from the vapor phase than from the dissolved phase. Volatilization from moist soil surfaces is expected to be an important removal process for the dichloropropenes. Volatilization from dry soil surfaces may also be important.

Dichloropropenes released to water are not expected to adsorb to suspended solids and sediment (HSDB, 2012). Volatilization from water surfaces is likely to be the major removal mechanism. Volatilization half-lives for a model river and model lake have been estimated at 1 and 101 hours (specific isomer[s] not specified), respectively. Hydrolysis may also be significant; a hydrolysis half-life of 11 days was estimated for the dichloropropenes at a temperature range of 15 to 25 °C. Biodegradation is also expected to be significant (ATSDR, 2006).

The dichloropropenes are expected to exist entirely in the vapor phase in the ambient atmosphere (HSDB, 2012). Vapor-phase dichloropropene is subject to reaction with photochemically-produced hydroxyl radicals; a half-life of 3 days (specific isomer[s] not specified) was estimated for this reaction. The dichloropropenes are not expected to directly photolyze in the presence of sunlight. Wet deposition may also be a significant removal mechanism (ATSDR, 2006) (1,3-dichloropropene has been detected in rainwater), but volatilization is likely to rapidly return the dichloropropenes to the atmosphere.

Their relatively low log K_{ow}, high water solubility and their potential for metabolism suggests that the dichloropropenes are unlikely to participate significantly in food-chain pathways (HSDB, 2012). 1,3-Dichloropropene was identified by the EPA (1995) as not being of concern for human health through the aquatic food chain. Therefore, biotransfer factors are not compiled or estimated.

3.0 Toxicokinetics

Data for 1,3- and 2,3-dichloropropene indicate that the dichloropropenes are readily absorbed following inhalation or oral exposure (ATSDR, 2006). Excretion data from rats indicate that 62 to 82 percent of inhaled 1,3-dichloropropene and 35 to 40 percent of inhaled 2,3-dichloropropene are absorbed. The higher absorption percentages were estimated at lower concentrations. Higher concentrations were shown to decrease respiratory rate and saturate elimination mechanisms, which effectively reduced respiratory absorption.

Excretion data for 1,3- and 2,3-dichloropropene in rats indicate that well upwards of 90 percent of an ingested dose is absorbed from the GI tract. Excretion data from human volunteers indicate that dermal uptake occurs, but reliable quantitative data were not located.

The dichloropropenes appear to be widely distributed following absorption. After 6-hour inhalation exposure to radiolabeled 2,3-dichloropropene, tissue levels of radioactivity from highest to lowest were found in the urinary bladder, nasal turbinates, kidneys, small intestine, liver, trachea and larynx (ATSDR, 2006). Approximately 9 percent of the absorbed radioactivity was accounted for in the body tissues. Following gavage treatment with radiolabeled 1,3-dichloropropene, highest levels of radioactivity were found in the forestomach and urinary bladder; lower levels were located in a wide variety of tissues. Tissue levels fall rapidly after exposure is terminated; there appears to be no tendency for the body to accumulate the parent compound or its metabolites. It is noteworthy that the forestomach is the target organ of prolonged oral exposure, the nasal turbinates are the target of prolonged inhalation exposure, and the urinary bladder is a target organ for the carcinogenicity of 1,3-dichloropropene.

Data from rats indicate that 1,3-dichloropropene is metabolized by three primary pathways. Most important is dechlorination and conjugation with glutathione at carbon-3, followed by conversion to a mecapturic acid and acetylation to form the N-acetyl-cysteine metabolite, which is excreted (ATSDR, 2006). Excretion data from occupationally exposed humans indicate that this pathway predominates in humans as well. A minor pathway involves hydrolysis and dechlorination at carbon-3 to form 1-chloroallyl alcohol, which undergoes further oxidation and oxidative dechlorination at carbon-1 and breakage of the chain to form carbon dioxide and acetyl-CoA, which may be incorporated into body tissues. Another minor pathway involves epoxide formation followed by dechlorination and additional oxidation to form glycidaldehyde and methylglyoxal.

Data from rats indicate that 2,3-dichloropropene is subject to the same three metabolic pathways as observed for the 1,3-isomer (ATSDR, 2006). Conjugation with glutathione predominantes. The other two minor pathways (epoxide formation and hydrolysis with dechlorination) yield metabolites that have been shown to be mutagenic, which apparently accounts for the carcinogenicity of the 1,3-isomer.

Excretion of dichloropropene metabolites is primarily in the urine following inhalation exposure of rats (ATSDR, 2006). Fecal excretion is also significant, more so for 2,3-dichloropropene than for 1,3-dichloropropene. Approximately 3 percent of the absorbed amount of 2,3-dichloropropene was excreted as carbon dioxide. Similar patterns are observed after oral exposure of rats; urinary excretion predominates. cis-1,3-Dichloropropene is metabolized and excreted in the urine as mercapturic acid metabolites more efficiently than the trans-isomer. trans-1,3-Dichloropropene is metabolized to carbon dioxide more efficiently than the cis-isomer.

The limited toxicokinetic data suggest that there is more variation between the dichloropropene isomers than between species. The differences appear to be quantitative rather than qualitative, supporting the assumption that the toxicity of the isomers may be similar.

4.0 Dermal Exposure

EPA (2004) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. As noted above, the dichloropropenes are extensively absorbed from the GI tract. Therefore, no

GAF is developed for the dichloropropenes and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

It appears from the previous section that the dichloropropenes are absorbed through the skin, but data are not available regarding the extent of dermal uptake from soil. VOCs tend to volatilize from soil when applied to the skin, reducing dermal uptake to toxicologically insignificant levels (EPA, 2004). Therefore, dermal uptake of the dichloropropenes from soil is not quantified.

The values for t*, K_p, τ, FA and B shown below for 1,3-dichloeopropene were taken directly from EPA (2004), even though as noted above the selected K_{ow} value for this compound differes slightly from that provided by EPA (2004). Values for t*, K_p, τ, FA and B for the other isomers were estimated from the MW and log K_{ow} values given above and the EPA (2004) method, as follows:

Chemical	t*	K_p	τ	FA	B
1,1-Dichloropropene	1.05	1.77E-2	0.44	1	0[a]
1,2-Dichloropropene	1.05	1.77E-2	0.44	1	0[a]
1,3-Dichloropropene	1.07	4.30E-3	0.45	1	0[a]
2,3-Dichloropropene	1.05	1.50E-2	0.44	1	0[a]

t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); τ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).
[a]Sufficiently small to be rounded to zero.

5.0 Noncancer Effects Evaluation

Toxicity data were not located for 1,1-dichloropropene. Acute toxicity data for 1,2-dichloropropene include an oral LD_{50} value of 2 g/kg in rats and a dermal LD_{50} of 8750 mg/kg in rabbits (HSDB, 2012), indicating that the acute toxicity of the 1,2-isomer is relatively low. Descriptions of agonal signs or necropsy findings were not located. Data regarding prolonged exposure to 1,2-dichloropropene were not located.

Oral LD_{50} values for 1,3-dichloropropene include 94 to 713 mg/kg in rats and 215 to 640 mg/kg in mice (ATSDR, 2006; HSDB, 2012). The wide range of values within species probably reflects differences in the preparations and formulations tested. Necropsy of the decedents from one study revealed liver and kidney damage. EPA (2012) verified a chronic oral RfD for 1,3-dichloropropene of 3E-2 mg/kg-day based on chronic stomach irritation in rats treated with a microencapsulated formulation of Telone II (96 percent 1,3-dichloropropene) in the diet. In the key study, male and female rats were fed diets that provided dose rates of 0 (control), 2.5, 12.5 or 25 mg/kg-day for 24 months. Decreased body weight gain was observed in a dose-related manner that reached statistical significance in rats of both sexes in the high dose group. The incidence of hyperplasia of the epithelium of the forestomach showed a statistically significant increase in rats in the 12.5 and 25 mg/kg-day groups. Hyperplasia of the forestomach was interpreted as a response to chronic stomach irritation, which was identified as the critical effect of prolonged ingestion exposure. The 95 percent lower confidence limit on the maximum likelihood estimate of the dose corresponding to a 10 percent response rate ($BMDL_{10}$) was estimated as 3.4 mg/kg-day. Application of an uncertainty factor of 100 (factors of 10 each for intra- and inter-species variation) to the $BMDL_{10}$ yields the verified chronic oral RfD of 3E-2

mg/kg-day. Confidence in the verified chronic oral RfD is high. Stomach irritation is considered the critical effect of prolonged oral exposure.

EPA (1997) provides a provisional subchronic oral RfD for 1,3-dichloropropene of 3E-3 mg/kg-day based on a NOEL for increased organ weights of 3 mg/kg-day in rats in a 90-day dietary study. A LOAEL was not identified. An uncertainty factor of 1000 was used. It is likely that the increase in organ weights reported by EPA (1997) may reflect increased organ-to-body weight ratios, which would be expected and consistent with the observation of decreased overall body weight gain in the chronic study described in the previous paragraph. The NOEL of 3 mg/kg-day in the 90-day study also is consistent with the effect levels observed in the chronic study described in the previous paragraph. It is not reasonable, however, that a subchronic oral RfD should be lower than a chronic oral RfD. Therefore, the verified chronic oral RfD of 3E-2 mg/kg-day is adopted as sufficiently protective for subchronic as well as chronic exposure.

Occupational exposure to high levels of 1,3-dichloropropene in air is associated with skin, eye and respiratory tract irritation (ACGIH, 1991). EPA (2012) presents a verified inhalation RfC for 1,3-dichloropropene of 2E-2 mg/m^3 based on a human equivalent adjusted 95 percent lower confidence limit on the maximum likelihood estimate of the concentration corresponding to a 10 percent response rate ($BMCL_{10}$) of 0.72 mg/m^3 in an intermittent exposure inhalation study in mice. In the key study rats and mice were exposed to technical grade 1,3-dichloropropene at concentrations of 0 (control), 5 ppm (22.7 mg/m^3), 20 ppm (90.8 mg/m^3) or 60 ppm (272 mg/m^3) 6 hours/day, 5 days/week for two years. The only treatment-related effects in rats were histopathological changes in the nasal epithelium in the high-concentration group after 24 months, but not after 6 or 12 months of exposure. Effects in mice included masses in the lungs in males in the high-dose group, and slight hypertrophy and hyperplasia of the nasal epithelium in the two lower concentration groups. Hyperplasia of the urinary bladder epithelium was also observed in female mice in the high-concentration group. Hypertrophy and hyperplasia in the nasal epithelium of mice was identified as the critical effect of inhalation exposure. An uncertainty factor of 30 was applied to the human equivalent adjusted $BMCL_{10}$ of 0.72 mg/m^3 to derive the verified chronic inhalation RfC of 2E-2 mg/m^3. The chronic inhalation RfC is equivalent to an inhalation RfD of 5.7E-3 mg/kg-day.

EPA (1997) adopted the verified chronic inhalation RfC of 2E-2 mg/m^3 (5.7E-3 mg/kg-day) as the provisional subchronic inhalation RfC. Hypertrophy and hyperplasia of the nasal epithelium is the critical effect of prolonged inhalation exposure to 1,3-dichloropropene.

Toxicity date for 2,3-dichloropropene are largely limited to an oral LD_{50} values in rats of 285 to 320 mg/kg and a dermal LD_{50} in rabbits of 1580 mg/kg (ATSDR, 2006; HSDB, 2012).

Toxicity information sufficient for RfD or RfC estimation is not available for 1,1-, 1,2- or 2,3-dichloropropene. 1,3-Dichloropropene is selected as a surrogate for 1,1-, 1,2- and 2,3-dichloropropene because of the similarity in chemical structure. Therefore, the noncancer oral and inhalation toxicity values described for 1,3-dichloropropene are applied also to 1,1-, 1,2- and 2,3-dichloropropene.

6.0 Carcinogenicity Evaluation

In an earlier assessment, EPA (2012) verified 1,3-dichloropropene as a cancer weight-of-evidence B2 compound – probable human carcinogen – on the basis of increased incidences of various tumor types in rats and mice in three oral studies and an inhalation study. Also, 1,3-dichloropropene yields positive results in tests for mutagenic activity and is structurally similar to chemicals known to produce similar types of tumors in rodents. Consistent with more recent EPA (2005) cancer assessment guidelines, EPA (2012) characterized 1,3-dichloropropene as likely to be a human carcinogen.

EPA (2012) developed and verified oral cancer SFs of 1E-1 per mg/kg-day from the incidence of urinary bladder tumors in female mice in a two-year gavage study, 5E-2 per mg/kg-day for liver tumors in male rats in the same study, and 5E-2 per mg/kg-day for liver tumors in male rats in a two-year dietary study. EPA (2012) recommended the SF of 1E-1 per mg/kg-day because it is the most conservative estimate and there was less uncertainty regarding the actual dose delivered.

EPA (2012) developed and verified an inhalation URF of 4E-6 per $\mu g/m^3$ based on the incidence of lung tumors in male mice in a two-year inhalation study. The URF is equivalent to an inhalation SF of 1.4E-2 per mg/kg-day.

The toxicokinetic data summarized above and the EPA (2012) cancer evaluation strongly indicate that the mode of action for carcinogenicity arises from genotoxicity. EPA (2005) proposed that the oral and inhalation cancer potency factors developed for genotoxic chemicals should be modified with the age dependent adjustment factors (ADAF) of 10 for children under 2 years of age, 3 for children 2 to 16 years of age, and 1 for adults and children over 16 years of age.

7.0 Toxicity Summary

Toxicity values for 1,3-dichloropropene are summarized as follows:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
3E-2	3E-2	St	2E-2/ 5.7E-3	2E-2/ 5.7E-3	NE	See above	1E-1	See above	4E-6	1.4E-2

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.
Target organ or critical effect abbreviations: St = stomach; NE = nasal epithelium.
[a]sRfDo, cRfDo and SFo should be used for dermal exposure without adjustment for GI absorption.

8.0 References

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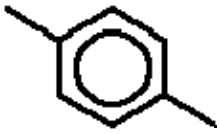
XYLENES (DIMETHYLBENZENE), TOTAL (1330-20-7)



p-Xylene

1.0 Introduction and Physical Properties

The xylenes, also known as dimethylbenzenes, exist as three isomers: 2-xylene (1,2-dimethylbenzene, ortho- or o-xylene) (95-47-6), 3-xylene (1,3-dimethylbenzene, meta- or m-xylene) (108-38-3) and 4-xylene (1,4-dimethylbenzene, para- or p-xylene) (106-42-3) (HSDB, 2012). The o-, m-, and p-xylene nomenclature will be used herein to be consistent with the manner in which xylene concentrations in environmental media are usually reported by the analytical laboratories.

The xylenes are **VOCs** derived from coal tar, coal gas, and petroleum distillation (ATSDR, 1995; HSDB, 2012). They occur as clear liquids in the pure state at most ambient temperatures, although 4-xylene occurs as colorless plates or prisms at temperatures below 56EF (13.33EC). Natural sources include petroleum, forest fires and volatiles from plants.

Xylenes are used in the manufacture of other organic compounds, dyes, insecticides and pharmaceuticals, and as solvents (ATSDR, 1995; HSDB, 2012). They are components of aviation gasoline, asphalt and naphtha, and automobile exhaust. Technical xylene consists of approximately 44 percent m-xylene, 20 percent o-xylene, 20 percent p-xylene, and 15 percent ethylbenzene. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
o-Xylene (95-47-6)										
106.16[a]	3.12[a]	5.20E-3[b] (25°C)	2.56[b]	8.70E-2[b] (25°C)	1.00E-5[b] (25°C)	8.70E-3[a] (25°C)	1.78E+2[b] (20-25°C)	417.60[c]	630.30[c]	8.66E+3[c]
m-Xylene (108-38-3)										
106.2[d]	3.20[d]	7.34E-3[b] (25°C)	2.61[b]	7.00E-2[b] (25°C)	7.80E-6[b] (25°C)	1.09E-2[a] (25°C)	1.16E+2[b] (20-25°C)	412.27[c]	617.05[c]	8.52E+3[c]
p-Xylene (106-42-3)										
106.16[a]	3.15[a]	7.66E-3[b] (25°C)	2.59[b]	7.69E-2[b] (25°C)	8.44E-6[b] (25°C)	1.16E-2[a] (25°C)	1.85E+2[b] (20-25°C)	411.52[c]	616.20[c]	8.53E+3[c]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K);.$H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole).

[a]Hazardous Substance Data Bank (HSDB), 2012, National Library of Medicine, on line.

[b]U.S. U.S. Environmental Protection Agency (EPA), 2002, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Office of Solid Waste and Emergency Response, Washington, D.C., 9355.4-24, December.

[c]U.S. Environmental Protection Agency (EPA), 2000, ***User's Guide for the Johnson and Ettinger (1991) Model for Subsurface Vapor Intrusion into Buildings, Revised***, Office of Emergency and Remedial Response, Washington, DC, December.

[d]U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part E - Supplemental Guidance for Dermal Risk Assessment)***, Final, Office of Superfund Remediation and Technology Innovation, Washington, D.C., EPA/540/R-99/005, July.

It is recommended that the physical properties for m-xylene should be applied to mixed xylene isomers or data where the specific isomer is not identified, because m-xylene is the major component of the technical mixture and is likely to predominate following xylene releases.

2.0 Environmental Fate and Transport

Naturally occurring sources of xylenes are petroleum, forest fires and volatiles from plants (ATSDR, 1995; HSDB, 2012). The production and use of xylenes in petroleum products and as chemical solvents and intermediates may result in their release to the environment as fugitives and through various waste streams. Off-gassing from landfills and automobile exhaust are other significant sources. Spills, leaking underground storage tanks and associated plumbing, and leaching from landfills may release xylenes to soil and groundwater.

Xylenes will exist solely in the vapor phase in the ambient atmosphere, where they are subject to degradation by reaction with photochemically-produced hydroxyl radicals as the only significant removal process (ATSDR, 1995; HSDB, 2012). The atmospheric lifetime of xylenes is about 1 to 2 days. Products of photooxidation include a wide variety of ring hydroxylation and ring cleavage products.

Volatilization is expected to be the major removal mechanism for xylenes released to surface soil, but, depending on the size and rate of release, the majority of the release may infiltrate to subsurface soil (ATSDR, 1995). Photooxidation may degrade a significant part of the small amount that remains at the surface. Biodegradation is probably the only significant subsurface removal mechanism, but it is expected to be slow. A wide range of experimental K_{oc} values have been reported in soil samples with differing pH and organic carbon content (HSDB, 2012), suggesting a wide range in the extent to which the xylenes adsorb to soil particles. Generally, however, xylene is fairly mobile and may readily leach to groundwater.

Volatilization is probably the most significant removal mechanism for xylenes in surface water (ATSDR, 1995). Biodegradation may occur in surface water, groundwater and landfill leachate, although quite slowly. Oxidative reactions are expected to be insignificant. Xylenes are expected to adsorb somewhat to suspended solids and sediment in water (HSDB, 2012).

Xylenes are not expected to participate significantly in food-chain pathways (ATSDR, 1995; HSDB, 2012); therefore, biotransfer factors are not provided.

3.0 Toxicokinetics

Xylenes are rapidly and extensively absorbed during inhalation and following oral exposure (ATSDR, 1995). In humans, approximately 50 to 73 percent of the inhaled concentration is retained. In laboratory animals, approximately 90 percent of an ingested dose is absorbed. Liquid xylene is absorbed through the skin of humans, but dermal uptake of xylene vapors approximates only 1 percent of inhalation uptake. A study in rats showed that dermal uptake of xylene adsorbed to soil is much slower than dermal uptake of the neat liquid.

Absorbed xylene is largely bound to serum protein in the blood and is distributed rapidly and widely throughout the body, but particularly to highly vascular tissues and those high in lipid content (e.g., blood, brain, liver) (ATSDR, 1995). Levels in fetal tissues approximate 2 percent of those measured in maternal brain.

The predominant metabolic pathway in humans and animals for all xylene isomers is oxidation of one of the methyl groups to the corresponding alcohol, with further oxidation to the

corresponding methylbenzoic acid (ATSDR, 1995). The methylbenzoic acids conjugate with glycine to form the corresponding methylhippuric acids, which are the major urinary metabolites. Much lesser quantities of the alcohols and o-methylbenzoic acid are also excreted in the urine. Methylbenzaldehyde, proposed as the ultimate toxicant because it inactivates enzymes involved in electron transport, has been identified in laboratory animals but not in humans. Metabolism in laboratory animals differs from that in humans largely in the nature of the conjugates that are formed. Ring hydroxylation to form phenolic compounds represents a minor metabolic pathway is both humans and animals.

The xylenes are rapidly excreted from the body, largely in the form of urinary metabolites (ATSDR, 1955) as described above. Approximately 5 percent of an oral dose is eliminated in the breath as unchanged compound. Residues are slightly more persistent in adiposa and muscle tissue than other tissues of the body, but no organ or tissue accumulates xylene residues.

4.0 Dermal Exposure

EPA (2004) recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. Xylenes are nearly completely absorbed from the GI tract; therefore, no GAF is developed for the xylenes and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

Xylene in soil is absorbed by the skin, albeit very slowly, but quantitative data were not located. VOCs tend to volatilize from soil when applied to the skin, reducing dermal uptake to toxicologically insignificant levels (EPA, 2004). Therefore, dermal uptake of xylenes from soil is not evaluated. Values for t*, K_p, τ, FA and B are provided by EPA (2004) for m-xylene as follows:

Chemical	t*	K_p	τ	FA	B
m-Xylene	1.01	5.3E-2	0.42	1.0	0.2
t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); τ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).					

The dermal uptake parameters presented by EPA (2004) for m-xylene are applied to all the xylene isomers as well as to total xylenes.

5.0 Noncancer Effects Evaluation

Oral LD_{50} values for xylenes include 3.5 to 8.6 g/kg in rats and 1.6 to 5.6 g/kg in mice (HSDB, 2012), suggesting that the acute toxicity is low, but that mice may be slightly more sensitive than rats to the acute effects of ingested xylenes. Prolonged oral exposure of animals to xylenes is associated with reduced body weight and survival without histopathological alterations in the internal organs (EPA, 2012). EPA (2012) confirmed a previously verified chronic oral RfD for total xylenes of 2E-1 mg/kg-day based on a NOAEL of 250 mg/kg, equivalent to a continuous dose rate of 179 mg/kg-day, for decreased body weight and survival in male rats in chronic gavage studies with mixed xylenes. The LOAEL was 500 mg/kg, equivalent to 357 mg/kg-day. Mice were also included in the study. The LOAEL in mice was 1000 mg/kg, equivalent to 714 mg/kg-day, associated with hyperactivity, which was consistently observed at 5 to 30 minutes

after treatment. The mice did not exhibit the effects on body weight or survival that was observed with the rats, establishing the rat as the more sensitive species to prolonged oral exposure. An uncertainty factor of 1000 was applied to the rat NOAEL to derive the verified chronic oral RfD. Confidence in the chronic oral RfD is medium.

EPA (1997) presented provisional chronic oral RfDs for o-xylene and m-xylene of 2E+0 mg/kg-day based on an earlier IRIS evaluation of the same rat and mouse gavage study. Given the EPA (2012) re-evaluation of this study and the lowering of the chronic oral RfD by an order of magnitude, it seems prudent to adopt the verified chronic oral RfD of 2E-1 mg/kg-day for use with mixed xylenes and all xylene isomers. The critical effects of prolonged oral exposure to xylenes are reduced body weight and reduced survival. The verified chronic oral RfD is adopted as sufficiently protective for subchronic oral exposure to mixed xylenes and all xylene isomers.

Occupational exposure to xylenes induces CNS effects and GI disturbances (ACGIH, 1991). Other effects attributed to occupational exposure to xylene (blood dyscrasias, and heart, liver and kidney damage) may arise from concurrent exposure to other chemicals. EPA (2012) verified a chronic inhalation RfC of 1E-1 mg/m^3 based on CNS effects. In the key study, male rats were intermittently exposed to m-xylene at airborne concentrations of 0, 50 or 100 ppm for three months. Endpoints evaluated included spontaneous motor activity and motor coordination as measured by performance on a rotorod. Body and organ weights and limited blood chemistry and hematological parameters were also evaluated, but minor alterations in these endpoints were not attributed to exposure to m-xylene. The study identified 50 ppm as the NOAEL and 100 ppm as the LOAEL for impaired rotorod performance. The NOAEL is equivalent to an adjusted human equivalent concentration of 39 mg/m^3. Application of an uncertainty factor of 300 to the NOAEL yields the verified chronic inhalation RfC of 1E-1 mg/m^3, which is equivalent to a chronic inhalation RfD of 2.9E-2 mg/kg-day. The uncertainty factor consists of a factor of 10 to provide greater protection for more sensitive individuals, and factors of 3 each to extrapolate from animals to humans, to expand from subchronic to chronic exposure, and to account for deficiencies in the data base. The CNS is considered to be the target organ for prolonged inhalation exposure to xylenes. Confidence in the chronic inhalation RfC is medium.

No EPA-derived subchronic inhalation RfC is available for exposure to xylene. However, a preliminary subchronic inhalation RfC can be derived by applying an uncertainty factor of 100 to the NOAEL of 39 mg/m^3 in the subchronic rotorod study in rats described above. The uncertainty factor of 100 reflects the chronic uncertainty factor of 300 without the factor of 3 to expand from subchronic to chronic exposure. The preliminary subchronic inhalation RfC so derived is 4E-1 mg/m^3, which is equivalent to a subchronic inhalation RfD of 1.1E-1 mg/kg-day.

6.0 Carcinogenicity Evaluation

Xylene was previously characterized as a cancer weight-of-evidence Group D compound (not classifiable as to carcinogenicity to humans). Using a more descriptive characterization, EPA (2012) concluded that the cancer *data are inadequate for an assessment of the carcinogenic potential of xylenes*. Adequate human data on the carcinogenicity of the xylenes are not available, and the available animal data are inconclusive as to the ability of xylenes to cause a carcinogenic response. Evaluations of the genotoxic effects of xylenes have consistently given negative results. Potency factors are not available.

7.0 Toxicity Summary

Toxicity values for the xylenes are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
2E-1	2E-1	BW, Su	4E-1/ 1.1E-1	1E-1/ 2.9E-2	CNS	D	NA	D	NA	NA

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); NA = not applicable.
Target organ or critical effect abbreviations: BW = reduced body weight; Su = reduced survival; CNS = central nervous system.
[a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.

8.0 References

Agency for Toxic Substances and Disease Registry (ATSDR), 1995, ***Update Toxicological Profile for Xylenes***, U.S. Department of Health and Human Services, Atlanta, Georgia, August, on line.

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U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part E - Supplemental Guidance for Dermal Risk Assessment)***, Final, Office of Superfund Remediation and Technology Innovation, Washington, D.C., EPA/540/R-99/005, July.

U.S. Environmental Protection Agency (EPA), 2012, ***Integrated Risk Information System (IRIS)***, National Center for Environmental Assessment, Cincinnati, OH, on line.

Miscellaneous

CYANIDE ANION (57-12-5), FREE CYANIDE, HYDROGEN CYANIDE (74-90-8)

Cyanide Anion

1.0 Introduction and Physical Properties

The term cyanide is properly used to mean the cyanide anion illustrated above. The term is also used herein to represent any form of cyanide, particularly if the form was not specified in the literature cited. The term free cyanide generally means the cyanide anion, hydrogen cyanide and some cyanide salts (e.g., sodium cyanide, potassium cyanide) that readily dissociate and release cyanide in water solutions within the biological pH range (ATSDR, 2006). Chlorine-amenable cyanide includes free cyanide as well as most organic complexes and most simple metal complexes. The chlorine-amenable fraction excludes iron cyanides, which resist degradation with release of cyanide. Total cyanide includes all of the above.

Concentrations of cyanide reported by various analytical procedures do not necessarily reflect the amount that is bioavailable, and data are not available with which to quantify bioavailability (ATSDR, 2006). Free cyanide and simple water soluble complexes (part of the chlorine-amenable fraction) are expected to be highly bioavailable. More complicated organic complexes and many metal complexes are expected to be somewhat less bioavailable, but the nature of the specific compound and pH of the matrix will greatly influence bioavailability. A reasonably conservative approach (adopted herein) is to evaluate total cyanide in the RA. A more reasonable approach, including only chlorine-amenable cyanide in the RA, might be justified if there were large differences between concentrations of chlorine-amenable and total cyanide. Large differences (upwards of an order of magnitude) might be expected in mining situations where metal complexes are expected to predominate.

Hydrogen cyanide is used in the synthesis of a wide range of organic chemicals (ATSDR, 2006; HSDB, 2012). Cyanide salts are used in metal treatment, ore extraction, as anticaking agents in road salt, and in a wide variety of other uses. Hydrogen cyanide has been used formerly to fumigate grain to control insects and rodents, and to exterminate rodents in their burrows. The cyanide anion is an **inorganic** substance. Hydrogen cyanide is a liquid, or gas above 26.5 EC (HSDB, 2012), and behaves very much like a **VOC** in the environment. Relevant physical properties of inorganic cyanide and hydrogen cyanide are compiled below:

Cyanide Anion (57-12-5)							
MW	log K_{ow}	H	K_d	D_a	D_w	VP	S
26.02[a]	NA	NA	NA	NA	NA	NA	Note 1[b]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; K_d = soil/water partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; NA = not applicable.
Note 1: Several simple complexes or salts (e.g., hydrogen cyanide, sodium cyanide, potassium cyanide) are highly soluble in water, while other salts and organic complexes are sparingly soluble or practically insoluble in water.
[a]Howard, P.H. and M. Neal, 1992, ***Dictionary of Chemical Names and Synonyms***, Lewis Publishers, Ann Arbor.
[b]Agency for Toxic Substances and Disease Registry (ATSDR), 1997, ***Update Toxicological Profile for Cyanide***,

Cyanide Anion (57-12-5)							
MW	log K_{ow}	H	K_d	D_a	D_w	VP	S
U.S. Department of Health and Human Services, Atlanta, GA, on line, September.							

Hydrogen Cyanide (74-90-8)										
MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
27.03[a]	-0.25[a]	1.33E-4[a] (25°C)[b]	-0.044[c]	2.11E-1[c] (25°C)[b]	2.44E-5[c] (25°C)[b]	9.76E-1[a] (25°C)	1E+6[a] (25°C)	298.8[a]	456.7[a]	6.02E+3[a]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K);.$H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole).
[a]Hazardous Substance Data Bank (HSDB), 2012, National Library of Medicine, on line.
[b]Assumed.
[c]Calculated as described in Introduction to Toxicity Profiles.

2.0 Environmental Fate and Transport

Cyanide is a naturally occurring substance (ATSDR, 2008; HSDB, 2012). Hydrogen cyanide may be produced naturally by microorganisms as well as from the degradation of cyanogenic glycosides, which are produced naturally by many plants. Several species of blue-green algae liberate hydrogen cyanide in the process of nitrate metabolism. Laetrile and amygdalin, which occur in substantial concentrations in several fruit pits (e.g., cherries, peaches, apricots, apples, pears) liberate cyanide following ingestion.

Major releases to the environment occur from metal treatment and ore extraction (primarily to water) and in automobile exhaust (primarily to the atmosphere) (ATSDR,2008). The production of hydrogen cyanide and its use as a starting material in the manufacture of acrylates, cyanide salts, herbicides and dyes as well as its former use as a fumigant may result in its release to the environment through various waste streams (HSDB, 2012). It also may be liberated from blast furnaces, gas works, coke ovens and oil shale retorting operations. Most hydrogen cyanide is emitted primarily to the atmosphere or waste water. Various cyanide salts may be released during their use in ore extraction and other metallurgic operations. Materials containing cyanide compounds disposed on land may cause elevated levels of cyanide in underlying strata and in groundwater. Cigarette smoke contains low levels of hydrogen cyanide.

Hydrogen cyanide released to the atmosphere is expected to remain solely in the vapor phase and to react slowly with photochemically generated hydroxyl radicals (HSDB, 2012). A half-life of approximately 300 to 550 days has been estimated for this reaction. Hydrogen cyanide is expected to be resistant to direct photolysis. The relatively slow rate of degradation suggests that hydrogen cyanide has the potential for transport over long distances before being removed by physical or chemical processes. Since hydrogen cyanide is miscible in water, wet deposition may be the most important removal process. Metal cyanide particles released to the air in dust are expected to be removed by both wet and dry deposition.

Cyanide may occur in the form of hydrogen cyanide, metal salts, or immobile metallocyanide complexes in soil (ATSDR, 2008; HSDB, 2012). It is expected that volatilization of hydrogen cyanide would be an important mechanism for cyanide removal from dry soil surfaces and from moist soil surfaces with pH less than 9.2. Hydrogen cyanide and many cyanide salts are very water soluble and are expected to be highly mobile in soil, readily leaching to deeper levels and to groundwater. Concentrations sufficiently low so as not to be toxic to microorganisms may undergo biodegradation in subsurface soil. Microbial degradation may yield formamide, or

complete mineralization may yield carbon dioxide and ammonia. Degradation of low concentrations in soil may substantially reduce the potential for leaching to groundwater.

Hydrogen cyanide is not expected to adsorb to suspended solids and sediment in water (HSDB, 2012). Volatilization from water surfaces is expected to be the most important removal mechanism. Biodegradation may be an important removal mechanism for low concentrations that are not toxic to microorganisms as explained for soil.

Hydrogen cyanide is volatile and labile at low concentrations. Its low log K_{ow} suggests that bioconcentration is unlikely to be significant. Some metal complexes have been shown to biotransfer, but the toxicity of these complexes is much less than that of hydrogen cyanide because of their very low solubility (ATSDR, 2008). There is no evidence of biomagnification in the food chain (ATSDR, 2008), and EPA (1995) has determined that cyanide is not a threat to human health through fish consumption. Biotransfer factors are not estimated for cyanide for these reasons.

3.0 Toxicokinetics

Inhalation exposure of humans to hydrogen cyanide results in very rapid absorption and high systemic retention (approximately 58 percent retention) (ATSDR,2008). Absorption is similarly rapid following oral exposure. Excretion data from orally treated animals suggest a minimum absorption factor of approximately 50 percent, but the extent of absorption is probably much higher. Dermal absorption of hydrogen cyanide by humans is inferred from toxicity data and supported by data from experimental animals. It is likely that some cyanide salts may also be absorbed but the extent has not been quantified.

Cyanide is rapidly and widely distributed throughout the body following absorption (ATSDR,2008).

The primary detoxication pathway involves the action of the enzyme rhodanese to combine cyanide with sulfane sulfur to yield thiocyanate, which is rapidly excreted through the urine (ATSDR, 2008). Rhodanese activity is located in most tissues of the body; the relative activity largely dependent on species. Highest levels are not generally found in the liver, which is often the primary site of metabolism for environmental contaminants. Minor detoxication pathways include pulmonary excretion of hydrogen cyanide, conversion of cyanide to carbon dioxide or other constituents that enter the single-carbon pool, and incorporation into cyanocobalamin (vitamin B_{12}). Elimination occurs rapidly, resulting in a half-life for cyanide of approximately 6 hours in humans. The incorporation of carbon into the single-carbon pool may account for the low estimate of extent of GI absorption from excretion data.

Hydrogen cyanide is the toxic moiety, complexing with ferric iron in various metalloenzymes, inhibiting mitochondrial cytochrome c oxidase and resulting in histotoxic anoxia (ATSDR,2008). Several changes follow that exacerbate the original biochemical lesion.

4.0 Dermal Exposure

GI absorption of cyanide almost certainly exceeds 50 percent as noted in Section 3.0. EPA (2004) suggests that oral toxicity values should not be adjusted when used for dermal exposure

unless GI absorption is less than 50 percent. Therefore, the oral toxicity values described below are adopted without modification for use for dermal exposure

EPA (1991) stated that, "performing an oral-to-dermal extrapolation would not be appropriate because of the uncertainty that the oral RfD for cyanide would provide protection for the effects caused by dermal exposure." The available data, however, suggest that the effects following oral and dermal exposure are similar (ATSDR, 2008). Furthermore, nothing in the toxicokinetic data suggest that detoxication would occur more efficiently following oral exposure so that the oral RfD may not be sufficiently protective for dermal exposure. Therefore, it is judged that the oral RfD is an appropriate value with which to evaluate the toxicity of dermal exposure to cyanide.

Two scenarios are relevant to dermal exposure to cyanide. The first scenario is exposure to cyanide in soil. Cyanide present in soil as hydrogen cyanide would be likely to volatilize so that dermal exposure is expected to be insignificant, as noted by EPA (2004) for other VOCs. Therefore, dermal exposure to hydrogen cyanide in soil is not quantified. It is possible that cyanide may exist as various salts or complexes in soil. Although these compounds may be dermally absorbed, the extent has not been quantified, so no ABS is available with which to quantify dermal uptake. Therefore, dermal uptake of cyanide from soil is not quantified, as recommended by EPA (2004).

The second scenario is exposure to cyanide in water, which may occur as hydrogen cyanide or soluble salts. Cyanide in water will be assumed to be present entirely as hydrogen cyanide to simplify the evaluation. Values for t*, K_p, τ, B and FA estimated by the EPA (2004) methodology follow:

Chemical	t*	K_p	τ	FA	B
Hydrogen Cyanide	0.36	7.65E-4	0.15	1	0.0
t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).					

5.0 Noncancer Effects Evaluation

Oral LD_{50} values in laboratory animals range from 8 to 22 mg/kg, depending on the particular cyanide compound and laboratory species (ATSDR, 2008; HSDB, 2012), indicating that the acute oral toxicity of cyanide is high. An updated, verified chronic oral RfD of 6E-4 mg/kg-day for hydrogen cyanide and cyanide salts was derived in September 2010 from a National Toxicology Program (NTP) examination of cyanide over a wide range of concentrations in both male and female rats and mice, under subchronic (91-day) conditions. Confidence in the RfD is low to medium.

Reproductive effects were observed in males of both species, though rats appeared to be more sensitive. A statistically significant decrease (7%) in cauda epididymis weight was observed at doses of 1.4 mg/kg-day or greater. This effect was identified by EPA as the critical effect. Other male reproductive effects (i.e., decrease in testis weight, number of spermatid heads, spermatid concentration) were found to be statistically significant at higher doses (≥12.5 mg/kg-day).

EPA Benchmark Dose Software was used to derive a benchmark dose (BMD) of 3.5 mg/kg-day, and a benchmark dose lower confidence limit of 1.9 mg/kg-day (BMDL). An overall UF of 3,000 was applied to this value to derive the updated RfD of 6E-4 mg/kg-day. This UF includes a 10-fold factor for extrapolation from subchroinc to chronic, a 10-fold factor to account for variation in sensitivities among humans in the population, and a 3-fold factor to account for deficiencies in the data base. It is noted that the previous RfD, based on thyroid and central nervous system effects, was 2E-2 mg/kg-day.

Use of the RfD for free cyanide to calculate RfDs of other cyanide compounds may be merited, but the ability of the individual cyanogenic species to dissociate and release free cyanide in aqueous solution (and at physiological pHs) should be taken into consideration. If dissociation of the compound is expected, then liberated cations should be considered for potential toxicity independent of CN^-. Also, some metallocyanides, such as copper cyanide, have chemical-specific data and are not included in this analysis.

EPA (2012) lists a verified a chronic inhalation RfC of 8E-4 mg/m^3 for hydrogen cyanide and cyanide salts based on thyroid effects and altered iodide uptake in occupationally exposed humans. The key study involved 36 non-smoking male workers employed in the electroplating sections of three factories in Egypt exposed for 5 to 10 years (1 man exposed for 15 years). Twenty non-smoking unexposed male volunteers served as controls. Breathing-zone cyanide concentrations ranged from 4.63 to 13.69 mg/m^3, with a mean of 7.07 to 11.45 mg/m^3. Symptoms reported more frequently in the exposed workers included (in decreasing order of frequency) headache, weakness, and changes in the senses of taste and smell. Lacrimation, abdominal colic, and precordial (lower stomach) pain, salivation, and nervous instability occurred less frequently. Twenty of the exposed workers had thyroid enlargement to a mild or moderate degree, and thyroid function (iodine uptake) was altered. The lowest mean concentration recorded in the three factories, 7.07 mg/m^3, corresponding to an exposure-adjusted concentration of 2.5 mg/m^3, was designated a LOAEL. Application of an uncertainty factor of 3,000 (a factor of 10 to estimate a NOAEL from a LOAEL, a 10-fold factor to account for variation in sensitivities among humans in the population, 10-fold factor to account for deficiencies in the data base, and a 3-fold factor to account for extrapolation from a largely subchronic study to a chronic RfC)yields the verified chronic inhalation RfC of 8E-4 mg/m^3. The chronic RfC is equivalent to a chronic inhalation RfD of 2.3E-4 mg/kg-day. Confidence in the verified RfC is low to medium.

6.0 Carcinogenicity Evaluation

EPA (2012) classified the cyanide data base as inadequate to assess carcinogenicity because of a lack of data in humans or laboratory animals. Cancer potency factors are not derived for these formerly Group D chemicals.

7.0 Toxicity Summary

Toxicity values for cyanide/hydrogen cyanide are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
6E-3	6E-4	Repro	3E-3/ 8.6E-4	8E-4/ .3E-4	T	D	NA	D	NA	NA

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); NA = not applicable.
Target organ or critical effect abbreviations: Repro = reproductive system; T = thyroid, [a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.

8.0 References

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U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, Washington, DC, EPA/540/R/99/005, OSWER 9285.7-02EP, NTIS No. PB99-963312, July.

U.S. Environmental Protection Agency (EPA), 2012, ***Integrated Risk Information System (IRIS)***, National Center for Environmental Assessment, Cincinnati, OH, on line.

NITRATE (14797-55-8) and NITRITE (14797-65-0)

Nitrate is a naturally occurring member of the nitrogen cycle, being formed and released by nitrogen-fixing bacteria (EPA, 1989; Kettrup and Huppe, 1988). Nitrates are used largely as fertilizers. Relevant physical properties are compiled below:

MW (g/mole)	log K_{ow} (unitless)	H (atm-m^3/mole)	K_d (L/kg)	D_a (cm^2/s)	D_w (cm^2/s)	VP (atm)	S (mg/L)
Nitrate							
62.00 (anion)	NA	NA	NA	NA	NA	NA	Note 1[a]
Nitrite							
46.01 (anion)	NA	NA	NA	NA	NA	NA	Note 1[a]

NA = not applicable.
Note 1: Variable; many nitrate and nitrate salts are very soluble.
[a]Budavari, S, Ed., 1989, ***The Merck Index, An Encyclopedia of Chemicals, Drugs, and Biologicals***, Eleventh Edition, Merck & Co., Rahway, NJ.

Agricultural application of synthetic fertilizer and animal waste is a major mechanism by which nitrates are released to the environment (EPA, 1989; HSDB, 2012). It is also possible that the degradation of nitroaromatic compounds could contribute nitrate to the environment. Data were not located regarding the fate of nitrate or nitrite in the atmosphere, but the high solubility of many nitrate/nitrite compounds suggests that wet deposition may be a major removal process. Nitrate and nitrite in soil and water will exist largely as the soluble anions (EPA, 1989). Chemical interconversion and microbial transformation to other nitrogenous species will occur in soil and water. Biotransfer factors for nitrogen are compiled below:

BCF (L/kg)	Bpr (unitless)	Bpv (unitless)	Bb (unitless)	Bm (unitless)
ND	3.0E+1[a]	3.0E+1[a]	NA (see below)	NA (see below)

ND = no data; NA = not applicable.
[a]Baes, C.F., R.D. Sharp, A.L. Sjoreen, R.W. Shor, 1984, ***A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture***, Health and Safety Division, Oak Ridge National Laboratory, ORNL-5786, September.

It is well established that certain plants grown in soil containing high levels of nitrates (e.g., highly fertilized) may accumulate high levels of nitrate (Menzer, 1991). This is of particular concern to the welfare of domestic ruminant species, which consume large quantities of heavily fertilized forages. Animals, however, do not tend to bioaccumulate nitrate or nitrate. Therefore, human ingestion of food products from animals that consumed feedstuffs obtained from soils with high levels of nitrate is not likely to be a matter for concern.

Data regarding the GI absorption of nitrate/nitrite nitrogen are of limited usefulness. Several competing processes may occur in the acidic and reducing milieu of the GI tract, including conversion of nitrite to N_2O_2, which is probably readily absorbed (EPA, 1989). *In vivo* and *in*

vitro studies indicate that GI absorption of nitrite (the first reduction product of nitrate) may approach 50 to 80 percent. A GAF is of 1 is used per the recommendation of EPA (2004) for chemicals that are absorbed from the GI tract at 50 percent or greater.

Data regarding the dermal absorption of nitrate/nitrite nitrogen were not located; therefore, no ABS value is selected, consistent with EPA (2004) guidance for the evaluation of inorganic constituents. Data were not located regarding the dermal uptake of nitrate/nitrite nitrogen from water. However, as noted above, most nitrate and nitrite salts are very soluble in water. Therefore, it is assumed that the nitrate and nitrite anion may be absorbed by the skin at the same rate as water. The PC for water of 1E-3 cm/hour (EPA, 1992) is adopted for nitrate/nitrite nitrogen.

The oral toxicity of nitrate is mediated by its reduction to nitrite by the microflora of the GI tract (EPA, 2002). Nitrite oxidizes hemoglobin to methemoglobin, which is incapable of transporting oxygen from the lungs to the tissues. Human toxicity is generally associated with high levels of nitrate or nitrite in drinking water. Infants are the most sensitive members of the population. EPA (2012) presents a verified chronic oral RfD for nitrate of 1.6E+0 mg nitrate nitrogen/kg-day, based on a NOAEL of 1.6 mg/kg-day for methemoglobinemia in infants and an uncertainty factor of 1. Confidence in the oral RfD is high. EPA (2012) also presents a verified chronic oral RfD for nitrite of 1E-1 mg nitrite nitrogen/kg-day, based on the same NOAEL and an uncertainty factor of 10. Confidence in the oral RfD is high. The target tissue for the toxicity of nitrate or nitrite is the erythrocyte. The chronic oral RfD of 1E-1 for nitrite nitrogen is adopted as the conservative estimate of a chronic oral RfD for nitrate/nitrite nitrogen.

Data regarding the toxicity of inhalation exposure to nitrate/nitrite nitrogen were not located; an inhalation RfC cannot be developed.

Data regarding the carcinogenicity of uncombined nitrate or nitrite were not located. Nitrite can combine with secondary amines in food or other nitrogenous compounds to form nitrosamines or other N-nitroso compounds, many of which are important animal carcinogens (Menzer, 1991).

References for Nitrate/Nitrite

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Menzer, R.E., 1991, "Water and Soil Pollutants." In: M.O. Amdur, J. Doull and C.D. Klaassen, eds., ***Casarett and Doull's Toxicology, the Basic Science of Poisons***, Fourth Edition, New York: Pergamon Press, p. 872-902.

U.S. Environmental Protection Agency (EPA), 1989, ***Health and Environmental Effects Document for Nitrite***, Final Draft, Prepared by the Environmental Criteria and Assessment Office, Cincinnati, OH, for the Office of Solid Waste, Washington, DC., ECAO-CIN-GO59.

U.S. Environmental Protection Agency (EPA), 1992, ***Dermal Exposure Assessment: Principles and Applications***, Interim Report, Office of Research and Development, Washington, DC, EPA/600/8-91/011B, January.

U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, Washington, DC, EPA/540/R/99/005, OSWER 9285.7-02EP July.

U.S. Environmental Protection Agency (EPA), 2012, ***Integrated Risk Information System (IRIS)***, National Center for Environmental Assessment, Cincinnati, OH, on line.

APPENDIX D

RISK CHARACTERIZATION SPREADSHEETS

Table D-1

Groundskeeper, Current Scenarios, Exposure to Surface Soil
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

(Page 1 of 2)

		Incidental Ingestion				Dermal Contact				
Chemicals of Potential Concern	EPC mg/kg	Cancer Dose mg/kg-day	Noncancer Dose mg/kg-day	ILCR	HQ	Dose Absorbed mg/cm^2-day	Cancer Dose mg/kg-day	Noncancer Dose mg/kg-day	ILCR	HQ
Polychlorinated biphenyls (PCB)										
Aroclor 1016	8.14E-01	2.84E-07	7.96E-07	1.99E-08	1.14E-02	2.28E-08	2.63E-07	7.36E-07	1.84E-08	1.05E-02
Explosives										
Amino-2,6-dinitrotoluene, 4-	1.10E+01	3.85E-06	1.08E-05	NA	5.39E-03	1.32E-08	1.52E-07	4.27E-07	NA	2.13E-04
Amino-4,6-dinitrotoluene, 2-	2.17E+01	7.58E-06	2.12E-05	NA	1.06E-02	3.90E-08	4.50E-07	1.26E-06	NA	6.30E-04
Trinitrotoluene, 2,4,6-	3.11E+02	1.09E-04	3.05E-04	3.26E-06	6.09E-01	1.99E-06	2.30E-05	6.43E-05	6.89E-07	1.29E-01
Semivolatile Organic Compounds										
Benzo(a)anthracene	1.17E+00	4.07E-07	1.14E-06	2.97E-07	NA	3.03E-08	3.50E-07	9.79E-07	2.55E-07	NA
Benzo(a)pyrene	1.01E+00	3.52E-07	9.84E-07	2.57E-06	NA	2.62E-08	3.02E-07	8.45E-07	2.20E-06	NA
Benzo(b)fluoranthene	1.52E+00	5.30E-07	1.48E-06	3.87E-07	NA	3.94E-08	4.55E-07	1.27E-06	3.32E-07	NA
Dibenz(a,h)anthracene	1.96E-01	6.85E-08	1.92E-07	5.00E-07	NA	5.10E-09	5.88E-08	1.65E-07	4.29E-07	NA
Dinitrotoluene, 2,4-	3.33E+00	1.16E-06	3.25E-06	7.90E-07	1.63E-03	6.79E-08	7.82E-07	2.19E-06	5.32E-07	1.10E-03
Dinitrotoluene, 2,6-	2.18E+00	7.62E-07	2.13E-06	5.18E-07	2.13E-03	4.32E-08	4.98E-07	1.39E-06	3.38E-07	1.39E-03
Indeno(1,2,3-cd)pyrene	8.73E-01	3.05E-07	8.54E-07	2.23E-07	NA	2.27E-08	2.62E-07	7.33E-07	1.91E-07	NA
Total ILCR or HI				**8.57E-06**	**6.40E-01**				**4.99E-06**	**1.43E-01**

EPC - Exposure Point Concentration
ILCR - Incremental Lifetime Cancer Risk
HQ - Hazard Quotient; HI - Hazard Index
mg/kg - milligram per kilogram
mg/m^3 - milligram per cubic meter

Table D-1

Groundskeeper, Current Scenarios, Exposure to Surface Soil
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Chemicals of Potential Concern	Concentration in Air C_a mg/m^3	Inhalation Cancer Dose mg/kg-day	Inhalation Noncancer Dose mg/kg-day	Inhalation ILCR	Inhalation HQ	**All Pathways Total ILCR**	**All Pathways Total HI**
Polychlorinated biphenyls (PCB)							
Aroclor 1016	8.14E-08	5.69E-09	1.59E-08	3.98E-10	NA	**3.87E-08**	**2.19E-02**
Explosives							
Amino-2,6-dinitrotoluene, 4-	1.10E-06	7.69E-08	2.15E-07	NA	NA	**NA**	**5.60E-03**
Amino-4,6-dinitrotoluene, 2-	2.17E-06	1.52E-07	4.24E-07	NA	NA	**NA**	**1.12E-02**
Trinitrotoluene, 2,4,6-	3.11E-05	2.18E-06	6.09E-06	NA	NA	**3.95E-06**	**7.38E-01**
Semivolatile Organic Compounds							
Benzo(a)anthracene	1.17E-07	8.15E-09	2.28E-08	2.53E-09	NA	**5.55E-07**	**NA**
Benzo(a)pyrene	1.01E-07	7.03E-09	1.97E-08	2.18E-08	NA	**4.79E-06**	**NA**
Benzo(b)fluoranthene	1.52E-07	1.06E-08	2.97E-08	3.29E-09	NA	**7.22E-07**	**NA**
Dibenz(a,h)anthracene	1.96E-08	1.37E-09	3.84E-09	4.25E-09	NA	**9.33E-07**	**NA**
Dinitrotoluene, 2,4-	3.33E-07	2.32E-08	6.51E-08	NA	NA	**1.32E-06**	**2.72E-03**
Dinitrotoluene, 2,6-	2.18E-07	1.52E-08	4.27E-08	NA	NA	**8.57E-07**	**3.53E-03**
Indeno(1,2,3-cd)pyrene	8.73E-08	6.10E-09	1.71E-08	1.89E-09	NA	**4.16E-07**	**NA**
Total ILCR or HI				**3.41E-08**	**NA**	**1.36E-05**	**7.83E-01**

EPC - Exposure point concentration.
ILCR - Incremental lifetime cancer risk.
HQ - Hazard quotient; HI - Hazard index.
mg/kg - Milligram per kilogram.
mg/m^3 - Milligrams per cubic meter.

Table D-2

Groundskeeper, Future Scenario, Exposure to Total Soil
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

(Page 1 of 2)

		Incidental Ingestion				Dermal Contact				
Chemicals of Potential Concern	EPC mg/kg	Cancer Dose mg/kg-day	Noncancer Dose mg/kg-day	ILCR	HQ	Dose Absorbed mg/cm^2-day	Cancer Dose mg/kg-day	Noncancer Dose mg/kg-day	ILCR	HQ
Polychlorinated biphenyls (PCB)										
Aroclor 1016	2.31E-01	8.07E-08	2.26E-07	5.65E-09	3.23E-03	6.47E-09	7.46E-08	2.09E-07	5.22E-09	2.98E-03
Explosives										
Amino-2,6-dinitrotoluene, 4-	2.51E+00	8.77E-07	2.46E-06	NA	1.23E-03	3.01E-09	3.47E-08	9.73E-08	NA	4.86E-05
Amino-4,6-dinitrotoluene, 2-	3.63E+00	1.27E-06	3.55E-06	NA	1.77E-03	6.53E-09	7.53E-08	2.11E-07	NA	1.05E-04
Dinitrotoluene, 2,6-	5.48E-01	1.92E-07	5.36E-07	1.30E-07	5.36E-04	1.09E-08	1.25E-07	3.50E-07	8.51E-08	3.50E-04
Trinitrotoluene, 2,4,6-	1.67E+02	5.84E-05	1.64E-04	1.75E-06	3.27E-01	1.07E-06	1.23E-05	3.45E-05	3.70E-07	6.91E-02
Semivolatile Organic Compounds										
Benzo(a)anthracene	5.11E-01	1.79E-07	5.00E-07	1.30E-07	NA	1.33E-08	1.53E-07	4.29E-07	1.12E-07	NA
Benzo(a)pyrene	4.48E-01	1.57E-07	4.38E-07	1.14E-06	NA	1.16E-08	1.34E-07	3.76E-07	9.81E-07	NA
Benzo(b)fluoranthene	6.71E-01	2.34E-07	6.57E-07	1.71E-07	NA	1.74E-08	2.01E-07	5.63E-07	1.47E-07	NA
Dibenz(a,h)anthracene	1.54E-01	5.38E-08	1.51E-07	3.93E-07	NA	4.00E-09	4.62E-08	1.29E-07	3.37E-07	NA
Dinitrotoluene, 2,4-	1.31E+00	4.58E-07	1.28E-06	3.12E-07	6.41E-04	2.67E-08	3.08E-07	8.64E-07	2.10E-07	4.32E-04
Indeno(1,2,3-cd)pyrene	4.37E-01	1.53E-07	4.28E-07	1.11E-07	NA	1.14E-08	1.31E-07	3.67E-07	9.56E-08	NA
Total ILCR or HI				**4.15E-06**	**3.34E-01**				**2.34E-06**	**7.30E-02**

EPC - Exposure Point Concentration
ILCR - Incremental Lifetime Cancer Risk
HQ - Hazard Quotient; HI - Hazard Index
mg/kg - milligram per kilogram
mg/m^3 - milligram per cubic meter

Table D-2

Groundskeeper, Future Scenario, Exposure to Total Soil
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Chemicals of Potential Concern	Concentration in Air C_a mg/m^3	Inhalation Cancer Dose mg/kg-day	Inhalation Noncancer Dose mg/kg-day	Inhalation ILCR	Inhalation HQ	**All Pathways Total ILCR**	**All Pathways Total HI**
Inorganics							
Aroclor 1016	2.31E-08	1.61E-09	4.52E-09	1.13E-10	NA	**1.10E-08**	**6.21E-03**
Explosives							
Amino-2,6-dinitrotoluene, 4-	2.51E-07	1.75E-08	4.91E-08	NA	NA	**NA**	**1.28E-03**
Amino-4,6-dinitrotoluene, 2-	3.63E-07	2.54E-08	7.10E-08	NA	NA	**NA**	**1.88E-03**
Dinitrotoluene, 2,6-	5.48E-08	3.83E-09	1.07E-08	NA	NA	**2.15E-07**	**8.87E-04**
Trinitrotoluene, 2,4,6-	1.67E-05	1.17E-06	3.27E-06	NA	NA	**2.12E-06**	**3.96E-01**
Semivolatile Organic Compounds							
Benzo(a)anthracene	5.11E-08	3.57E-09	1.00E-08	1.11E-09	NA	**2.43E-07**	**NA**
Benzo(a)pyrene	4.48E-08	3.13E-09	8.77E-09	9.71E-09	NA	**2.13E-06**	**NA**
Benzo(b)fluoranthene	6.71E-08	4.69E-09	1.31E-08	1.45E-09	NA	**3.19E-07**	**NA**
Dibenz(a,h)anthracene	1.54E-08	1.08E-09	3.01E-09	3.34E-09	NA	**7.33E-07**	**NA**
Dinitrotoluene, 2,4-	1.31E-07	9.16E-09	2.57E-08	NA	NA	**5.21E-07**	**1.07E-03**
Indeno(1,2,3-cd)pyrene	4.37E-08	3.05E-09	8.55E-09	9.47E-10	NA	**2.08E-07**	**NA**
Total ILCR or HI				**1.67E-08**	**NA**	**6.51E-06**	**4.07E-01**

EPC - Exposure point concentration.
ILCR - Incremental lifetime cancer risk.
HQ - Hazard quotient; HI - Hazard index.
mg/kg - Milligrams per kilogram.
mg/m^3 - Milligrams per cubic meter.

Table D-3

Groundskeeper, Future Scenario, Exposure to Bedrock Groundwater
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion				Dermal Contact					All Pathways	
		Cancer	Noncancer			Dose	Cancer	Noncancer				
Chemicals of Potential Concern	EPC mg/L	Dose mg/kg-day	Dose mg/kg-day	ILCR	HQ	Absorbed mg/cm^2-day	Dose mg/kg-day	Dose mg/kg-day	ILCR	HQ	**Total ILCR**	**Total HI**
Inorganics												
Aluminum	1.75E+00	6.10E-03	1.71E-02	NA	1.71E-02	NA	NA	NA	NA	NA	**NA**	**1.71E-02**
Arsenic	7.07E-02	2.47E-04	6.92E-04	3.71E-04	2.31E+00	7.07E-08	8.15E-07	2.28E-06	1.22E-06	7.61E-03	**3.72E-04**	**2.31E+00**
Chromium, Total	4.00E-03	1.40E-05	3.91E-05	NA	1.86E-03	4.00E-09	4.61E-08	1.29E-07	NA	4.78E-04	**NA**	**2.34E-03**
Iron	3.24E+00	1.13E-02	3.17E-02	NA	4.53E-02	3.24E-06	3.74E-05	1.05E-04	NA	NA	**NA**	**4.53E-02**
Selenium	2.93E-02	1.02E-04	2.86E-04	NA	5.72E-02	2.93E-08	3.37E-07	9.44E-07	NA	1.89E-04	**NA**	**5.74E-02**
Semivolatile Organic Compounds												
Methylnaphthalene, 2-	3.38E-02	1.18E-04	3.31E-04	NA	8.27E-02	6.77E-06	7.81E-05	2.19E-04	NA	5.46E-02	**NA**	**1.37E-01**
Naphthalene	3.20E-02	1.12E-04	3.13E-04	NA	1.57E-02	3.11E-06	3.59E-05	1.00E-04	NA	5.02E-03	**NA**	**2.07E-02**
Volatile Organic Compounds												
Benzene	1.47E-01	5.14E-04	1.44E-03	2.83E-05	3.60E-01	3.28E-06	3.78E-05	1.06E-04	2.08E-06	2.65E-02	**3.03E-05**	**3.86E-01**
Chloroform	1.53E-02	5.35E-05	1.50E-04	NA	1.50E-02	2.03E-07	2.34E-06	6.57E-06	NA	6.57E-04	**NA**	**1.56E-02**
Chloromethane	4.31E-01	1.50E-03	4.21E-03	NA	NA	1.76E-06	2.03E-05	5.67E-05	NA	NA	**NA**	**NA**
Dichloropropene, trans-1,3-	2.90E-03	1.01E-05	2.84E-05	1.01E-06	9.46E-04	2.31E-08	2.67E-07	7.47E-07	2.67E-08	2.49E-05	**1.04E-06**	**9.71E-04**
Ethylbenzene	1.52E-01	5.31E-04	1.49E-03	NA	1.49E-02	1.33E-05	1.54E-04	4.31E-04	NA	4.31E-03	**NA**	**1.92E-02**
Toluene	6.06E-01	2.12E-03	5.92E-03	NA	7.41E-02	3.07E-05	3.54E-04	9.91E-04	NA	1.24E-02	**NA**	**8.64E-02**
Xylenes, total	8.12E-01	2.84E-03	7.95E-03	NA	3.97E-02	7.71E-05	8.89E-04	2.49E-03	NA	1.24E-02	**NA**	**5.22E-02**
General Chemistry												
Cyanide, total	4.10E-02	1.43E-04	4.01E-04	NA	6.69E-01	4.10E-08	4.73E-07	1.32E-06	NA	2.21E-03	**NA**	**6.71E-01**
Nitrate-Nitrite	1.50E+00	5.24E-03	1.47E-02	NA	1.47E-01	1.50E-06	1.73E-05	4.84E-05	NA	4.84E-04	**NA**	**1.47E-01**
Total ILCR or HI				**4.00E-04**	**3.85E+00**				**3.33E-06**	**1.27E-01**	**4.03E-04**	**3.97E+00**

EPC - Exposure point concentration.
ILCR - Incremental lifetime cancer risk.
HQ - Hazard quotient; HI - Hazard index.
mg/L - Milligrams per liter.
mg/cm^2 - Milligrams per square meter.

Table D-4

Groundskeeper, Future Scenario, Exposure to Overburden Groundwater
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion				Dermal Contact					All Pathways	
		Cancer	Noncancer			Dose	Cancer	Noncancer				
	EPC	Dose	Dose			Absorbed	Dose	Dose			**Total**	**Total**
Chemicals of Potential Concern	mg/L	mg/kg-day	mg/kg-day	ILCR	HQ	mg/cm^2-day	mg/kg-day	mg/kg-day	ILCR	HQ	**ILCR**	**HI**
Inorganics												
Cobalt	1.66E-02	5.79E-05	1.62E-04	NA	5.41E-01	6.63E-09	7.65E-08	2.14E-07	NA	7.14E-04	**NA**	**5.41E-01**
Nickel	5.63E-02	1.97E-04	5.51E-04	NA	2.75E-02	1.13E-08	1.30E-07	3.63E-07	NA	4.54E-04	**NA**	**2.80E-02**
Thallium	4.06E-03	1.42E-05	3.97E-05	NA	3.97E+00	4.06E-09	4.68E-08	1.31E-07	NA	1.31E-02	**NA**	**3.99E+00**
General Chemistry												
Sulfate	1.27E+03	4.44E+00	1.24E+01	NA	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Total ILCR or HI				**NA**	**4.54E+00**				**NA**	**1.43E-02**	**NA**	**4.56E+00**

EPC - Exposure point concentration.
ILCR - Incremental lifetime cancer risk.
HQ - Hazard quotient; HI - Hazard index.
mg/L - Milligrams per liter.
mg/cm^2 - Milligrams per square meter.

Table D-5

Indoor Worker, Future Scenario, Exposure to Surface Soil
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion					
Chemicals of Potential Concern	EPC mg/kg	Cancer Dose mg/kg-day	Noncancer Dose mg/kg-day	ILCR	HQ	**Total ILCR**	**Total HI**
Polychlorinated biphenyls (PCB)							
Aroclor 1016	8.14E-01	1.42E-07	3.98E-07	9.96E-09	5.69E-03	**9.96E-09**	**5.69E-03**
Explosives							
Amino-2,6-dinitrotoluene, 4-	1.10E+01	1.92E-06	5.39E-06	NA	2.69E-03	**NA**	**2.69E-03**
Amino-4,6-dinitrotoluene, 2-	2.17E+01	3.79E-06	1.06E-05	NA	5.30E-03	**NA**	**5.30E-03**
Trinitrotoluene, 2,4,6-	3.11E+02	5.44E-05	1.52E-04	1.63E-06	3.05E-01	**1.63E-06**	**3.05E-01**
Semivolatile Organic Compounds							
Benzo(a)anthracene	1.17E+00	2.04E-07	5.70E-07	1.49E-07	NA	**1.49E-07**	**NA**
Benzo(a)pyrene	1.01E+00	1.76E-07	4.92E-07	1.28E-06	NA	**1.28E-06**	**NA**
Benzo(b)fluoranthene	1.52E+00	2.65E-07	7.42E-07	1.93E-07	NA	**1.93E-07**	**NA**
Dibenz(a,h)anthracene	1.96E-01	3.42E-08	9.59E-08	2.50E-07	NA	**2.50E-07**	**NA**
Dinitrotoluene, 2,4-	3.33E+00	5.81E-07	1.63E-06	3.95E-07	8.14E-04	**3.95E-07**	**8.14E-04**
Dinitrotoluene, 2,6-	2.18E+00	3.81E-07	1.07E-06	2.59E-07	1.07E-03	**2.59E-07**	**1.07E-03**
Indeno(1,2,3-cd)pyrene	8.73E-01	1.53E-07	4.27E-07	1.11E-07	NA	**1.11E-07**	**NA**
Total ILCR or HI						**4.28E-06**	**3.20E-01**

EPC - Exposure point concentration.
ILCR - Incremental lifetime cancer risk.
HQ - Hazard quotient; HI - Hazard index.
mg/kg - Milligrams per kilogram.

Table D-6

Indoor Worker, Future Scenario, Exposure to Bedrock Groundwater
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion				Dermal Contact					All Pathways	
		Cancer	Noncancer			Dose	Cancer	Noncancer				
	EPC	Dose	Dose			Absorbed	Dose	Dose			**Total**	**Total**
Chemicals of Potential Concern	mg/L	mg/kg-day	mg/kg-day	ILCR	HQ	mg/cm^2-day	mg/kg-day	mg/kg-day	ILCR	HQ	**ILCR**	**HI**
Inorganics												
Aluminum	1.75E+00	6.10E-03	1.71E-02	NA	1.71E-02	NA	NA	NA	NA	NA	**NA**	**1.71E-02**
Arsenic	7.07E-02	2.47E-04	6.92E-04	3.71E-04	2.31E+00	7.07E-08	8.15E-07	2.28E-06	1.22E-06	7.61E-03	**3.72E-04**	**2.31E+00**
Chromium, Total	4.00E-03	1.40E-05	3.91E-05	NA	1.86E-03	4.00E-09	4.61E-08	1.29E-07	NA	4.78E-04	**NA**	**2.34E-03**
Iron	3.24E+00	1.13E-02	3.17E-02	NA	4.53E-02	3.24E-06	3.74E-05	1.05E-04	NA	NA	**NA**	**4.53E-02**
Selenium	2.93E-02	1.02E-04	2.86E-04	NA	5.72E-02	2.93E-08	3.37E-07	9.44E-07	NA	1.89E-04	**NA**	**5.74E-02**
Semivolatile Organic Compounds												
Methylnaphthalene, 2-	3.38E-02	1.18E-04	3.31E-04	NA	8.27E-02	6.77E-06	7.81E-05	2.19E-04	NA	5.46E-02	**NA**	**1.37E-01**
Naphthalene	3.20E-02	1.12E-04	3.13E-04	NA	1.57E-02	3.11E-06	3.59E-05	1.00E-04	NA	5.02E-03	**NA**	**2.07E-02**
Volatile Organic Compounds												
Benzene	1.47E-01	5.14E-04	1.44E-03	2.83E-05	3.60E-01	3.28E-06	3.78E-05	1.06E-04	2.08E-06	2.65E-02	**3.03E-05**	**3.86E-01**
Chloroform	1.53E-02	5.35E-05	1.50E-04	NA	1.50E-02	2.03E-07	2.34E-06	6.57E-06	NA	6.57E-04	**NA**	**1.56E-02**
Chloromethane	4.31E-01	1.50E-03	4.21E-03	NA	NA	1.76E-06	2.03E-05	5.67E-05	NA	NA	**NA**	**NA**
Dichloropropene, trans-1,3-	2.90E-03	1.01E-05	2.84E-05	1.01E-06	9.46E-04	2.31E-08	2.67E-07	7.47E-07	2.67E-08	2.49E-05	**1.04E-06**	**9.71E-04**
Ethylbenzene	1.52E-01	5.31E-04	1.49E-03	NA	1.49E-02	1.33E-05	1.54E-04	4.31E-04	NA	4.31E-03	**NA**	**1.92E-02**
Toluene	6.06E-01	2.12E-03	5.92E-03	NA	7.41E-02	3.07E-05	3.54E-04	9.91E-04	NA	1.24E-02	**NA**	**8.64E-02**
Xylenes, total	8.12E-01	2.84E-03	7.95E-03	NA	3.97E-02	7.71E-05	8.89E-04	2.49E-03	NA	1.24E-02	**NA**	**5.22E-02**
General Chemistry												
Cyanide, total	4.10E-02	1.43E-04	4.01E-04	NA	6.69E-01	4.10E-08	4.73E-07	1.32E-06	NA	2.21E-03	**NA**	**6.71E-01**
Nitrate-Nitrite	1.50E+00	5.24E-03	1.47E-02	NA	1.47E-01	1.50E-06	1.73E-05	4.84E-05	NA	4.84E-04	**NA**	**1.47E-01**
Total ILCR or HI				**4.00E-04**	**3.85E+00**				**3.33E-06**	**1.27E-01**	**4.03E-04**	**3.97E+00**

EPC - Exposure point concentration.
ILCR - Incremental lifetime cancer risk.
HQ - Hazard quotient; HI - Hazard index.
mg/L - Milligrams per liter.
mg/cm^2 - Milligrams per square meter.

Table D-7

Indoor Worker, Future Scenario, Exposure to Overburden Groundwater
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion				Dermal Contact					All Pathways	
		Cancer	Noncancer			Dose	Cancer	Noncancer				
	EPC	Dose	Dose			Absorbed	Dose	Dose			**Total**	**Total**
Chemicals of Potential Concern	mg/L	mg/kg-day	mg/kg-day	ILCR	HQ	mg/cm^2-day	mg/kg-day	mg/kg-day	ILCR	HQ	**ILCR**	**HI**
Inorganics												
Cobalt	1.66E-02	5.79E-05	1.62E-04	NA	5.41E-01	6.63E-09	7.65E-08	2.14E-07	NA	7.14E-04	**NA**	**5.41E-01**
Nickel	5.63E-02	1.97E-04	5.51E-04	NA	2.75E-02	1.13E-08	1.30E-07	3.63E-07	NA	4.54E-04	**NA**	**2.80E-02**
Thallium	4.06E-03	1.42E-05	3.97E-05	NA	3.97E+00	4.06E-09	4.68E-08	1.31E-07	NA	1.31E-02	**NA**	**3.99E+00**
General Chemistry												
Sulfate	1.27E+03	4.44E+00	1.24E+01	NA	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Total ILCR or HI				**NA**	**4.54E+00**				**NA**	**1.43E-02**	**NA**	**4.56E+00**

EPC - Exposure point concentration.
ILCR - Incremental lifetime cancer risk.
HQ - Hazard quotient; HI - Hazard index.
mg/L - Milligrams per liter.
mg/cm^2 - Milligrams per square meter.

Table D-8

Construction Worker, Current and Future Scenarios, Exposure to Total Soil
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

(Page 1 of 2)

		Incidental Ingestion				Dermal Contact				
Chemicals of Potential Concern	EPC mg/kg	Cancer Dose mg/kg-day	Noncancer Dose mg/kg-day	ILCR	HQ	Dose Absorbed mg/cm^2-day	Cancer Dose mg/kg-day	Noncancer Dose mg/kg-day	ILCR	HQ
Polychlorinated biphenyls (PCB)										
Aroclor 1016	2.31E-01	5.33E-09	7.44E-07	3.73E-10	1.06E-02	9.70E-09	2.24E-09	3.12E-07	1.57E-10	4.46E-03
Explosives										
Amino-2,6-dinitrotoluene, 4-	2.51E+00	5.79E-08	8.08E-06	NA	4.04E-03	4.52E-09	1.04E-09	1.45E-07	NA	7.27E-05
Amino-4,6-dinitrotoluene, 2-	3.63E+00	8.37E-08	1.17E-05	NA	5.84E-03	9.80E-09	2.26E-09	3.15E-07	NA	1.58E-04
Dinitrotoluene, 2,6-	5.48E-01	1.26E-08	1.76E-06	8.59E-09	1.76E-03	1.63E-08	3.75E-09	5.24E-07	2.55E-09	5.24E-04
Trinitrotoluene, 2,4,6-	1.67E+02	3.85E-06	5.38E-04	1.16E-07	1.08E+00	1.60E-06	3.70E-07	5.17E-05	1.11E-08	1.03E-01
Semivolatile Organic Compounds										
Benzo(a)anthracene	5.11E-01	1.18E-08	1.65E-06	8.60E-09	NA	1.99E-08	4.60E-09	6.42E-07	3.36E-09	NA
Benzo(a)pyrene	4.48E-01	1.03E-08	1.44E-06	7.54E-08	NA	1.75E-08	4.03E-09	5.63E-07	2.94E-08	NA
Benzo(b)fluoranthene	6.71E-01	1.55E-08	2.16E-06	1.13E-08	NA	2.62E-08	6.04E-09	8.43E-07	4.41E-09	NA
Dibenz(a,h)anthracene	1.54E-01	3.55E-09	4.96E-07	2.59E-08	NA	6.01E-09	1.39E-09	1.93E-07	1.01E-08	NA
Dinitrotoluene, 2,4-	1.31E+00	3.02E-08	4.22E-06	2.06E-08	2.11E-03	4.01E-08	9.25E-09	1.29E-06	6.29E-09	6.46E-04
Indeno(1,2,3-cd)pyrene	4.37E-01	1.01E-08	1.41E-06	7.36E-09	NA	1.70E-08	3.93E-09	5.49E-07	2.87E-09	NA
Total ILCR or HI				**2.74E-07**	**1.10E+00**				**7.03E-08**	**1.09E-01**

EPC - Exposure point concentration.
ILCR - Incremental lifetime cancer risk.
HQ - Hazard quotient; HI - Hazard index.
mg/kg - Milligrams per kilogram.
mg/m^3 - Milligrams per cubic meter.

Table D-8

Construction Worker, Current and Future Scenarios, Exposure to Total Soil
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Chemicals of Potential Concern	Concentration in Air C_a mg/m^3	Inhalation Cancer Dose mg/kg-day	Inhalation Noncancer Dose mg/kg-day	Inhalation ILCR	Inhalation HQ	**All Pathways Total ILCR**	**All Pathways Total HI**
Polychlorinated biphenyls (PCB)							
Aroclor 1016	8.09E-08	1.13E-10	1.58E-08	7.91E-12	NA	**5.37E-10**	**1.51E-02**
Explosives							
Amino-2,6-dinitrotoluene, 4-	8.79E-07	1.23E-09	1.71E-07	NA	NA	**NA**	**4.11E-03**
Amino-4,6-dinitrotoluene, 2-	1.27E-06	1.77E-09	2.48E-07	NA	NA	**NA**	**6.00E-03**
Dinitrotoluene, 2,6-	1.92E-07	2.68E-10	3.74E-08	NA	NA	**1.11E-08**	**2.29E-03**
Trinitrotoluene, 2,4,6-	5.85E-05	8.18E-08	1.14E-05	NA	NA	**1.27E-07**	**1.18E+00**
Semivolatile Organic Compounds							
Benzo(a)anthracene	1.79E-07	2.50E-10	3.49E-08	7.75E-11	NA	**1.20E-08**	**NA**
Benzo(a)pyrene	1.57E-07	2.19E-10	3.06E-08	6.79E-10	NA	**1.06E-07**	**NA**
Benzo(b)fluoranthene	2.35E-07	3.28E-10	4.58E-08	1.02E-10	NA	**1.58E-08**	**NA**
Dibenz(a,h)anthracene	5.39E-08	7.53E-11	1.05E-08	2.34E-10	NA	**3.63E-08**	**NA**
Dinitrotoluene, 2,4-	4.59E-07	6.41E-10	8.95E-08	NA	NA	**2.69E-08**	**2.76E-03**
Indeno(1,2,3-cd)pyrene	1.53E-07	2.14E-10	2.98E-08	6.63E-11	NA	**1.03E-08**	**NA**
Total ILCR or HI				**1.17E-09**	**NA**	**3.45E-07**	**1.21E+00**

EPC - Exposure point concentration.
ILCR - Incremental lifetime cancer risk.
HQ - Hazard quotient; HI - Hazard index.
mg/kg - Milligrams per kilogram.
mg/m^3 - Milligrams per cubic meter.

Table D-9

Construction Worker, Current and Future Scenarios, Exposure to Sediment
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion				Dermal Contact					All Pathways	
		Cancer	Noncancer			Dose	Cancer	Noncancer				
Chemicals of Potential Concern	EPC mg/kg	Dose mg/kg-day	Dose mg/kg-day	ILCR	HQ	Absorbed mg/cm^2-day	Dose mg/kg-day	Dose mg/kg-day	ILCR	HQ	**Total ILCR**	**Total HI**
Polychlorinated biphenyls												
Aroclor 1254	1.69E-01	3.90E-09	5.44E-07	7.80E-09	2.72E-02	7.10E-09	1.64E-09	2.29E-07	3.27E-09	1.14E-02	**1.11E-08**	**3.86E-02**
Total ILCR or HI				**7.80E-09**	**2.72E-02**				**3.27E-09**	**1.14E-02**	**1.11E-08**	**3.86E-02**

EPC - Exposure point concentration.
ILCR - Incremental lifetime cancer risk.
HQ - Hazard quotient; HI - Hazard index.
mg/kg - Milligrams per kilogram.
mg/cm^2 - Milligrams per centimeter squared.

Table D-10

On-Site Resident, Cancer Risk, Future Scenario, Exposure to Total Soil
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion			Dermal Contact				
Chemicals of Potential Concern	EPC mg/kg	Adult Dose mg/kg-day	Child Dose mg/kg-day	Resident ILCR	Adult Dose Absorbed mg/cm^2-day	Adult Dose mg/kg-day	Child Dose Absorbed mg/cm^2-day	Child Dose mg/kg-day	Resident ILCR
Polychlorinated biphenyls (PCB)									
Aroclor 1016	2.31E-01	9.76E-08	2.28E-07	2.28E-08	2.26E-09	6.06E-08	6.47E-09	9.92E-08	1.12E-08
Explosives									
Amino-2,6-dinitrotoluene, 4-	2.51E+00	1.06E-06	2.48E-06	NA	1.05E-09	2.82E-08	3.01E-09	4.62E-08	NA
Amino-4,6-dinitrotoluene, 2-	3.63E+00	1.53E-06	3.58E-06	NA	2.29E-09	6.12E-08	6.53E-09	1.00E-07	NA
Dinitrotoluene, 2,6-	5.48E-01	2.32E-07	5.40E-07	5.25E-07	3.80E-09	1.02E-07	1.09E-08	1.66E-07	1.82E-07
Trinitrotoluene, 2,4,6-	1.67E+02	7.06E-05	1.65E-04	7.06E-06	3.74E-07	1.00E-05	1.07E-06	1.64E-05	7.93E-07
Semivolatile Organic Compounds									
Benzo(a)anthracene	5.11E-01	2.16E-07	5.04E-07	5.26E-07	4.65E-09	1.24E-07	1.33E-08	2.04E-07	2.40E-07
Benzo(a)pyrene	4.48E-01	1.89E-07	4.42E-07	4.61E-06	4.08E-09	1.09E-07	1.16E-08	1.79E-07	2.10E-06
Benzo(b)fluoranthene	6.71E-01	2.84E-07	6.62E-07	6.90E-07	6.11E-09	1.63E-07	1.74E-08	2.68E-07	3.15E-07
Dibenz(a,h)anthracene	1.54E-01	6.51E-08	1.52E-07	1.58E-06	1.40E-09	3.75E-08	4.00E-09	6.14E-08	7.22E-07
Dinitrotoluene, 2,4-	1.31E+00	5.54E-07	1.29E-06	1.26E-06	9.36E-09	2.51E-07	2.67E-08	4.10E-07	4.49E-07
Indeno(1,2,3-cd)pyrene	4.37E-01	1.85E-07	4.31E-07	4.49E-07	3.98E-09	1.06E-07	1.14E-08	1.74E-07	2.05E-07
Total ILCR				**1.67E-05**					**5.02E-06**

EPC - Exposure point concentration.
ILCR - Incremental lifetime cancer risk.
mg/kg - Milligrams per kilogram.
mg/cm^2 - Milligrams per square meter.
mg/m^3 - Milligrams per cubic meter.

Table D-10

On-Site Resident, Cancer Risk, Future Scenario, Exposure to Total Soil
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Chemicals of Potential Concern	Concentration in Air C_a mg/m^3	Inhalation Adult Dose mg/kg-day	Inhalation Child Dose mg/kg-day	Inhalation Resident ILCR	**All Pathways Total ILCR**
Polychlorinated biphenyls (PCB)					
Aroclor 1016	4.55E-10	4.27E-11	2.49E-11	4.74E-12	**3.40E-08**
Explosives					
Amino-2,6-dinitrotoluene, 4-	4.94E-09	4.64E-10	2.71E-10	NA	**NA**
Amino-4,6-dinitrotoluene, 2-	7.15E-09	6.71E-10	3.92E-10	NA	**NA**
Dinitrotoluene, 2,6-	1.08E-09	1.01E-10	5.91E-11	NA	**7.07E-07**
Trinitrotoluene, 2,4,6-	3.29E-07	3.09E-08	1.80E-08	NA	**7.86E-06**
Semivolatile Organic Compounds					
Benzo(a)anthracene	1.01E-09	9.45E-11	5.52E-11	4.64E-11	**7.65E-07**
Benzo(a)pyrene	8.82E-10	8.29E-11	4.84E-11	4.07E-10	**6.71E-06**
Benzo(b)fluoranthene	1.32E-09	1.24E-10	7.24E-11	6.09E-11	**1.00E-06**
Dibenz(a,h)anthracene	3.03E-10	2.85E-11	1.66E-11	1.40E-10	**2.31E-06**
Dinitrotoluene, 2,4-	2.58E-09	2.43E-10	1.41E-10	NA	**1.71E-06**
Indeno(1,2,3-cd)pyrene	8.61E-10	8.09E-11	4.72E-11	3.97E-11	**6.54E-07**
Total ILCR				**6.98E-10**	**2.17E-05**

EPC - Exposure point concentration.
ILCR - Incremental lifetime cancer risk.
mg/kg - Milligrams per kilogram.
mg/cm^2 - Milligrams per square meter.
mg/m^3 - Milligrams per cubic meter.

Table D-11

On-Site Child Resident, Noncancer Risk, Future Scenario, Exposure to Total Soil
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion		Dermal Contact			Concentration	Inhalation		**All**
	EPC	Child Dose	Child Resident	Dose Absorbed	Child Dose	Child Resident	in Air C_a	Child Dose	Child Resident	**Pathways Total**
Chemicals of Potential Concern	mg/kg	mg/kg-day	HQ	mg/cm^2-day	mg/kg-day	HQ	mg/m^3	mg/kg-day	HQ	**HI**
Polychlorinated biphenyls (PCB)										
Aroclor 1016	2.31E-01	2.66E-06	3.80E-02	6.47E-09	1.16E-06	1.65E-02	4.55E-10	2.91E-10	NA	**5.45E-02**
Explosives										
Amino-2,6-dinitrotoluene, 4-	2.51E+00	2.89E-05	1.44E-02	3.01E-09	5.39E-07	2.70E-04	4.94E-09	3.16E-09	NA	**1.47E-02**
Amino-4,6-dinitrotoluene, 2-	3.63E+00	4.17E-05	2.09E-02	6.53E-09	1.17E-06	5.84E-04	7.15E-09	4.57E-09	NA	**2.15E-02**
Dinitrotoluene, 2,6-	5.48E-01	6.31E-06	6.31E-03	1.09E-08	1.94E-06	1.94E-03	1.08E-09	6.90E-10	NA	**8.25E-03**
Trinitrotoluene, 2,4,6-	1.67E+02	1.92E-03	3.85E+00	1.07E-06	1.91E-04	3.83E-01	3.29E-07	2.10E-07	NA	**4.23E+00**
Semivolatile Organic Compounds										
Benzo(a)anthracene	5.11E-01	5.88E-06	NA	1.33E-08	2.38E-06	NA	1.01E-09	6.43E-10	NA	**NA**
Benzo(a)pyrene	4.48E-01	5.16E-06	NA	1.16E-08	2.08E-06	NA	8.82E-10	5.64E-10	NA	**NA**
Benzo(b)fluoranthene	6.71E-01	7.72E-06	NA	1.74E-08	3.12E-06	NA	1.32E-09	8.45E-10	NA	**NA**
Dibenz(a,h)anthracene	1.54E-01	1.77E-06	NA	4.00E-09	7.17E-07	NA	3.03E-10	1.94E-10	NA	**NA**
Dinitrotoluene, 2,4-	1.31E+00	1.51E-05	7.54E-03	2.67E-08	4.79E-06	2.39E-03	2.58E-09	1.65E-09	NA	**9.94E-03**
Indeno(1,2,3-cd)pyrene	4.37E-01	5.03E-06	NA	1.14E-08	2.03E-06	NA	8.61E-10	5.50E-10	NA	**NA**
Total HI			**3.93E+00**			**4.05E-01**			**NA**	**4.34E+00**

EPC - Exposure point concentration.
HQ - Hazard quotient; HI - Hazard index.
mg/kg - Milligrams per kilogram.
mg/cm^2 - Milligrams per square meter.
mg/m^3 - Milligrams per cubic meter.

Table D-12

On-Site Adult Resident, Noncancer Risk, Future Scenario, Exposure to Total Soil
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion		Dermal Contact			Concentration	Inhalation		**All**
	EPC	Adult Dose	Adult Resident	Dose Absorbed	Adult Dose	Adult Resident	in Air C_a	Adult Dose	Adult Resident	**Pathways Total**
Chemicals of Potential Concern	mg/kg	mg/kg-day	HQ	mg/cm^2-day	mg/kg-day	HQ	mg/m^3	mg/kg-day	HQ	**HI**
Polychlorinated biphenyls (PCB)										
Aroclor 1016	2.31E-01	2.85E-07	4.07E-03	2.26E-09	1.77E-07	2.53E-03	4.55E-10	1.25E-10	NA	**6.59E-03**
Explosives										
Amino-2,6-dinitrotoluene, 4-	2.51E+00	3.09E-06	1.55E-03	1.05E-09	8.23E-08	4.12E-05	4.94E-09	1.35E-09	NA	**1.59E-03**
Amino-4,6-dinitrotoluene, 2-	3.63E+00	4.47E-06	2.24E-03	2.29E-09	1.78E-07	8.92E-05	7.15E-09	1.96E-09	NA	**2.33E-03**
Dinitrotoluene, 2,6-	5.48E-01	6.76E-07	6.76E-04	3.80E-09	2.97E-07	2.97E-04	1.08E-09	2.96E-10	NA	**9.72E-04**
Trinitrotoluene, 2,4,6-	1.67E+02	2.06E-04	4.12E-01	3.74E-07	2.92E-05	5.85E-02	3.29E-07	9.02E-08	NA	**4.70E-01**
Semivolatile Organic Compounds										
Benzo(a)anthracene	5.11E-01	6.30E-07	NA	4.65E-09	3.63E-07	NA	1.01E-09	2.76E-10	NA	**NA**
Benzo(a)pyrene	4.48E-01	5.52E-07	NA	4.08E-09	3.18E-07	NA	8.82E-10	2.42E-10	NA	**NA**
Benzo(b)fluoranthene	6.71E-01	8.27E-07	NA	6.11E-09	4.77E-07	NA	1.32E-09	3.62E-10	NA	**NA**
Dibenz(a,h)anthracene	1.54E-01	1.90E-07	NA	1.40E-09	1.09E-07	NA	3.03E-10	8.31E-11	NA	**NA**
Dinitrotoluene, 2,4-	1.31E+00	1.62E-06	8.08E-04	9.36E-09	7.31E-07	3.65E-04	2.58E-09	7.07E-10	NA	**1.17E-03**
Indeno(1,2,3-cd)pyrene	4.37E-01	5.39E-07	NA	3.98E-09	3.11E-07	NA	8.61E-10	2.36E-10	NA	**NA**
Total HI			**4.21E-01**			**6.18E-02**			**NA**	**4.83E-01**

EPC - Exposure point concentration.
HQ - Hazard quotient; HI - Hazard index.
mg/kg - Milligrams per kilogram.
mg/cm^2 - Milligrams per square meter.
mg/m^3 - Milligrams per cubic meter.

Table D-13

On-Site Resident, Future Scenario, Cancer Risk from Exposure to Bedrock Groundwater
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion			Dermal Contact					Inhalation of VOCs				All
		Adult	Child		Dose	Adult	Dose	Child		Concentration	Adult	Child		Pathways
	EPC	Dose	Dose		Absorbed	Dose	Absorbed	Dose		in Air	Dose	Dose		Total
Chemicals of Potential Concern	mg/L	mg/kg-day	mg/kg-day	ILCR	mg/cm^2-day	mg/kg-day	mg/cm^2-day	mg/kg-day	ILCR	mg/m^3	mg/kg-day	mg/kg-day	ILCR	ILCR
Inorganics														
Aluminum	1.75E+00	1.64E-02	9.56E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Arsenic	7.07E-02	6.64E-04	3.87E-04	1.58E-03	1.41E-08	1.33E-06	2.35E-08	8.51E-07	3.27E-06	NA	NA	NA	NA	**1.58E-03**
Chromium, Total	4.00E-03	3.76E-05	2.19E-05	NA	8.00E-10	7.51E-08	1.33E-09	4.82E-08	NA	NA	NA	NA	NA	**NA**
Iron	3.24E+00	3.04E-02	1.78E-02	NA	6.48E-07	6.09E-05	1.08E-06	3.90E-05	NA	NA	NA	NA	NA	**NA**
Selenium	2.93E-02	2.75E-04	1.60E-04	NA	5.85E-09	5.50E-07	9.74E-09	3.52E-07	NA	NA	NA	NA	NA	**NA**
Semivolatile Organic Compounds														
Methylnaphthalene, 2-	3.38E-02	3.17E-04	1.85E-04	NA	3.03E-06	2.84E-04	3.91E-06	1.41E-04	NA	1.69E-02	6.61E-05	3.85E-05	NA	**NA**
Naphthalene	3.20E-02	3.01E-04	1.75E-04	NA	1.39E-06	1.31E-04	1.80E-06	6.49E-05	NA	1.60E-02	6.26E-05	3.65E-05	1.19E-05	**1.19E-05**
Volatile Organic Compounds														
Benzene	1.47E-01	1.38E-03	8.05E-04	1.20E-04	1.47E-06	1.38E-04	1.89E-06	6.85E-05	1.13E-05	7.35E-02	2.88E-04	1.68E-04	1.23E-05	**1.44E-04**
Chloroform	1.53E-02	1.44E-04	8.38E-05	NA	9.09E-08	8.54E-06	1.17E-07	4.24E-06	NA	7.65E-03	2.99E-05	1.74E-05	NA	**NA**
Chloromethane	4.31E-01	4.04E-03	2.36E-03	NA	7.85E-07	7.38E-05	1.01E-06	3.66E-05	NA	2.15E-01	8.42E-04	4.91E-04	NA	**NA**
Dichloropropene, trans-1,3-	2.90E-03	2.72E-05	1.59E-05	4.31E-06	1.03E-08	9.71E-07	1.33E-08	4.83E-07	1.45E-07	1.45E-03	5.67E-06	3.31E-06	1.26E-07	**4.58E-06**
Ethylbenzene	1.52E-01	1.43E-03	8.33E-04	NA	5.97E-06	5.60E-04	7.70E-06	2.78E-04	NA	7.60E-02	2.97E-04	1.73E-04	NA	**NA**
Toluene	6.06E-01	5.69E-03	3.32E-03	NA	1.37E-05	1.29E-03	1.77E-05	6.41E-04	NA	3.03E-01	1.18E-03	6.90E-04	NA	**NA**
Xylenes, total	8.12E-01	7.63E-03	4.45E-03	NA	3.45E-05	3.24E-03	4.45E-05	1.61E-03	NA	4.06E-01	1.59E-03	9.25E-04	NA	**NA**
General Chemistry														
Cyanide, total	4.10E-02	3.85E-04	2.25E-04	NA	8.20E-09	7.70E-07	1.37E-08	4.94E-07	NA	NA	NA	NA	NA	**NA**
Nitrate-Nitrite	1.50E+00	1.41E-02	8.22E-03	NA	3.00E-07	2.82E-05	5.00E-07	1.81E-05	NA	NA	NA	NA	NA	**NA**
Total ILCR				**1.70E-03**					**1.48E-05**				**2.43E-05**	**1.74E-03**

EPC - Exposure point concentration.
ILCR - Incremental lifetime cancer risk.
mg/L - Milligrams per liter.
mg/cm^2 - Milligrams per square meter.
mg/kg - Milligrams per kilogram.
mg/m^3- Milligrams per cubic meter.

Table D-14

Child On-Site Resident, Future Scenario, Noncancer Hazard from Exposure to Bedrock Groundwater
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion		Dermal Contact			Inhalation of VOCs			**All**
		Child		Dose	Child		Concentration	Child		**Pathways**
	EPC	Dose		Absorbed	Dose		in Air	Dose		**Total**
Chemicals of Potential Concern	mg/L	mg/kg-day	HQ	mg/cm^2-day	mg/kg-day	HQ	mg/m^3	mg/kg-day	HQ	**HI**
Inorganics										
Aluminum	1.75E+00	1.12E-01	1.12E-01	NA	NA	NA	NA	NA	NA	**1.12E-01**
Arsenic	7.07E-02	4.52E-03	1.51E+01	2.35E-08	9.93E-06	3.31E-02	NA	NA	NA	**1.51E+01**
Chromium, Total	4.00E-03	2.56E-04	1.22E-02	1.33E-09	5.62E-07	2.08E-03	NA	NA	NA	**1.43E-02**
Iron	3.24E+00	2.07E-01	2.96E-01	1.08E-06	4.55E-04	NA	NA	NA	NA	**2.96E-01**
Selenium	2.93E-02	1.87E-03	3.74E-01	9.74E-09	4.11E-06	8.22E-04	NA	NA	NA	**3.75E-01**
Semivolatile Organic Compounds										
Methylnaphthalene, 2-	3.38E-02	2.16E-03	5.40E-01	3.91E-06	1.65E-03	4.12E-01	1.69E-02	4.49E-04	NA	**9.52E-01**
Naphthalene	3.20E-02	2.05E-03	1.02E-01	1.80E-06	7.57E-04	3.79E-02	1.60E-02	4.25E-04	4.95E-01	**6.35E-01**
Volatile Organic Compounds										
Benzene	1.47E-01	9.40E-03	2.35E+00	1.89E-06	7.99E-04	2.00E-01	7.35E-02	1.95E-03	2.27E-01	**2.78E+00**
Chloroform	1.53E-02	9.78E-04	9.78E-02	1.17E-07	4.95E-05	4.95E-03	7.65E-03	2.03E-04	7.27E-03	**1.10E-01**
Chloromethane	4.31E-01	2.75E-02	NA	1.01E-06	4.28E-04	NA	2.15E-01	5.72E-03	2.20E-01	**2.20E-01**
Dichloropropene, trans-1,3-	2.90E-03	1.85E-04	6.18E-03	1.33E-08	5.63E-06	1.88E-04	1.45E-03	3.86E-05	6.77E-03	**1.31E-02**
Ethylbenzene	1.52E-01	9.72E-03	9.72E-02	7.70E-06	3.25E-03	3.25E-02	7.60E-02	2.02E-03	6.97E-03	**1.37E-01**
Toluene	6.06E-01	3.87E-02	4.84E-01	1.77E-05	7.47E-03	9.34E-02	3.03E-01	8.05E-03	5.75E-03	**5.83E-01**
Xylenes, total	8.12E-01	5.19E-02	2.60E-01	4.45E-05	1.88E-02	9.38E-02	4.06E-01	1.08E-02	3.72E-01	**7.26E-01**
General Chemistry										
Cyanide, total	4.10E-02	2.62E-03	4.37E+00	1.37E-08	5.76E-06	9.60E-03	NA	NA	NA	**4.38E+00**
Nitrate-Nitrite	1.50E+00	9.59E-02	9.59E-01	5.00E-07	2.11E-04	2.11E-03	NA	NA	NA	**9.61E-01**
Total HI			**2.51E+01**			**9.22E-01**			**1.34E+00**	**2.74E+01**

EPC - Exposure point concentration.
HQ - Hazard quotient; HI - Hazard index.
mg/L - Milligrams per liter.
mg/cm^2 - Milligrams per square meter.
mg/kg - Milligrams per kilogram.
mg/m^3- Milligrams per cubic meter.

Table D-15

Adult On-Site Resident, Future Scenario, Noncancer Hazard from Exposure to Bedrock Groundwater
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion		Dermal Contact			Inhalation of VOCs			**All**
		Noncancer		Dose	Adult		Concentration	Adult		**Pathways**
	EPC	Dose		Absorbed	Dose		in Air	Dose		**Total**
Chemicals of Potential Concern	mg/L	mg/kg-day	HQ	mg/cm^2-day	mg/kg-day	HQ	mg/m^3	mg/kg-day	HQ	**HI**
Inorganics										
Aluminum	1.75E+00	4.78E-02	4.78E-02	NA	NA	NA	NA	NA	NA	**4.78E-02**
Arsenic	7.07E-02	1.94E-03	6.46E+00	1.41E-08	3.87E-06	1.29E-02	NA	NA	NA	**6.47E+00**
Chromium, Total	4.00E-03	1.10E-04	5.22E-03	8.00E-10	2.19E-07	8.12E-04	NA	NA	NA	**6.03E-03**
Iron	3.24E+00	8.88E-02	1.27E-01	6.48E-07	1.78E-04	NA	NA	NA	NA	**1.27E-01**
Selenium	2.93E-02	8.01E-04	1.60E-01	5.85E-09	1.60E-06	3.21E-04	NA	NA	NA	**1.61E-01**
Semivolatile Organic Compounds										
Methylnaphthalene, 2-	3.38E-02	9.26E-04	2.32E-01	3.03E-06	8.29E-04	2.07E-01	1.69E-02	1.93E-04	NA	**4.39E-01**
Naphthalene	3.20E-02	8.77E-04	4.38E-02	1.39E-06	3.81E-04	1.91E-02	1.60E-02	1.83E-04	2.12E-01	**2.75E-01**
Volatile Organic Compounds										
Benzene	1.47E-01	4.03E-03	1.01E+00	1.47E-06	4.02E-04	1.01E-01	7.35E-02	8.39E-04	9.75E-02	**1.20E+00**
Chloroform	1.53E-02	4.19E-04	4.19E-02	9.09E-08	2.49E-05	2.49E-03	7.65E-03	8.73E-05	3.12E-03	**4.75E-02**
Chloromethane	4.31E-01	1.18E-02	NA	7.85E-07	2.15E-04	NA	2.15E-01	2.46E-03	9.45E-02	**9.45E-02**
Dichloropropene, trans-1,3-	2.90E-03	7.95E-05	2.65E-03	1.03E-08	2.83E-06	9.44E-05	1.45E-03	1.65E-05	2.90E-03	**5.65E-03**
Ethylbenzene	1.52E-01	4.16E-03	4.16E-02	5.97E-06	1.63E-03	1.63E-02	7.60E-02	8.67E-04	2.99E-03	**6.10E-02**
Toluene	6.06E-01	1.66E-02	2.07E-01	1.37E-05	3.76E-03	4.70E-02	3.03E-01	3.45E-03	2.47E-03	**2.57E-01**
Xylenes, total	8.12E-01	2.22E-02	1.11E-01	3.45E-05	9.45E-03	4.72E-02	4.06E-01	4.63E-03	1.60E-01	**3.18E-01**
General Chemistry										
Cyanide, total	4.10E-02	1.12E-03	1.87E+00	8.20E-09	2.25E-06	3.74E-03	NA	NA	NA	**1.88E+00**
Nitrate-Nitrite	1.50E+00	4.11E-02	4.11E-01	3.00E-07	8.22E-05	8.22E-04	NA	NA	NA	**4.12E-01**
Total HI			**1.08E+01**			**4.59E-01**			**5.76E-01**	**1.18E+01**

EPC - Exposure point concentration.
HQ - Hazard quotient; HI - Hazard index.
mg/L - Milligrams per liter.
mg/cm^2 - Milligrams per square meter.
mg/kg - Milligrams per kilogram.
mg/m^3- Milligrams per cubic meter.

Table D-16

On-Site Resident, Future Scenario, Cancer Risk from Exposure to Overburden Groundwater
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion			Dermal Contact					Inhalation of VOCs				**All**
		Adult	Child		Dose	Adult	Dose	Child		Concentration	Adult	Child		**Pathways**
	EPC	Dose	Dose		Absorbed	Dose	Absorbed	Dose		in Air	Dose	Dose		**Total**
Chemicals of Potential Concern	mg/L	mg/kg-day	mg/kg-day	ILCR	mg/cm^2-day	mg/kg-day	mg/cm^2-day	mg/kg-day	ILCR	mg/m^3	mg/kg-day	mg/kg-day	ILCR	**ILCR**
Inorganics														
Cobalt	1.66E-02	1.56E-04	9.08E-05	NA	1.33E-09	1.25E-07	2.21E-09	7.99E-08	NA	NA	NA	NA	NA	**NA**
Nickel	5.63E-02	5.29E-04	3.08E-04	NA	2.25E-09	2.11E-07	3.75E-09	1.36E-07	NA	NA	NA	NA	NA	**NA**
Thallium	4.06E-03	3.81E-05	2.22E-05	NA	8.12E-10	7.63E-08	1.35E-09	4.89E-08	NA	NA	NA	NA	NA	**NA**
General Chemistry														
Sulfate	1.27E+03	1.19E+01	6.96E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Total ILCR				**NA**					**NA**				**NA**	**NA**

EPC - Exposure point concentration.
ILCR - Incremental lifetime cancer risk.
mg/L - Milligrams per liter.
mg/cm^2 - Milligrams per square meter.
mg/kg - Milligrams per kilogram.
mg/m^3- Milligrams per cubic meter.

Table D-17

Child On-Site Resident, Future Scenario, Noncancer Hazard from Exposure to Overburden Groundwater
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion		Dermal Contact			Inhalation of VOCs			**All**
		Child		Dose	Child		Concentration	Child		**Pathways**
	EPC	Dose		Absorbed	Dose		in Air	Dose		**Total**
Chemicals of Potential Concern	mg/L	mg/kg-day	HQ	mg/cm^2-day	mg/kg-day	HQ	mg/m^3	mg/kg-day	HQ	**HI**
Inorganics										
Cobalt	1.66E-02	1.06E-03	3.53E+00	2.21E-09	9.32E-07	3.11E-03	NA	NA	NA	**3.54E+00**
Nickel	5.63E-02	3.60E-03	1.80E-01	3.75E-09	1.58E-06	1.98E-03	NA	NA	NA	**1.82E-01**
Thallium	4.06E-03	2.60E-04	2.60E+01	1.35E-09	5.70E-07	5.70E-02	NA	NA	NA	**2.60E+01**
General Chemistry										
Sulfate	1.27E+03	8.12E+01	NA	NA	NA	NA	NA	NA	NA	**NA**
Total HI			**2.97E+01**			**6.21E-02**			**NA**	**2.97E+01**

EPC - Exposure point concentration.
HQ - Hazard quotient; HI - Hazard index.
mg/L - Milligrams per liter.
mg/cm^2 - Milligrams per square meter.
mg/kg - Milligrams per kilogram.
mg/m^3- Milligrams per cubic meter.

Table D-18

Adult On-Site Resident, Future Scenario, Noncancer Hazard from Exposure to Overburden Groundwater
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion		Dermal Contact			Inhalation of VOCs			**All**
		Noncancer		Dose	Adult		Concentration	Adult		**Pathways**
	EPC	Dose		Absorbed	Dose		in Air	Dose		**Total**
Chemicals of Potential Concern	mg/L	mg/kg-day	HQ	mg/cm^2-day	mg/kg-day	HQ	mg/m^3	mg/kg-day	HQ	**HI**
Inorganics										
Cobalt	1.66E-02	4.54E-04	1.51E+00	1.33E-09	3.63E-07	1.21E-03	NA	NA	NA	**1.52E+00**
Nickel	5.63E-02	1.54E-03	7.71E-02	2.25E-09	6.17E-07	7.71E-04	NA	NA	NA	**7.79E-02**
Thallium	4.06E-03	1.11E-04	1.11E+01	8.12E-10	2.22E-07	2.22E-02	NA	NA	NA	**1.11E+01**
General Chemistry										
Sulfate	1.27E+03	3.48E+01	NA	NA	NA	NA	NA	NA	NA	**NA**
Total HI			**1.27E+01**			**2.42E-02**			**NA**	**1.27E+01**

EPC - Exposure point concentration.
HQ - Hazard quotient; HI - Hazard index.
mg/L - Milligrams per liter.
mg/cm^2 - Milligrams per square meter.
mg/kg - Milligrams per kilogram.
mg/m^3- Milligrams per cubic meter.

Table D-19

On-Site Resident, Future Scenario, Exposure to Sediment Cancer Risk
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion			Dermal Contact					**All**
		Adult	Child		Dose	Adult	Dose	Child		**Pathways**
	EPC	Dose	Dose	Resident	Absorbed	Dose	Absorbed	Dose	Resident	**Total**
Chemicals of Potential Concern	mg/kg	mg/kg-day	mg/kg-day	ILCR	mg/cm^2-day	mg/kg-day	mg/cm^2-day	mg/kg-day	ILCR	**ILCR**
Polychlorinated biphenyls										
Aroclor 1254	1.69E-01	7.94E-09	1.85E-08	5.29E-08	1.66E-10	6.59E-10	4.73E-10	1.08E-09	3.47E-09	**5.64E-08**
Total ILCR or HI				**5.29E-08**					**3.47E-09**	**5.64E-08**

EPC - Exposure point concentration.
ILCR - Incremental lifetime cancer risk.
mg/kg - Milligrams per kilogram.
mg/cm^2 - Milligrams per centimeter squared.

Table D-20

On-Site Child Resident, Future Scenario, Exposure to Sediment Noncancer Risk
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion		Dermal Contact			**All**
		Child		Dose	Child		**Pathways**
	EPC	Dose	Child	Absorbed	Dose	Child	**Total**
Chemicals of Potential Concern	mg/kg	mg/kg-day	HQ	mg/cm^2-day	mg/kg-day	HQ	**HI**
Polychlorinated biphenyls							
Aroclor 1254	1.69E-01	2.16E-07	1.08E-02	4.73E-10	1.26E-08	6.29E-04	**1.14E-02**
Total ILCR or HI			**1.08E-02**			**6.29E-04**	**1.14E-02**

EPC - Exposure point concentration.
HQ - Hazard quotient; HI - Hazard index.
mg/kg - Milligrams per kilogram.
mg/cm^2 - Milligrams per centimeter squared.

Table D-21

On-Site Adult Resident, Future Scenario, Exposure to Sediment Noncancer Risk
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion		Dermal Contact			**All**
		Adult		Dose	Adult		**Pathways**
	EPC	Dose	Adult	Absorbed	Dose	Adult	**Total**
Chemicals of Potential Concern	mg/kg	mg/kg-day	HQ	mg/cm^2-day	mg/kg-day	HQ	**HI**
Polychlorinated biphenyls							
Aroclor 1254	1.69E-01	2.32E-08	1.16E-03	1.66E-10	1.92E-09	9.61E-05	**1.25E-03**
Total ILCR or HI			**1.16E-03**			**9.61E-05**	**1.25E-03**

EPC - Exposure point concentration.
HQ - Hazard quotient; HI - Hazard index.
mg/kg - Milligrams per kilogram.
mg/cm^2 - Milligrams per centimeter squared.

Table D-22

Adult Hunter, Future Scenario, Exposure to Surface Soil
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion				Dermal Contact				
Chemicals of Potential Concern	EPC mg/kg	Cancer Dose mg/kg-day	Noncancer Dose mg/kg-day	Adult Hunter ILCR	Adult Hunter HQ	Dose Absorbed mg/cm^2-day	Cancer Dose mg/kg-day	Noncancer Dose mg/kg-day	Adult Hunter ILCR	Adult Hunter HQ
Polychlorinated biphenyls (PCB)										
Aroclor 1016	8.14E-01	1.91E-08	4.46E-08	1.34E-09	6.37E-04	2.28E-08	1.77E-08	4.12E-08	1.24E-09	5.89E-04
Explosives										
Amino-2,6-dinitrotoluene, 4-	1.10E+01	2.59E-07	6.03E-07	NA	3.02E-04	1.32E-08	1.02E-08	2.39E-08	NA	1.19E-05
Amino-4,6-dinitrotoluene, 2-	2.17E+01	5.09E-07	1.19E-06	NA	5.94E-04	3.90E-08	3.02E-08	7.06E-08	NA	3.53E-05
Trinitrotoluene, 2,4,6-	3.11E+02	7.31E-06	1.71E-05	2.19E-07	3.41E-02	1.99E-06	1.54E-06	3.60E-06	4.63E-08	7.21E-03
Semivolatile Organic Compounds										
Benzo(a)anthracene	1.17E+00	2.74E-08	6.39E-08	2.00E-08	NA	3.03E-08	2.35E-08	5.48E-08	1.72E-08	NA
Benzo(a)pyrene	1.01E+00	2.36E-08	5.51E-08	1.72E-07	NA	2.62E-08	2.03E-08	4.73E-08	1.48E-07	NA
Benzo(b)fluoranthene	1.52E+00	3.56E-08	8.31E-08	2.60E-08	NA	3.94E-08	3.06E-08	7.13E-08	2.23E-08	NA
Dibenz(a,h)anthracene	1.96E-01	4.60E-09	1.07E-08	3.36E-08	NA	5.10E-09	3.95E-09	9.21E-09	2.88E-08	NA
Dinitrotoluene, 2,4-	3.33E+00	7.81E-08	1.82E-07	5.31E-08	9.11E-05	6.79E-08	5.26E-08	1.23E-07	3.58E-08	6.13E-05
Dinitrotoluene, 2,6-	2.18E+00	5.12E-08	1.19E-07	3.48E-08	1.19E-04	4.32E-08	3.34E-08	7.80E-08	2.27E-08	7.80E-05
Indeno(1,2,3-cd)pyrene	8.73E-01	2.05E-08	4.78E-08	1.50E-08	NA	2.27E-08	1.76E-08	4.10E-08	1.28E-08	NA
Total ILCR and HI				**5.76E-07**	**3.59E-02**				**3.35E-07**	**7.98E-03**

EPC - Exposure point concentration.
HQ - Hazard quotient; HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
mg/kg - Milligrams per kilogram.
mg/cm^2 - Milligrams per square meter.

Table D-22

Adult Hunter, Future Scenario, Exposure to Surface Soil
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Chemicals of Potential Concern	Concentration in Forage C_p mg/kg	Concentration in Venison C_v mg/kg	Consumption of Venison: Cancer Dose mg/kg-day	Consumption of Venison: Noncancer Dose mg/kg-day	ILCR	HQ	**All Pathways: Total ILCR**	**All Pathways: Total HI**
Polychlorinated biphenyls (PCB)								
Aroclor 1016	2.28E-02	1.19E-06	9.08E-11	2.12E-10	6.36E-12	3.03E-06	**2.58E-09**	**1.23E-03**
Explosives								
Amino-2,6-dinitrotoluene, 4-	NA	NA	NA	NA	NA	NA	**NA**	**3.14E-04**
Amino-4,6-dinitrotoluene, 2-	NA	NA	NA	NA	NA	NA	**NA**	**6.29E-04**
Trinitrotoluene, 2,4,6-	NA	NA	NA	NA	NA	NA	**2.66E-07**	**4.13E-02**
Semivolatile Organic Compounds								
Benzo(a)anthracene	NA	NA	NA	NA	NA	NA	**3.71E-08**	**NA**
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	**3.20E-07**	**NA**
Benzo(b)fluoranthene	NA	NA	NA	NA	NA	NA	**4.83E-08**	**NA**
Dibenz(a,h)anthracene	NA	NA	NA	NA	NA	NA	**6.24E-08**	**NA**
Dinitrotoluene, 2,4-	NA	NA	NA	NA	NA	NA	**8.89E-08**	**1.52E-04**
Dinitrotoluene, 2,6-	NA	NA	NA	NA	NA	NA	**5.76E-08**	**1.98E-04**
Indeno(1,2,3-cd)pyrene	NA	NA	NA	NA	NA	NA	**2.78E-08**	**NA**
Total ILCR and HI					**6.36E-12**	**3.03E-06**	**9.11E-07**	**4.38E-02**

EPC - Exposure point concentration.
HQ - Hazard quotient; HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
mg/kg - Milligrams per kilogram.
mg/cm^2 - Milligrams per square meter.

Table D-23

Hunter's Child, Future Scenario, Exposure to Surface Soil
TNTA/WWTP1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio

Chemicals of Potential Concern	EPC mg/kg	Concentration in Forage C_p mg/kg	Concentration in Venison C_v mg/kg	Consumption of Venison: Cancer Dose mg/kg-day	Consumption of Venison: Noncancer Dose mg/kg-day	ILCR	HQ	**Total ILCR**	**Total HI**
Polychlorinated biphenyls (PCB)									
Aroclor 1016	8.14E-01	2.28E-02	1.19E-06	3.26E-11	3.80E-10	2.28E-12	5.43E-06	**2.28E-12**	**5.43E-06**
Explosives									
Amino-2,6-dinitrotoluene, 4-	1.10E+01	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Amino-4,6-dinitrotoluene, 2-	2.17E+01	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Trinitrotoluene, 2,4,6-	3.11E+02	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Semivolatile Organic Compounds									
Benzo(a)anthracene	1.17E+00	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Benzo(a)pyrene	1.01E+00	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Benzo(b)fluoranthene	1.52E+00	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Dibenz(a,h)anthracene	1.96E-01	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Dinitrotoluene, 2,4-	3.33E+00	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Dinitrotoluene, 2,6-	2.18E+00	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Indeno(1,2,3-cd)pyrene	8.73E-01	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Total ILCR and HI						**2.28E-12**	**5.43E-06**	**2.28E-12**	**5.43E-06**

EPC - Exposure point concentration.
HQ - Hazard quotient; HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
mg/kg - Milligrams per kilogram.

APPENDIX E

ANALYTICAL DATA SETS USED IN THE BHHRA

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		45A 1N-5N					45A 1S-5S					45A CL-1					45A CL-2					45A CL-3					53B 1N-5N					53B 1S-5S			
SAMPLE_NO		45A 1N-5N					45A 1S-5S					45A CL-1					45A CL-2					45A CL-3					53B 1N-5N					53B 1S-5S			
SAMPLE DATE		4-Nov-10					4-Nov-10					4-Nov-10					4-Nov-10					4-Nov-10					5-Nov-10					5-Nov-10			
DEPTH		0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft			
SAMPLE PURPOSE		REG					REG					REG					REG					REG					REG					REG			
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ
EXPLOSIVES																																			
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.078	0.2	0.078	U	U	0.066	0.17	0.066	U	U	0.061	0.15	0.061	U	U	0.071	0.18	0.071	U	U	0.056	0.14	0.056	U	U	0.073	0.18	0.073	U	U	0.066	0.16	0.066	U
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.078	0.2	0.078	U	U	0.066	0.17	0.066	U	U	0.061	0.15	0.061	U	U	0.071	0.18	0.071	U	U	0.056	0.14	0.056	U	U	0.073	0.18	0.073	U	U	0.066	0.16	0.066	U
Dinitrobenzene, 1,3-	mg/kg	0.078	0.2	0.078	U	U	0.066	0.17	0.066	U	U	0.061	0.15	0.061	U	U	0.071	0.18	0.071	U	U	0.056	0.14	0.056	U	U	0.073	0.18	0.073	U	U	0.066	0.16	0.066	U
Dinitrotoluene, 2,4-	mg/kg	0.095	0.2	0.095	U	U	0.08	0.17	0.08	U	U	0.074	0.15	0.074	U	U	0.086	0.18	0.086	U	U	0.068	0.14	0.068	U	U	0.089	0.18	0.089	U	U	0.08	0.16	0.08	U
Dinitrotoluene, 2,6-	mg/kg	0.085	0.2	0.085	U	U	0.072	0.17	0.072	U	U	0.067	0.15	0.067	U	U	0.077	0.18	0.077	U	U	0.061	0.14	0.061	U	U	0.079	0.18	0.079	U	U	0.072	0.16	0.072	U
HMX	mg/kg	0.078	0.2	0.078	U	U	0.066	0.17	0.066	U	U	0.061	0.15	0.061	U	U	0.071	0.18	0.071	U	U	0.056	0.14	0.056	U	U	0.073	0.18	0.073	U	U	0.066	0.16	0.066	U
Nitrobenzene	mg/kg	0.091	0.2	0.091	U	U	0.077	0.17	0.077	U	U	0.071	0.15	0.071	U	U	0.083	0.18	0.083	U	U	0.065	0.14	0.065	U	U	0.085	0.18	0.085	U	U	0.077	0.16	0.077	U
Nitrotoluene, 2-	mg/kg	0.078	0.2	0.078	U	U	0.066	0.17	0.066	U	U	0.061	0.15	0.061	U	U	0.071	0.18	0.071	U	U	0.056	0.14	0.056	U	U	0.073	0.18	0.073	U	U	0.066	0.16	0.066	U
Nitrotoluene, 3-	mg/kg	0.078	0.2	0.078	U	U	0.066	0.17	0.066	U	U	0.061	0.15	0.061	U	U	0.071	0.18	0.071	U	U	0.056	0.14	0.056	U	U	0.073	0.18	0.073	U	U	0.066	0.16	0.066	U
Nitrotoluene, 4-	mg/kg	0.099	0.2	0.099	U	U	0.083	0.17	0.083	U	U	0.077	0.15	0.077	U	U	0.09	0.18	0.09	U	U	0.071	0.14	0.071	U	U	0.092	0.18	0.092	U	U	0.083	0.16	0.083	U
RDX	mg/kg	0.078	0.2	0.078	U	U	0.066	0.17	0.066	U	U	0.061	0.15	0.061	U	U	0.071	0.18	0.071	U	U	0.056	0.14	0.056	U	U	0.073	0.18	0.073	U	U	0.066	0.16	0.066	U
Tetryl	mg/kg	0.078	0.2	0.078	U	U	0.066	0.17	0.066	U	U	0.061	0.15	0.061	U	U	0.071	0.18	0.071	U	U	0.056	0.14	0.056	U	U	0.073	0.18	0.073	U	U	0.066	0.16	0.066	U
Trinitrobenzene, 1,3,5-	mg/kg	0.078	0.2	0.078	U	U	0.066	0.17	0.066	U	U	0.061	0.15	0.061	U	U	0.0911	0.18	0.071	J	J	0.056	0.14	0.056	U	U	0.073	0.18	0.073	U	U	0.066	0.16	0.066	U
Trinitrotoluene, 2,4,6-	mg/kg	0.078	0.2	0.078	U	U	0.066	0.17	0.066	U	U	0.061	0.15	0.061	U	U	0.0895	0.18	0.071	J	J	0.056	0.14	0.056	U	U	0.073	0.18	0.073	U	U	0.066	0.16	0.066	U
METALS (UNFILTERED)																																			
Aluminum	mg/kg																																		
Antimony	mg/kg																																		
Arsenic	mg/kg																																		
Barium	mg/kg																																		
Beryllium	mg/kg																																		
Cadmium	mg/kg																																		
Calcium	mg/kg																																		
Chromium	mg/kg																																		
Cobalt	mg/kg																																		
Copper	mg/kg																																		
Iron	mg/kg																																		
Lead	mg/kg																																		
Magnesium	mg/kg																																		
Manganese	mg/kg																																		
Mercury	mg/kg																																		
Nickel	mg/kg																																		
Potassium	mg/kg																																		
Selenium	mg/kg																																		
Silver	mg/kg																																		
Sodium	mg/kg																																		
Thallium	mg/kg																																		
Vanadium	mg/kg																																		
Zinc	mg/kg																																		
PESTICIDES/PCBS																																			
Aroclor 1016	mg/kg																																		
Aroclor 1221	mg/kg																																		
Aroclor 1232	mg/kg																																		
Aroclor 1242	mg/kg																																		
Aroclor 1248	mg/kg																																		
Aroclor 1254	mg/kg																																		
Aroclor 1260	mg/kg																																		
SEMIVOLATILES																																			
3-Methylphenol and 4-Methylphenol	mg/kg																																		
Acenaphthene	mg/kg																																		
Acenaphthylene	mg/kg																																		
ACETOPHENONE	mg/kg																																		

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		45A 1N-5N					45A 1S-5S					45A CL-1					45A CL-2					45A CL-3					53B 1N-5N					53B 1S-5S			
SAMPLE_NO		45A 1N-5N					45A 1S-5S					45A CL-1					45A CL-2					45A CL-3					53B 1N-5N					53B 1S-5S			
SAMPLE DATE		4-Nov-10					4-Nov-10					4-Nov-10					4-Nov-10					4-Nov-10					5-Nov-10					5-Nov-10			
DEPTH		0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft			
SAMPLE PURPOSE		REG					REG					REG					REG					REG					REG					REG			
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ
Anthracene	mg/kg																																		
Atrazine	mg/kg																																		
Benzaldehyde	mg/kg																																		
Benzo(a)anthracene	mg/kg																																		
Benzo(a)pyrene	mg/kg																																		
Benzo(b)fluoranthene	mg/kg																																		
Benzo(ghi)perylene	mg/kg																																		
Benzo(k)fluoranthene	mg/kg																																		
Benzoic acid	mg/kg																																		
Benzyl alcohol	mg/kg																																		
BIBENZENE	mg/kg																																		
Bis(2-chloroethoxy)methane	mg/kg																																		
Bis(2-chloroethyl)ether	mg/kg																																		
Bis(2-chloroisopropyl)ether	mg/kg																																		
Bis(2-ethylhexyl)phthalate	mg/kg																																		
Bromophenyl phenyl ether, 4-	mg/kg																																		
Butyl benzyl phthalate	mg/kg																																		
Caprolactam	mg/kg																																		
Carbazole	mg/kg																																		
Chloro-3-methylphenol, 4-	mg/kg																																		
Chloroaniline, 4-	mg/kg																																		
Chloronaphthalene, 2-	mg/kg																																		
Chlorophenol, 2-	mg/kg																																		
Chlorophenyl phenyl ether, 4-	mg/kg																																		
Chrysene	mg/kg																																		
Dibenz(a,h)anthracene	mg/kg																																		
Dibenzofuran	mg/kg																																		
Dichlorobenzene, 1,2-	mg/kg																																		
Dichlorobenzene, 1,3-	mg/kg																																		
Dichlorobenzene, 1,4-	mg/kg																																		
Dichlorobenzidine, 3,3'-	mg/kg																																		
Dichlorophenol, 2,4-	mg/kg																																		
Diethyl phthalate	mg/kg																																		
Dimethyl phthalate	mg/kg																																		
Dimethylphenol, 2,4-	mg/kg																																		
Di-n-butyl phthalate	mg/kg																																		
Dinitro-2-methylphenol, 4,6-	mg/kg																																		
Dinitrophenol, 2,4-	mg/kg																																		
Dinitrotoluene, 2,4-	mg/kg																																		
Dinitrotoluene, 2,6-	mg/kg																																		
Di-n-octyl phthalate	mg/kg																																		
DIPHENYLAMINE	mg/kg																																		
Fluoranthene	mg/kg																																		
Fluorene	mg/kg																																		
Hexachlorobenzene	mg/kg																																		
Hexachlorobutadiene	mg/kg																																		
Hexachlorocyclopentadiene	mg/kg																																		
Hexachloroethane	mg/kg																																		
Indeno(1,2,3-cd)pyrene	mg/kg																																		
Isophorone	mg/kg																																		
Methylnaphthalene, 2-	mg/kg																																		
Methylphenol, 2-	mg/kg																																		

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		45A 1N-5N					45A 1S-5S					45A CL-1					45A CL-2					45A CL-3					53B 1N-5N					53B 1S-5S			
SAMPLE_NO		45A 1N-5N					45A 1S-5S					45A CL-1					45A CL-2					45A CL-3					53B 1N-5N					53B 1S-5S			
SAMPLE DATE		4-Nov-10					4-Nov-10					4-Nov-10					4-Nov-10					4-Nov-10					5-Nov-10					5-Nov-10			
DEPTH		0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft			
SAMPLE PURPOSE		REG					REG					REG					REG					REG					REG					REG			
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ
Methylphenol, 4-	mg/kg																																		
Naphthalene	mg/kg																																		
Nitroaniline, 2-	mg/kg																																		
Nitroaniline, 3-	mg/kg																																		
Nitroaniline, 4-	mg/kg																																		
Nitrobenzene	mg/kg																																		
Nitrophenol, 2-	mg/kg																																		
Nitrophenol, 4-	mg/kg																																		
n-Nitrosodimethylamine	mg/kg																																		
n-Nitroso-di-n-propylamine	mg/kg																																		
n-Nitrosodiphenylamine	mg/kg																																		
Pentachlorophenol	mg/kg																																		
Phenanthrene	mg/kg																																		
Phenol	mg/kg																																		
Pyrene	mg/kg																																		
Trichlorobenzene, 1,2,4-	mg/kg																																		
Trichlorophenol, 2,4,5-	mg/kg																																		
Trichlorophenol, 2,4,6-	mg/kg																																		
WATER QUALITY																																			
% Solids	Percent																																		
Total organic carbon	mg/kg																																		

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE			53B CL-1					53B CL-2					53B CL-3					SL-SB01					SL-SB01					SL-SB03			
SAMPLE_NO			53B CL-1					53B CL-2					53B CL-3					SL0061					SL0062					SL0067			
SAMPLE DATE			5-Nov-10					5-Nov-10					5-Nov-10					13-Jan-09					13-Jan-09					13-Jan-09			
DEPTH			0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 1 Ft					4 - 6 Ft					0 - 1 Ft			
SAMPLE PURPOSE			REG					REG					REG					REG					REG					REG			
Parameter	Units	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ
EXPLOSIVES																															
Amino-2,6-dinitrotoluene, 4-	mg/kg	U	0.061	0.15	0.061	U	U	0.065	0.16	0.065	U	U	0.064	0.16	0.064	U	U	0.471	0.296	0.148			0.15	0.3	0.15	U	U	0.149	0.297	0.149	U
Amino-4,6-dinitrotoluene, 2-	mg/kg	U	0.061	0.15	0.061	U	U	0.065	0.16	0.065	U	U	0.064	0.16	0.064	U	U	0.605	0.296	0.148			0.15	0.3	0.15	U	U	0.149	0.297	0.149	U
Dinitrobenzene, 1,3-	mg/kg	U	0.061	0.15	0.061	U	U	0.065	0.16	0.065	U	U	0.064	0.16	0.064	U	U	0.148	0.296	0.148	U	U	0.15	0.3	0.15	U	U	0.149	0.297	0.149	U
Dinitrotoluene, 2,4-	mg/kg	U	0.074	0.15	0.074	U	U	0.078	0.16	0.078	U	U	0.078	0.16	0.078	U	U	0.148	0.296	0.148	U	U	0.15	0.3	0.15	U	U	0.149	0.297	0.149	U
Dinitrotoluene, 2,6-	mg/kg	U	0.067	0.15	0.067	U	U	0.16	0.16	0.16	U	U	0.07	0.16	0.07	U	U	0.148	0.296	0.148	U	U	0.15	0.3	0.15	Q1,U	U	0.149	0.297	0.149	U
HMX	mg/kg	U	0.061	0.15	0.061	U	U	0.065	0.16	0.065	U	U	0.064	0.16	0.064	U	U	0.148	0.296	0.148	U	U	0.15	0.3	0.15	U	U	0.149	0.297	0.149	U
Nitrobenzene	mg/kg	U	0.071	0.15	0.071	U	U	0.075	0.16	0.075	U	U	0.075	0.16	0.075	U	U	0.148	0.296	0.148	U	U	0.15	0.3	0.15	U	U	0.149	0.297	0.149	U
Nitrotoluene, 2-	mg/kg	U	0.061	0.15	0.061	U	U	0.065	0.16	0.065	U	U	0.064	0.16	0.064	U	U	0.148	0.296	0.148	U	U	0.15	0.3	0.15	U	U	0.149	0.297	0.149	U
Nitrotoluene, 3-	mg/kg	U	0.061	0.15	0.061	U	U	0.065	0.16	0.065	U	U	0.064	0.16	0.064	U	U	0.148	0.296	0.148	U	U	0.15	0.3	0.15	U	U	0.149	0.297	0.149	U
Nitrotoluene, 4-	mg/kg	U	0.077	0.15	0.077	U	U	0.081	0.16	0.081	U	U	0.081	0.16	0.081	U	U	0.148	0.296	0.148	U	U	0.15	0.3	0.15	U	U	0.149	0.297	0.149	U
RDX	mg/kg	U	0.061	0.15	0.061	U	U	0.065	0.16	0.065	U	U	0.064	0.16	0.064	U	U	0.148	0.296	0.148	U	U	0.15	0.3	0.15	U	U	0.149	0.297	0.149	U
Tetryl	mg/kg	U	0.061	0.15	0.061	U	U	0.065	0.16	0.065	U	U	0.064	0.16	0.064	U	U	0.148	0.296	0.148	U	U	0.15	0.3	0.15	U	U	0.149	0.297	0.149	U
Trinitrobenzene, 1,3,5-	mg/kg	U	0.061	0.15	0.061	U	U	0.065	0.16	0.065	U	U	0.064	0.16	0.064	U	U	0.148	0.296	0.148	U	U	0.15	0.3	0.15	U	U	0.149	0.297	0.149	U
Trinitrotoluene, 2,4,6-	mg/kg	U	0.061	0.15	0.061	U	U	0.487	0.16	0.065			0.064	0.16	0.064	U	U	0.148	0.296	0.148	U	U	0.15	0.3	0.15	U	U	0.149	0.297	0.149	U
METALS (UNFILTERED)																															
Aluminum	mg/kg																	8710	4.3	2.15			7040	3.28	1.64			9090	4.16	2.08	
Antimony	mg/kg																	0.269	0.538	0.269	U	UJ	0.391	0.41	0.205	J	J	0.357	0.52	0.26	J
Arsenic	mg/kg																	4.8	1.08	0.538		J	13.8	0.82	0.41		J	12.2	1.04	0.52	
Barium	mg/kg																	52.3	0.215	0.108			41.7	0.164	0.082			51.7	0.208	0.104	
Beryllium	mg/kg																	5.22	0.215	0.108		J	6.99	0.164	0.082		J	7.87	0.208	0.104	
Cadmium	mg/kg																	0.269	0.538	0.269	U	U	0.234	0.41	0.205	J	J	0.26	0.52	0.26	U
Calcium	mg/kg																	4090	10.8	5.38			27800	8.2	4.1			7330	10.4	5.2	
Chromium	mg/kg																	11.2	0.538	0.269			10.8	0.41	0.205			14.1	0.52	0.26	
Cobalt	mg/kg																	4.19	0.215	0.108			9.15	0.164	0.082			8.65	0.208	0.104	
Copper	mg/kg																	15.4	0.538	0.269			36.3	0.41	0.205			27.8	0.52	0.26	
Iron	mg/kg																	14600	2.15	1.08			26600	3.28	1.64			25200	2.08	1.04	
Lead	mg/kg																	14	0.538	0.269			14	0.41	0.205			13.9	0.52	0.26	
Magnesium	mg/kg																	1610	2.15	1.08		J	5470	1.64	0.82		J	3500	2.08	1.04	
Manganese	mg/kg																	156	0.215	0.108			326	0.164	0.082			306	0.208	0.104	
Mercury	mg/kg																	0.443	0.0236	0.0118			0.0164	0.0216	0.0108	J	J	0.0419	0.0252	0.0126	
Nickel	mg/kg																	2.68	0.323	0.161		J	14.6	0.246	0.123		J	11.8	0.312	0.156	
Potassium	mg/kg																	480	26.9	13.5			775	20.5	10.2			900	26	13	
Selenium	mg/kg																	0.538	1.08	0.538	U	UJ	0.41	0.82	0.41	U	UJ	0.52	1.04	0.52	U
Silver	mg/kg																	0.269	0.538	0.269	U	U	0.205	0.41	0.205	U	U	0.26	0.52	0.26	U
Sodium	mg/kg																	48.1	21.5	10.8			82.7	16.4	8.2			76.7	20.8	10.4	
Thallium	mg/kg																	0.269	0.538	0.269	U	U	0.414	0.41	0.205			0.366	0.52	0.26	J
Vanadium	mg/kg																	20.4	0.215	0.108			15.5	0.164	0.082			20.2	0.208	0.104	
Zinc	mg/kg																	34	2.69	1.35		J	88.1	2.05	1.02		J	65.2	2.6	1.3	
PESTICIDES/PCBS																															
Aroclor 1016	mg/kg																	0.00846	0.0422	0.00846	U	U	0.00796	0.0398	0.00796	U	U	0.0478	0.0427	0.00855	P
Aroclor 1221	mg/kg																	0.00846	0.0422	0.00846	U	U	0.00796	0.0398	0.00796	U	U	0.00855	0.0427	0.00855	U
Aroclor 1232	mg/kg																	0.00846	0.0422	0.00846	U	U	0.00796	0.0398	0.00796	U	U	0.00855	0.0427	0.00855	U
Aroclor 1242	mg/kg																	0.00846	0.0422	0.00846	U	U	0.00796	0.0398	0.00796	U	U	0.00855	0.0427	0.00855	U
Aroclor 1248	mg/kg																	0.00846	0.0422	0.00846	U	U	0.00796	0.0398	0.00796	U	U	0.00855	0.0427	0.00855	U
Aroclor 1254	mg/kg																	0.00846	0.0422	0.00846	U	U	0.00796	0.0398	0.00796	U	U	0.00855	0.0427	0.00855	U
Aroclor 1260	mg/kg																	0.00846	0.0422	0.00846	U	U	0.00796	0.0398	0.00796	U	U	0.00855	0.0427	0.00855	U
SEMIVOLATILES																															
3-Methylphenol and 4-Methylphenol	mg/kg																														
Acenaphthene	mg/kg																	0.00769	0.427	0.00769	U	U	0.00716	0.398	0.00716	U	U	0.00784	0.435	0.00784	U
Acenaphthylene	mg/kg																	0.00512	0.427	0.00512	U	U	0.00478	0.398	0.00478	U	U	0.00523	0.435	0.00523	U
ACETOPHENONE	mg/kg																														

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE			53B CL-1					53B CL-2					53B CL-3					SL-SB01					SL-SB01					SL-SB03			
SAMPLE_NO			53B CL-1					53B CL-2					53B CL-3					SL0061					SL0062					SL0067			
SAMPLE DATE			5-Nov-10					5-Nov-10					5-Nov-10					13-Jan-09					13-Jan-09					13-Jan-09			
DEPTH			0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 1 Ft					4 - 6 Ft					0 - 1 Ft			
SAMPLE PURPOSE			REG					REG					REG					REG					REG					REG			
Parameter	Units	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ
Anthracene	mg/kg																	0.00922	0.427	0.00922	U	U	0.0086	0.398	0.0086	U	U	0.00941	0.435	0.00941	U
Atrazine	mg/kg																															
Benzaldehyde	mg/kg																															
Benzo(a)anthracene	mg/kg																	0.047	0.427	0.0281	J	J	0.0261	0.398	0.0261	U	U	0.0286	0.435	0.0286	U
Benzo(a)pyrene	mg/kg																	0.0281	0.427	0.0281	U	U	0.0261	0.398	0.0261	U	U	0.0286	0.435	0.0286	U
Benzo(b)fluoranthene	mg/kg																	0.0713	0.427	0.0711	J	J	0.0663	0.398	0.0663	U	U	0.0725	0.435	0.0725	U
Benzo(ghi)perylene	mg/kg																	0.104	0.427	0.104	U	U	0.0969	0.398	0.0969	U	U	0.106	0.435	0.106	U
Benzo(k)fluoranthene	mg/kg																	0.129	0.427	0.129	U	U	0.121	0.398	0.121	U	U	0.132	0.435	0.132	U
Benzoic acid	mg/kg																	0.639	0.427	0.104		QJ	0.0969	0.398	0.0969	U	U	0.106	0.435	0.106	U
Benzyl alcohol	mg/kg																	0.104	0.427	0.104	U	U	0.0969	0.398	0.0969	U	U	0.106	0.435	0.106	U
BIBENZENE	mg/kg																															
Bis(2-chloroethoxy)methane	mg/kg																	0.00897	0.427	0.00897	U	U	0.00836	0.398	0.00836	U	U	0.00915	0.435	0.00915	U
Bis(2-chloroethyl)ether	mg/kg																	0.0109	0.427	0.0109	U	U	0.0101	0.398	0.0101	U	U	0.0111	0.435	0.0111	U
Bis(2-chloroisopropyl)ether	mg/kg																	0.0186	0.427	0.0186	U	U	0.0173	0.398	0.0173	U	U	0.0189	0.435	0.0189	U
Bis(2-ethylhexyl)phthalate	mg/kg																	0.0395	0.427	0.0395	U	U	0.0368	0.398	0.0368	U	U	0.0402	0.435	0.0402	U
Bromophenyl phenyl ether, 4-	mg/kg																	0.0152	0.427	0.0152	U	U	0.0142	0.398	0.0142	U	U	0.0155	0.435	0.0155	U
Butyl benzyl phthalate	mg/kg																	0.0173	0.427	0.0173	U	U	0.0161	0.398	0.0161	U	U	0.0176	0.435	0.0176	U
Caprolactam	mg/kg																															
Carbazole	mg/kg																	0.0427	0.427	0.0427	U	U	0.0398	0.398	0.0398	U	U	0.0435	0.435	0.0435	U
Chloro-3-methylphenol, 4-	mg/kg																	0.0105	0.427	0.0105	U	U	0.00979	0.398	0.00979	U	U	0.0107	0.435	0.0107	U
Chloroaniline, 4-	mg/kg																	0.037	0.427	0.037	U	U	0.0345	0.398	0.0345	Q1,U	UJ	0.0378	0.435	0.0378	Q1,U
Chloronaphthalene, 2-	mg/kg																	0.00679	0.427	0.00679	U	U	0.00633	0.398	0.00633	U	U	0.00692	0.435	0.00692	U
Chlorophenol, 2-	mg/kg																	0.00525	0.427	0.00525	U	U	0.00489	0.398	0.00489	U	U	0.00536	0.435	0.00536	U
Chlorophenyl phenyl ether, 4-	mg/kg																	0.0327	0.427	0.0327	U	U	0.0304	0.398	0.0304	U	U	0.0333	0.435	0.0333	U
Chrysene	mg/kg																	0.0632	0.427	0.0169	J	J	0.0158	0.398	0.0158	U	U	0.0172	0.435	0.0172	U
Dibenz(a,h)anthracene	mg/kg																	0.0965	0.427	0.0965	U	U	0.0899	0.398	0.0899	U	U	0.0984	0.435	0.0984	U
Dibenzofuran	mg/kg																	0.00717	0.427	0.00717	U	U	0.00669	0.398	0.00669	U	U	0.00732	0.435	0.00732	U
Dichlorobenzene, 1,2-	mg/kg																	0.00986	0.427	0.00986	U	U	0.00919	0.398	0.00919	U	U	0.0101	0.435	0.0101	U
Dichlorobenzene, 1,3-	mg/kg																	0.0155	0.427	0.0155	U	U	0.0144	0.398	0.0144	U	U	0.0158	0.435	0.0158	U
Dichlorobenzene, 1,4-	mg/kg																	0.00833	0.427	0.00833	U	U	0.00776	0.398	0.00776	U	U	0.00849	0.435	0.00849	U
Dichlorobenzidine, 3,3'-	mg/kg																	0.0423	0.427	0.0423	U	U	0.0394	0.398	0.0394	Q1,U	UJ	0.0431	0.435	0.0431	Q1,U
Dichlorophenol, 2,4-	mg/kg																	0.0152	0.427	0.0152	U	U	0.0142	0.398	0.0142	U	U	0.0155	0.435	0.0155	U
Diethyl phthalate	mg/kg																	0.0173	0.427	0.0173	U	U	0.0161	0.398	0.0161	U	U	0.0176	0.435	0.0176	U
Dimethyl phthalate	mg/kg																	0.0131	0.427	0.0131	U	U	0.0122	0.398	0.0122	U	U	0.0133	0.435	0.0133	U
Dimethylphenol, 2,4-	mg/kg																	0.0113	0.427	0.0113	U	U	0.0105	0.398	0.0105	U	U	0.0115	0.435	0.0115	U
Di-n-butyl phthalate	mg/kg																	0.00922	0.427	0.00922	U	U	0.0086	0.398	0.0086	U	U	0.00941	0.435	0.00941	U
Dinitro-2-methylphenol, 4,6-	mg/kg																	0.0429	0.427	0.0429	U	U	0.04	0.398	0.04	U	U	0.0438	0.435	0.0438	U
Dinitrophenol, 2,4-	mg/kg																	0.068	0.427	0.068	U	U	0.0634	0.398	0.0634	U	U	0.0694	0.435	0.0694	U
Dinitrotoluene, 2,4-	mg/kg																	0.015	0.427	0.015	U	U	0.014	0.398	0.014	U	U	0.0153	0.435	0.0153	U
Dinitrotoluene, 2,6-	mg/kg																	0.0102	0.427	0.0102	U	U	0.00955	0.398	0.00955	U	U	0.0105	0.435	0.0105	U
Di-n-octyl phthalate	mg/kg																	0.0803	0.427	0.0803	U	U	0.0749	0.398	0.0749	U	U	0.0819	0.435	0.0819	U
DIPHENYLAMINE	mg/kg																	0.0423	0.427	0.0423	U	U	0.0394	0.398	0.0394	U	U	0.0431	0.435	0.0431	U
Fluoranthene	mg/kg																	0.111	0.427	0.00922	J	J	0.0086	0.398	0.0086	U	U	0.00941	0.435	0.00941	U
Fluorene	mg/kg																	0.0181	0.427	0.0181	U	U	0.0168	0.398	0.0168	U	U	0.0184	0.435	0.0184	U
Hexachlorobenzene	mg/kg																	0.0265	0.427	0.0265	U	U	0.0247	0.398	0.0247	U	U	0.027	0.435	0.027	U
Hexachlorobutadiene	mg/kg																	0.0405	0.427	0.0405	U	U	0.0377	0.398	0.0377	U	U	0.0413	0.435	0.0413	U
Hexachlorocyclopentadiene	mg/kg																	0.0136	0.427	0.0136	U	U	0.0127	0.398	0.0127	Q2,U	UJ	0.0138	0.435	0.0138	Q2,U
Hexachloroethane	mg/kg																	0.0131	0.427	0.0131	U	U	0.0122	0.398	0.0122	U	U	0.0133	0.435	0.0133	U
Indeno(1,2,3-cd)pyrene	mg/kg																	0.138	0.427	0.138	U	U	0.129	0.398	0.129	U	U	0.141	0.435	0.141	U
Isophorone	mg/kg																	0.00512	0.427	0.00512	U	U	0.00478	0.398	0.00478	U	U	0.00523	0.435	0.00523	U
Methylnaphthalene, 2-	mg/kg																	0.112	0.427	0.112	U	U	0.104	0.398	0.104	U	U	0.114	0.435	0.114	U
Methylphenol, 2-	mg/kg																	0.0064	0.427	0.0064	U	U	0.00597	0.398	0.00597	U	U	0.00653	0.435	0.00653	U

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE			53B CL-1					53B CL-2					53B CL-3					SL-SB01					SL-SB01					SL-SB03			
SAMPLE_NO			53B CL-1					53B CL-2					53B CL-3					SL0061					SL0062					SL0067			
SAMPLE DATE			5-Nov-10					5-Nov-10					5-Nov-10					13-Jan-09					13-Jan-09					13-Jan-09			
DEPTH			0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 1 Ft					4 - 6 Ft					0 - 1 Ft			
SAMPLE PURPOSE			REG					REG					REG					REG					REG					REG			
Parameter	Units	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ
Methylphenol, 4-	mg/kg																	0.0133	0.427	0.0133	U	U	0.0124	0.398	0.0124	U	U	0.0136	0.435	0.0136	U
Naphthalene	mg/kg																	0.0101	0.427	0.0101	U	U	0.00943	0.398	0.00943	U	U	0.0103	0.435	0.0103	U
Nitroaniline, 2-	mg/kg																	0.0184	0.427	0.0184	U	U	0.0172	0.398	0.0172	U	U	0.0188	0.435	0.0188	U
Nitroaniline, 3-	mg/kg																	0.0145	0.427	0.0145	U	U	0.0135	0.398	0.0135	U	U	0.0148	0.435	0.0148	U
Nitroaniline, 4-	mg/kg																	0.151	0.427	0.151	U	U	0.141	0.398	0.141	U	U	0.154	0.435	0.154	U
Nitrobenzene	mg/kg																	0.014	0.427	0.014	U	U	0.013	0.398	0.013	U	U	0.0142	0.435	0.0142	U
Nitrophenol, 2-	mg/kg																	0.0151	0.427	0.0151	U	U	0.0141	0.398	0.0141	U	U	0.0154	0.435	0.0154	U
Nitrophenol, 4-	mg/kg																	0.0346	0.427	0.0346	U	U	0.0322	0.398	0.0322	U	U	0.0353	0.435	0.0353	U
n-Nitrosodimethylamine	mg/kg																	0.0128	0.427	0.0128	U	U	0.0119	0.398	0.0119	U	U	0.0131	0.435	0.0131	U
n-Nitroso-di-n-propylamine	mg/kg																	0.0152	0.427	0.0152	U	U	0.0142	0.398	0.0142	U	U	0.0155	0.435	0.0155	U
n-Nitrosodiphenylamine	mg/kg																	0.00602	0.427	0.00602	U	U	0.00561	0.398	0.00561	U	U	0.00614	0.435	0.00614	U
Pentachlorophenol	mg/kg																	0.0383	0.427	0.0383	U	U	0.0357	0.398	0.0357	U	U	0.0391	0.435	0.0391	U
Phenanthrene	mg/kg																	0.0427	0.427	0.0104	J	J	0.00967	0.398	0.00967	U	U	0.0106	0.435	0.0106	U
Phenol	mg/kg																	0.00512	0.427	0.00512	U	U	0.00478	0.398	0.00478	U	U	0.00523	0.435	0.00523	U
Pyrene	mg/kg																	0.0726	0.427	0.017	J	J	0.0159	0.398	0.0159	U	U	0.0174	0.435	0.0174	U
Trichlorobenzene, 1,2,4-	mg/kg																	0.0105	0.427	0.0105	U	U	0.00979	0.398	0.00979	U	U	0.0107	0.435	0.0107	U
Trichlorophenol, 2,4,5-	mg/kg																	0.0366	0.427	0.0366	U	U	0.0341	0.398	0.0341	U	U	0.0374	0.435	0.0374	U
Trichlorophenol, 2,4,6-	mg/kg																	0.0288	0.427	0.0288	U	U	0.0269	0.398	0.0269	U	U	0.0294	0.435	0.0294	U
WATER QUALITY																															
% Solids	Percent																														
Total organic carbon	mg/kg																	3260	2600	65	B										

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE			SL-SB03					SL-SB04					SL-SB04					SL-SB06					SL-SB06				
SAMPLE_NO			SL0068					SL0069					SL0070					SL0073					SL0074				
SAMPLE DATE			13-Jan-09					13-Jan-09					13-Jan-09					13-Jan-09					13-Jan-09				
DEPTH			5 - 6 Ft					0 - 1 Ft					3_4 - 5_4 Ft					0 - 1 Ft					5 - 6 Ft				
SAMPLE PURPOSE			REG					REG					REG					REG					REG				
Parameter	Units	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
EXPLOSIVES																											
Amino-2,6-dinitrotoluene, 4-	mg/kg	U	0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U	0.209	0.294	0.147	J	J	0.15	0.3	0.15	U	U	0.149	0.299	0.149	U	U
Amino-4,6-dinitrotoluene, 2-	mg/kg	U	0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U	0.149	0.294	0.147	J	J	0.15	0.3	0.15	U	U	0.149	0.299	0.149	U	U
Dinitrobenzene, 1,3-	mg/kg	U	0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U	0.147	0.294	0.147	U	U	0.15	0.3	0.15	U	U	0.149	0.299	0.149	U	U
Dinitrotoluene, 2,4-	mg/kg	U	0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U	0.201	0.294	0.147	J	J	0.15	0.3	0.15	U	U	0.404	0.299	0.149		
Dinitrotoluene, 2,6-	mg/kg	U	0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U	0.147	0.294	0.147	U	U	0.15	0.3	0.15	U	U	0.149	0.299	0.149	U	U
HMX	mg/kg	U	0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U	0.147	0.294	0.147	U	U	0.15	0.3	0.15	U	U	0.149	0.299	0.149	U	U
Nitrobenzene	mg/kg	U	0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U	0.147	0.294	0.147	U	U	0.15	0.3	0.15	U	U	0.149	0.299	0.149	U	U
Nitrotoluene, 2-	mg/kg	U	0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U	0.147	0.294	0.147	U	U	0.15	0.3	0.15	U	U	0.149	0.299	0.149	U	U
Nitrotoluene, 3-	mg/kg	U	0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U	0.147	0.294	0.147	U	U	0.15	0.3	0.15	U	U	0.149	0.299	0.149	U	U
Nitrotoluene, 4-	mg/kg	U	0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U	0.147	0.294	0.147	U	U	0.15	0.3	0.15	U	U	0.149	0.299	0.149	U	U
RDX	mg/kg	U	0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U	0.147	0.294	0.147	U	U	0.15	0.3	0.15	U	U	0.149	0.299	0.149	U	U
Tetryl	mg/kg	U	0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U	0.147	0.294	0.147	U	U	0.15	0.3	0.15	U	U	0.149	0.299	0.149	U	U
Trinitrobenzene, 1,3,5-	mg/kg	U	0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U	0.147	0.294	0.147	U	U	0.15	0.3	0.15	U	U	1.31	0.299	0.149		
Trinitrotoluene, 2,4,6-	mg/kg	U	0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U	0.147	0.294	0.147	U	U	0.15	0.3	0.15	U	U	0.21	0.299	0.149	J	J
METALS (UNFILTERED)																											
Aluminum	mg/kg		7740	3.61	1.81			8870	4.26	2.13			9430	3.86	1.93			9020	3.69	1.85			9100	3.59	1.8		
Antimony	mg/kg	J	0.448	0.452	0.226	J	J	0.266	0.532	0.266	U	UJ	0.517	0.482	0.241		J	0.231	0.462	0.231	U	UJ	0.294	0.449	0.224	J	J
Arsenic	mg/kg	J	12.6	0.903	0.452		J	5.76	1.06	0.532		J	14.2	0.964	0.482		J	6.15	0.923	0.462		J	14.3	0.898	0.449		J
Barium	mg/kg		70.2	0.181	0.0903			52.2	0.213	0.106			57.7	0.193	0.0964			51.2	0.185	0.0923			38	0.18	0.0898		
Beryllium	mg/kg	J	10.3	0.181	0.0903		J	5.95	0.213	0.106		J	8.69	0.193	0.0964		J	5.88	0.185	0.0923		J	6.95	0.18	0.0898		J
Cadmium	mg/kg	U	0.275	0.452	0.226	J	J	0.266	0.532	0.266	U	U	0.285	0.482	0.241	J	J	0.231	0.462	0.231	U	U	0.224	0.449	0.224	U	U
Calcium	mg/kg		23200	9.03	4.52			5630	10.6	5.32			2790	9.64	4.82			4210	9.23	4.62			32100	8.98	4.49		
Chromium	mg/kg		12.7	0.452	0.226			13.2	0.532	0.266			15.3	0.482	0.241			13.5	0.462	0.231			13.4	0.449	0.244		
Cobalt	mg/kg		8.57	0.181	0.09			5.36	0.213	0.106			16.4	0.193	0.096			6.09	0.185	0.092			9.25	0.18	0.0898		
Copper	mg/kg		30.4	0.452	0.226			20.9	0.532	0.266			31	0.482	0.214			17.1	0.462	0.231			34.2	0.449	0.244		
Iron	mg/kg		65600	9.03	4.52			16400	2.13	1.06			33900	3.86	1.93			17800	1.85	0.923			24200	1.8	0.898		
Lead	mg/kg		14.1	0.452	0.226			11.9	0.532	0.266			15	0.482	0.241			10.3	0.462	0.231			13.8	0.449	0.224		
Magnesium	mg/kg	J	5040	1.81	0.903		J	2350	2.13	1.06		J	3600	1.93	0.964		J	2260	1.85	0.923		J	7810	1.8	0.898		J
Manganese	mg/kg		499	0.181	0.0903			153	0.213	0.106			504	0.193	0.0964			190	0.185	0.0923			371	0.18	0.0898		
Mercury	mg/kg		0.0153	0.0245	0.0123	J	J	0.0406	0.0232	0.0116			0.02	0.0227	0.0114	J	J	0.0348	0.0232	0.0116			0.0174	0.0221	0.011	J	J
Nickel	mg/kg	J	0.135	0.271	0.135	U	U	9.5	0.319	0.16		J	19.2	0.289	0.145		J	7	0.277	0.139		J	14.1	0.269	0.135		J
Potassium	mg/kg		1020	22.6	11.3			633	26.6	13.3			986	24.1	12			485	23.1	11.5			1130	22.4	11.2		
Selenium	mg/kg	UJ	1.32	0.903	0.452		J	0.532	1.06	0.532	U	UJ	0.818	0.964	0.482	J	J	0.51	0.923	0.462	J	J	0.449	0.898	0.449	U	UJ
Silver	mg/kg	U	0.226	0.452	0.226	U	U	0.266	0.532	0.266	U	U	0.241	0.482	0.241	U	U	0.231	0.462	0.231	U	U	0.224	0.449	0.224	U	U
Sodium	mg/kg		122	18.1	9.03			51.6	21.3	10.6			71.5	19.3	9.64			53.9	18.5	9.23			99.1	18	8.98		
Thallium	mg/kg	J	0.496	0.452	0.226			0.266	0.532	0.266	U	U	0.484	0.482	0.241			0.231	0.462	0.231	U	U	0.295	0.449	0.224	J	J
Vanadium	mg/kg		27	0.181	0.0903			21.1	0.213	0.106			21.7	0.193	0.0964			22.5	0.185	0.0923			17.6	0.18	0.0898		
Zinc	mg/kg	J	65	2.26	1.13		J	46.9	2.66	1.33		J	80.3	2.41	1.2		J	43.7	2.31	1.15		J	64.1	2.24	1.12		J
PESTICIDES/PCBS																											
Aroclor 1016	mg/kg	J	0.00802	0.0401	0.00802	U	U	0.0191	0.0437	0.00874	J,P	J	0.0553	0.0398	0.00797	P	J	0.0828	0.041	0.00821	P	J	0.00768	0.0384	0.00768	U	U
Aroclor 1221	mg/kg	U	0.00802	0.0401	0.00802	U	U	0.00874	0.0437	0.00874	U	U	0.00797	0.0398	0.00797	U	U	0.00821	0.041	0.00821	U	U	0.00768	0.0384	0.00768	U	U
Aroclor 1232	mg/kg	U	0.00802	0.0401	0.00802	U	U	0.00874	0.0437	0.00874	U	U	0.00797	0.0398	0.00797	U	U	0.00821	0.041	0.00821	U	U	0.00768	0.0384	0.00768	U	U
Aroclor 1242	mg/kg	U	0.00802	0.0401	0.00802	U	U	0.00874	0.0437	0.00874	U	U	0.00797	0.0398	0.00797	U	U	0.00821	0.041	0.00821	U	U	0.00768	0.0384	0.00768	U	U
Aroclor 1248	mg/kg	U	0.00802	0.0401	0.00802	U	U	0.00874	0.0437	0.00874	U	U	0.00797	0.0398	0.00797	U	U	0.00821	0.041	0.00821	U	U	0.00768	0.0384	0.00768	U	U
Aroclor 1254	mg/kg	U	0.00802	0.0401	0.00802	U	U	0.00874	0.0437	0.00874	U	U	0.00797	0.0398	0.00797	U	U	0.00821	0.041	0.00821	U	U	0.00768	0.0384	0.00768	U	U
Aroclor 1260	mg/kg	U	0.00802	0.0401	0.00802	U	U	0.00874	0.0437	0.00874	U	U	0.00797	0.0398	0.00797	U	U	0.00821	0.041	0.00821	U	U	0.00768	0.0384	0.00768	U	U
SEMIVOLATILES																											
3-Methylphenol and 4-Methylphenol	mg/kg																										
Acenaphthene	mg/kg	U	0.00719	0.399	0.00719	U	U	0.00781	0.434	0.00781	U	U	0.00714	0.396	0.00714	U	U	0.00745	0.414	0.00745	U	U	0.00693	0.385	0.00693	U	U
Acenaphthylene	mg/kg	U	0.0048	0.399	0.0048	U	U	0.00521	0.434	0.00521	U	U	0.00476	0.396	0.00476	U	U	0.00497	0.414	0.00497	U	U	0.00462	0.385	0.00462	U	U
ACETOPHENONE	mg/kg																										

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE			SL-SB03					SL-SB04					SL-SB04					SL-SB06					SL-SB06				
SAMPLE_NO			SL0068					SL0069					SL0070					SL0073					SL0074				
SAMPLE DATE			13-Jan-09					13-Jan-09					13-Jan-09					13-Jan-09					13-Jan-09				
DEPTH			5 - 6 Ft					0 - 1 Ft					3_4 - 5_4 Ft					0 - 1 Ft					5 - 6 Ft				
SAMPLE PURPOSE			REG					REG					REG					REG					REG				
Parameter	Units	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Anthracene	mg/kg	U	0.00863	0.399	0.00863	U	U	0.00938	0.434	0.00938	U	U	0.00857	0.396	0.00857	U	U	0.00895	0.414	0.00895	U	U	0.00832	0.385	0.00832	U	U
Atrazine	mg/kg																										
Benzaldehyde	mg/kg																										
Benzo(a)anthracene	mg/kg	U	0.0263	0.399	0.0263	U	U	0.0285	0.434	0.0285	U	U	0.0261	0.396	0.0261	U	U	0.0272	0.414	0.0272	U	U	0.0253	0.385	0.0253	U	U
Benzo(a)pyrene	mg/kg	U	0.0263	0.399	0.0263	U	U	0.0285	0.434	0.0285	U	U	0.0261	0.396	0.0261	U	U	0.0272	0.414	0.0272	U	U	0.0253	0.385	0.0253	U	U
Benzo(b)fluoranthene	mg/kg	U	0.0665	0.399	0.0665	U	U	0.0723	0.434	0.0723	U	U	0.0661	0.396	0.0661	U	U	0.069	0.414	0.069	U	U	0.0641	0.385	0.0641	U	U
Benzo(ghi)perylene	mg/kg	U	0.0974	0.399	0.0974	U	U	0.106	0.434	0.106	U	U	0.0967	0.396	0.0967	U	U	0.101	0.414	0.101	U	U	0.0938	0.385	0.0938	U	U
Benzo(k)fluoranthene	mg/kg	U	0.121	0.399	0.121	U	U	0.132	0.434	0.132	U	U	0.12	0.396	0.12	U	U	0.125	0.414	0.125	U	U	0.117	0.385	0.117	U	U
Benzoic acid	mg/kg	U	0.0974	0.399	0.0974	U	U	0.106	0.434	0.106	U	U	0.0967	0.396	0.0967	U	U	0.101	0.414	0.101	U	U	0.0938	0.385	0.0938	U	U
Benzyl alcohol	mg/kg	U	0.0974	0.399	0.0974	U	U	0.106	0.434	0.106	U	U	0.0967	0.396	0.0967	U	U	0.101	0.414	0.101	U	U	0.0938	0.385	0.0938	U	U
BIBENZENE	mg/kg																										
Bis(2-chloroethoxy)methane	mg/kg	U	0.00839	0.399	0.00839	U	U	0.00912	0.434	0.00912	U	U	0.00833	0.396	0.00833	U	U	0.0087	0.414	0.0087	U	U	0.00809	0.385	0.00809	U	U
Bis(2-chloroethyl)ether	mg/kg	U	0.0102	0.399	0.0102	U	U	0.0111	0.434	0.0111	U	U	0.0101	0.396	0.0101	U	U	0.0106	0.414	0.0106	U	U	0.00982	0.385	0.00982	U	U
Bis(2-chloroisopropyl)ether	mg/kg	U	0.0174	0.399	0.0174	U	U	0.0189	0.434	0.0189	U	U	0.0173	0.396	0.0173	U	U	0.018	0.414	0.018	U	U	0.0168	0.385	0.0168	U	U
Bis(2-ethylhexyl)phthalate	mg/kg	U	0.0369	0.399	0.0369	U	U	0.0401	0.434	0.0401	U	U	0.0367	0.396	0.0367	U	U	0.0383	0.414	0.0383	U	U	0.0356	0.385	0.0356	U	U
Bromophenyl phenyl ether, 4-	mg/kg	U	0.0143	0.399	0.0143	U	U	0.0155	0.434	0.0155	U	U	0.0142	0.396	0.0142	U	U	0.0148	0.414	0.0148	U	U	0.0138	0.385	0.0138	U	U
Butyl benzyl phthalate	mg/kg	U	0.0162	0.399	0.0162	U	U	0.0176	0.434	0.0176	U	U	0.0161	0.396	0.0161	U	U	0.0168	0.414	0.0168	U	U	0.0156	0.385	0.0156	U	U
Caprolactam	mg/kg																										
Carbazole	mg/kg	U	0.0099	0.399	0.0099	U	U	0.0434	0.434	0.0434	U	U	0.0396	0.396	0.0396	U	U	0.0414	0.414	0.0414	U	U	0.0385	0.385	0.0385	U	U
Chloro-3-methylphenol, 4-	mg/kg	U	0.00983	0.399	0.00983	U	U	0.0107	0.434	0.0107	U	U	0.00976	0.396	0.00976	U	U	0.0102	0.414	0.0102	U	U	0.00948	0.385	0.00948	U	U
Chloroaniline, 4-	mg/kg	UJ	0.0347	0.399	0.0347	Q1,U	UJ	0.0376	0.434	0.0376	Q1,U	UJ	0.0344	0.396	0.0344	Q1,U	UJ	0.0359	0.414	0.0359	Q1,U	UJ	0.0334	0.385	0.0334	Q1,U	UJ
Chloronaphthalene, 2-	mg/kg	U	0.00636	0.399	0.00636	U	U	0.0069	0.434	0.0069	U	U	0.00631	0.396	0.00631	U	U	0.00658	0.414	0.00658	U	U	0.00612	0.385	0.00612	U	U
Chlorophenol, 2-	mg/kg	U	0.00492	0.399	0.00492	U	U	0.00534	0.434	0.00534	U	U	0.00488	0.396	0.00488	U	U	0.00509	0.414	0.00509	U	U	0.00474	0.385	0.00474	U	U
Chlorophenyl phenyl ether, 4-	mg/kg	U	0.0306	0.399	0.0306	U	U	0.0332	0.434	0.0332	U	U	0.0304	0.396	0.0304	U	U	0.0317	0.414	0.0317	U	U	0.0295	0.385	0.0295	U	U
Chrysene	mg/kg	U	0.0158	0.399	0.0158	U	U	0.0172	0.434	0.0172	U	U	0.0157	0.396	0.0157	U	U	0.0164	0.414	0.0164	U	U	0.0153	0.385	0.0153	U	U
Dibenz(a,h)anthracene	mg/kg	U	0.0903	0.399	0.0903	U	U	0.0981	0.434	0.0981	U	U	0.0896	0.396	0.0896	U	U	0.0936	0.414	0.0936	U	U	0.087	0.385	0.087	U	U
Dibenzofuran	mg/kg	U	0.00671	0.399	0.00671	U	U	0.00729	0.434	0.00729	U	U	0.00667	0.396	0.00667	U	U	0.00696	0.414	0.00696	U	U	0.00647	0.385	0.00647	U	U
Dichlorobenzene, 1,2-	mg/kg	U	0.00923	0.399	0.00923	U	U	0.01	0.434	0.01	U	U	0.00917	0.396	0.00917	U	U	0.00957	0.414	0.00957	U	U	0.0089	0.385	0.0089	U	U
Dichlorobenzene, 1,3-	mg/kg	U	0.0145	0.399	0.0145	U	U	0.0158	0.434	0.0158	U	U	0.0144	0.396	0.0144	U	U	0.015	0.414	0.015	U	U	0.014	0.385	0.014	U	U
Dichlorobenzene, 1,4-	mg/kg	U	0.00779	0.399	0.00779	U	U	0.00846	0.434	0.00846	U	U	0.00774	0.396	0.00774	U	U	0.00808	0.414	0.00808	U	U	0.00751	0.385	0.00751	U	U
Dichlorobenzidine, 3,3'-	mg/kg	UJ	0.0396	0.399	0.0396	Q1,U	UJ	0.043	0.434	0.043	Q1,U	UJ	0.0393	0.396	0.0393	Q1,U	UJ	0.041	0.414	0.041	Q1,U	UJ	0.0381	0.385	0.0381	Q1,U	UJ
Dichlorophenol, 2,4-	mg/kg	U	0.0143	0.399	0.0143	U	U	0.0155	0.434	0.0155	U	U	0.0142	0.396	0.0142	U	U	0.0148	0.414	0.0148	U	U	0.0138	0.385	0.0138	U	U
Diethyl phthalate	mg/kg	U	0.0162	0.399	0.0162	U	U	0.0176	0.434	0.0176	U	U	0.0161	0.396	0.0161	U	U	0.0168	0.414	0.0168	U	U	0.0156	0.385	0.0156	U	U
Dimethyl phthalate	mg/kg	U	0.0122	0.399	0.0122	U	U	0.0133	0.434	0.0133	U	U	0.0121	0.396	0.0121	U	U	0.0127	0.414	0.0127	U	U	0.0118	0.385	0.0118	U	U
Dimethylphenol, 2,4-	mg/kg	U	0.0106	0.399	0.0106	U	U	0.0115	0.434	0.0115	U	U	0.0105	0.396	0.0105	U	U	0.0109	0.414	0.0109	U	U	0.0102	0.385	0.0102	U	U
Di-n-butyl phthalate	mg/kg	U	0.00863	0.399	0.00863	U	U	0.00938	0.434	0.00938	U	U	0.00857	0.396	0.00857	U	U	0.00895	0.414	0.00895	U	U	0.00832	0.385	0.00832	U	U
Dinitro-2-methylphenol, 4,6-	mg/kg	U	0.0402	0.399	0.0402	U	U	0.0436	0.434	0.0436	U	U	0.0399	0.396	0.0399	U	U	0.0416	0.414	0.0416	U	U	0.0387	0.385	0.0387	U	U
Dinitrophenol, 2,4-	mg/kg	U	0.0637	0.399	0.0637	U	U	0.0691	0.434	0.0691	U	U	0.0632	0.396	0.0632	U	U	0.066	0.414	0.066	U	U	0.0614	0.385	0.0614	U	U
Dinitrotoluene, 2,4-	mg/kg	U	0.014	0.399	0.014	U	U	0.0152	0.434	0.0152	U	U	0.104	0.396	0.0139	J	J	0.0563	0.414	0.0145	J	J	0.434	0.385	0.0135		
Dinitrotoluene, 2,6-	mg/kg	U	0.00959	0.399	0.00959	U	U	0.0104	0.434	0.0104	U	U	0.00952	0.396	0.00952	U	U	0.00994	0.414	0.00994	U	U	0.128	0.385	0.00924	J	J
Di-n-octyl phthalate	mg/kg	U	0.0752	0.399	0.0752	U	U	0.0817	0.434	0.0817	U	U	0.0746	0.396	0.0746	U	U	0.0779	0.414	0.0779	U	U	0.0725	0.385	0.0725	U	U
DIPHENYLAMINE	mg/kg	U	0.0396	0.399	0.0396	U	U	0.043	0.434	0.043	U	U	0.0393	0.396	0.0393	U	U	0.041	0.414	0.041	U	U	0.0381	0.385	0.0381	U	U
Fluoranthene	mg/kg	U	0.00863	0.399	0.00863	U	U	0.00938	0.434	0.00938	U	U	0.00857	0.396	0.00857	U	U	0.00895	0.414	0.00895	U	U	0.00832	0.385	0.00832	U	U
Fluorene	mg/kg	U	0.0169	0.399	0.0169	U	U	0.0184	0.434	0.0184	U	U	0.0168	0.396	0.0168	U	U	0.0175	0.414	0.0175	U	U	0.0163	0.385	0.0163	U	U
Hexachlorobenzene	mg/kg	U	0.0248	0.399	0.0248	U	U	0.027	0.434	0.027	U	U	0.0246	0.396	0.0246	U	U	0.0257	0.414	0.0257	U	U	0.0239	0.385	0.0239	U	U
Hexachlorobutadiene	mg/kg	U	0.0379	0.399	0.0379	U	U	0.0412	0.434	0.0412	U	U	0.0376	0.396	0.0376	U	U	0.0393	0.414	0.0393	U	U	0.0365	0.385	0.0365	U	U
Hexachlorocyclopentadiene	mg/kg	UJ	0.0127	0.399	0.0127	Q2,U	UJ	0.0138	0.434	0.0138	Q2,U	UJ	0.0126	0.396	0.0126	Q2,U	UJ	0.0132	0.414	0.0132	Q2,U	UJ	0.0122	0.385	0.0122	Q2,U	UJ
Hexachloroethane	mg/kg	U	0.0122	0.399	0.0122	U	U	0.0133	0.434	0.0133	U	U	0.0121	0.396	0.0121	U	U	0.0127	0.414	0.0127	U	U	0.0118	0.385	0.0118	U	U
Indeno(1,2,3-cd)pyrene	mg/kg	U	0.13	0.399	0.13	U	U	0.141	0.434	0.141	U	U	0.129	0.396	0.129	U	U	0.134	0.414	0.134	U	U	0.125	0.385	0.125	U	U
Isophorone	mg/kg	U	0.0048	0.399	0.0048	U	U	0.00521	0.434	0.00521	U	U	0.00476	0.396	0.00476	U	U	0.00497	0.414	0.00497	U	U	0.00462	0.385	0.00462	U	U
Methylnaphthalene, 2-	mg/kg	U	0.105	0.399	0.105	U	U	0.114	0.434	0.114	U	U	0.104	0.396	0.104	U	U	0.109	0.414	0.109	U	U	0.101	0.385	0.101	U	U
Methylphenol, 2-	mg/kg	U	0.006	0.399	0.006	U	U	0.00651	0.434	0.00651	U	U	0.00595	0.396	0.00595	U	U	0.00621	0.414	0.00621	U	U	0.00578	0.385	0.00578	U	U

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE			SL-SB03					SL-SB04					SL-SB04					SL-SB06					SL-SB06				
SAMPLE_NO			SL0068					SL0069					SL0070					SL0073					SL0074				
SAMPLE DATE			13-Jan-09					13-Jan-09					13-Jan-09					13-Jan-09					13-Jan-09				
DEPTH			5 - 6 Ft					0 - 1 Ft					3_4 - 5_4 Ft					0 - 1 Ft					5 - 6 Ft				
SAMPLE PURPOSE			REG					REG					REG					REG					REG				
Parameter	Units	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Methylphenol, 4-	mg/kg	U	0.0125	0.399	0.0125	U	U	0.0135	0.434	0.0135	U	U	0.0124	0.396	0.0124	U	U	0.0129	0.414	0.0129	U	U	0.012	0.385	0.012	U	U
Naphthalene	mg/kg	U	0.00947	0.399	0.00947	U	U	0.0103	0.434	0.0103	U	U	0.00941	0.396	0.00941	U	U	0.00982	0.414	0.00982	U	U	0.00913	0.385	0.00913	U	U
Nitroaniline, 2-	mg/kg	U	0.0173	0.399	0.0173	U	U	0.0188	0.434	0.0188	U	U	0.0171	0.396	0.0171	U	U	0.0179	0.414	0.0179	U	U	0.0166	0.385	0.0166	U	U
Nitroaniline, 3-	mg/kg	U	0.0135	0.399	0.0135	U	U	0.0147	0.434	0.0147	U	U	0.0135	0.396	0.0135	U	U	0.014	0.414	0.014	U	U	0.0131	0.385	0.0131	U	U
Nitroaniline, 4-	mg/kg	U	0.141	0.399	0.141	U	U	0.154	0.434	0.154	U	U	0.14	0.396	0.14	U	U	0.147	0.414	0.147	U	U	0.136	0.385	0.136	U	U
Nitrobenzene	mg/kg	U	0.0131	0.399	0.0131	U	U	0.0142	0.434	0.0142	U	U	0.013	0.396	0.013	U	U	0.0135	0.414	0.0135	U	U	0.0126	0.385	0.0126	U	U
Nitrophenol, 2-	mg/kg	U	0.0141	0.399	0.0141	U	U	0.0154	0.434	0.0154	U	U	0.014	0.396	0.014	U	U	0.0147	0.414	0.0147	U	U	0.0136	0.385	0.0136	U	U
Nitrophenol, 4-	mg/kg	U	0.0324	0.399	0.0324	U	U	0.0352	0.434	0.0352	U	U	0.0321	0.396	0.0321	U	U	0.0335	0.414	0.0335	U	U	0.0312	0.385	0.0312	U	U
n-Nitrosodimethylamine	mg/kg	U	0.012	0.399	0.012	U	U	0.013	0.434	0.013	U	U	0.0119	0.396	0.0119	U	U	0.0124	0.414	0.0124	U	U	0.0116	0.385	0.0116	U	U
n-Nitroso-di-n-propylamine	mg/kg	U	0.0143	0.399	0.0143	U	U	0.0155	0.434	0.0155	U	U	0.0142	0.396	0.0142	U	U	0.0148	0.414	0.0148	U	U	0.0138	0.385	0.0138	U	U
n-Nitrosodiphenylamine	mg/kg	U	0.00564	0.399	0.00564	U	U	0.00612	0.434	0.00612	U	U	0.0056	0.396	0.0056	U	U	0.00584	0.414	0.00584	U	U	0.00543	0.385	0.00543	U	U
Pentachlorophenol	mg/kg	U	0.0359	0.399	0.0359	U	U	0.0389	0.434	0.0389	U	U	0.0356	0.396	0.0356	U	U	0.0371	0.414	0.0371	U	U	0.0346	0.385	0.0346	U	U
Phenanthrene	mg/kg	U	0.00971	0.399	0.00971	U	U	0.0105	0.434	0.0105	U	U	0.00964	0.396	0.00964	U	U	0.0101	0.414	0.0101	U	U	0.00936	0.385	0.00936	U	U
Phenol	mg/kg	U	0.0048	0.399	0.0048	U	U	0.00521	0.434	0.00521	U	U	0.00476	0.396	0.00476	U	U	0.00497	0.414	0.00497	U	U	0.00462	0.385	0.00462	U	U
Pyrene	mg/kg	U	0.0159	0.399	0.0159	U	U	0.0173	0.434	0.0173	U	U	0.0158	0.396	0.0158	U	U	0.0165	0.414	0.0165	U	U	0.0154	0.385	0.0154	U	U
Trichlorobenzene, 1,2,4-	mg/kg	U	0.00983	0.399	0.00983	U	U	0.0107	0.434	0.0107	U	U	0.00976	0.396	0.00976	U	U	0.0102	0.414	0.0102	U	U	0.00948	0.385	0.00948	U	U
Trichlorophenol, 2,4,5-	mg/kg	U	0.0343	0.399	0.0343	U	U	0.0372	0.434	0.0372	U	U	0.034	0.396	0.034	U	U	0.0355	0.414	0.0355	U	U	0.033	0.385	0.033	U	U
Trichlorophenol, 2,4,6-	mg/kg	U	0.027	0.399	0.027	U	U	0.0293	0.434	0.0293	U	U	0.0268	0.396	0.0268	U	U	0.028	0.414	0.028	U	U	0.026	0.385	0.026	U	U
WATER QUALITY																											
% Solids	Percent																										
Total organic carbon	mg/kg																										

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		SL-SB07					SL-SB07					SL-SB07					SL-SB08					SL-SB08				
SAMPLE_NO		SL0075					SL0076					SL0078					SL0079					SL0080				
SAMPLE DATE		14-Jan-09					14-Jan-09					14-Jan-09					14-Jan-09					14-Jan-09				
DEPTH		0 - 1 Ft					0 - 1 Ft					5 - 6 Ft					0 - 1 Ft					7_1 - 9_1 Ft				
SAMPLE PURPOSE		REG					FD					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
EXPLOSIVES																										
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.179	0.296	0.148	J	J	0.146	0.293	0.146	U	U	0.144	0.287	0.144	U	U	0.149	0.297	0.149	U	U	0.146	0.293	0.146	U	U
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.148	0.296	0.148	U	U	0.146	0.293	0.146	U	U	0.144	0.287	0.144	U	U	0.149	0.297	0.149	U	U	0.146	0.293	0.146	U	U
Dinitrobenzene, 1,3-	mg/kg	0.148	0.296	0.148	U	U	0.146	0.293	0.146	U	U	0.144	0.287	0.144	U	U	0.149	0.297	0.149	U	U	0.146	0.293	0.146	U	U
Dinitrotoluene, 2,4-	mg/kg	0.148	0.296	0.148	U	U	0.146	0.293	0.146	U	U	0.144	0.287	0.144	U	U	0.149	0.297	0.149	U	U	0.146	0.293	0.146	U	U
Dinitrotoluene, 2,6-	mg/kg	0.148	0.296	0.148	U	U	0.146	0.293	0.146	U	U	0.144	0.287	0.144	U	U	0.149	0.297	0.149	U	U	0.146	0.293	0.146	U	U
HMX	mg/kg	0.148	0.296	0.148	U	U	0.146	0.293	0.146	U	U	0.144	0.287	0.144	U	U	0.149	0.297	0.149	U	U	0.146	0.293	0.146	U	U
Nitrobenzene	mg/kg	0.148	0.296	0.148	U	U	0.146	0.293	0.146	U	U	0.144	0.287	0.144	U	U	0.149	0.297	0.149	U	U	0.146	0.293	0.146	U	U
Nitrotoluene, 2-	mg/kg	0.148	0.296	0.148	U	U	0.146	0.293	0.146	U	U	0.144	0.287	0.144	U	U	0.149	0.297	0.149	U	U	0.146	0.293	0.146	U	U
Nitrotoluene, 3-	mg/kg	0.148	0.296	0.148	U	U	0.146	0.293	0.146	U	U	0.144	0.287	0.144	U	U	0.149	0.297	0.149	U	U	0.146	0.293	0.146	U	U
Nitrotoluene, 4-	mg/kg	0.148	0.296	0.148	U	U	0.146	0.293	0.146	U	U	0.144	0.287	0.144	U	U	0.149	0.297	0.149	U	U	0.146	0.293	0.146	U	U
RDX	mg/kg	0.148	0.296	0.148	U	U	0.146	0.293	0.146	U	U	0.144	0.287	0.144	U	U	0.149	0.297	0.149	U	U	0.146	0.293	0.146	U	U
Tetryl	mg/kg	0.148	0.296	0.148	U	U	0.146	0.293	0.146	U	U	0.144	0.287	0.144	U	U	0.149	0.297	0.149	U	U	0.146	0.293	0.146	U	U
Trinitrobenzene, 1,3,5-	mg/kg	0.148	0.296	0.148	U	U	0.146	0.293	0.146	U	U	1.75	0.287	0.144			0.149	0.297	0.149	U	U	0.146	0.293	0.146	U	U
Trinitrotoluene, 2,4,6-	mg/kg	0.868	0.296	0.148			0.196	0.293	0.146	J	J	0.144	0.287	0.144	U	U	0.271	0.297	0.149	J	J	0.146	0.293	0.146	U	U
METALS (UNFILTERED)																										
Aluminum	mg/kg	7890	2.09	1.05		J	7110	1.94	0.972		J	8920	1.75	0.877		J	8280	2.03	1.01		J	7980	1.78	0.892		J
Antimony	mg/kg	0.67	0.523	0.261		J	0.388	0.486	0.243	J	J	0.572	0.438	0.219			0.33	0.507	0.253	J	J	0.376	0.446	0.223	J	J
Arsenic	mg/kg	6.3	1.05	0.523			6.25	0.972	0.486			14.9	0.877	0.438			7.71	1.01	0.507			12.4	0.892	0.446		
Barium	mg/kg	51.2	0.209	0.105			47.9	0.194	0.0972			116	0.175	0.0877			46	0.203	0.101			27	0.178	0.0892		
Beryllium	mg/kg	5.94	0.209	0.105			5.43	0.194	0.0972			8	0.175	0.0877			6.36	0.203	0.101			7.03	0.178	0.0892		
Cadmium	mg/kg	0.297	0.523	0.261	J	J	0.273	0.486	0.243	J	J	0.323	0.438	0.219	J	J	0.387	0.507	0.253	J	J	0.223	0.446	0.223	U	U
Calcium	mg/kg	4350	5.23	2.61			3630	4.86	2.43			25700	4.38	2.19			4510	5.07	2.53			45800	4.46	2.23		
Chromium	mg/kg	11.9	0.523	0.261			10.7	0.486	0.243			14	0.438	0.219			12.6	0.507	0.253			13	0.446	0.223		
Cobalt	mg/kg	5.52	0.418	0.209			5.16	0.389	0.194			17.3	0.351	0.175			6.24	0.405	0.203			10.6	0.357	0.178		
Copper	mg/kg	17.5	0.523	0.261		J	14.7	0.486	0.243		J	33.6	0.438	0.219		J	19.7	0.507	0.253		J	27.7	0.446	0.223		J
Iron	mg/kg	16300	4.18	2.09		J	15000	3.89	1.94		J	30300	7.01	3.51		J	18300	4.05	2.03		J	24300	3.57	1.78		J
Lead	mg/kg	20.7	0.523	0.261			20.6	0.486	0.243			16.4	0.438	0.219			28.3	0.507	0.253			11.9	0.446	0.223		
Magnesium	mg/kg	2000	2.09	1.05		J	1780	1.94	0.972		J	6600	1.75	0.877		J	2110	2.03	1.01		J	8720	1.78	0.892		J
Manganese	mg/kg	180	0.209	0.105			225	0.194	0.0972			833	0.175	0.0877			286	0.203	0.101			410	0.178	0.0892		
Mercury	mg/kg	0.0352	0.0264	0.0132			0.0276	0.0216	0.0108			0.0115	0.0229	0.0115	U	U	0.0437	0.0254	0.0127			0.00998	0.02	0.00998	U	U
Nickel	mg/kg	17.3	0.314	0.157			15.5	0.291	0.146			39.7	0.263	0.131			19.6	0.304	0.152			32.9	0.268	0.134		
Potassium	mg/kg	489	26.1	13.1			433	24.3	12.1			1070	21.9	11			682	25.3	12.7			1090	22.3	11.1		
Selenium	mg/kg	0.523	1.05	0.523	U	U	0.486	0.972	0.486	U	U	0.453	0.877	0.428	J	J	0.517	1.01	0.507	J	J	0.446	0.892	0.446	U	U
Silver	mg/kg	0.261	0.523	0.261	U	U	0.243	0.486	0.243	U	U	0.219	0.438	0.219	U	U	0.253	0.507	0.253	U	U	0.223	0.446	0.223	U	U
Sodium	mg/kg	46.7	10.5	5.23			32	9.72	4.86			83.8	8.77	4.38			31.1	10.1	5.07			139	8.92	4.46		
Thallium	mg/kg	0.261	0.523	0.261	U	U	0.243	0.486	0.243	U	U	0.697	0.438	0.219			0.253	0.507	0.253	U	U	0.265	0.446	0.223	J	J
Vanadium	mg/kg	20.6	0.209	0.105			19	0.194	0.0972			18.4	0.175	0.0877			21.4	0.203	0.101			16.6	0.178	0.0892		
Zinc	mg/kg	58.3	2.61	1.31			54.1	2.43	1.21			99.4	2.19	1.1			72.3	2.53	1.27			69.7	2.23	1.11		
PESTICIDES/PCBS																										
Aroclor 1016	mg/kg	0.00879	0.0439	0.00879	U	U	0.00823	0.0411	0.00823	U	U	0.00783	0.0391	0.00783	U	U	0.0828	0.0461	0.00924	P	J	0.00762	0.038	0.00762	U	U
Aroclor 1221	mg/kg	0.00879	0.0439	0.00879	U	U	0.00823	0.0411	0.00823	U	U	0.00783	0.0391	0.00783	U	U	0.00924	0.0461	0.00924	U	U	0.134	0.038	0.00762		
Aroclor 1232	mg/kg	0.00879	0.0439	0.00879	U	U	0.00823	0.0411	0.00823	U	U	0.00783	0.0391	0.00783	U	U	0.00924	0.0461	0.00924	U	U	0.00762	0.038	0.00762	U	U
Aroclor 1242	mg/kg	0.00879	0.0439	0.00879	U	U	0.00823	0.0411	0.00823	U	U	0.00783	0.0391	0.00783	U	U	0.00924	0.0461	0.00924	U	U	0.00762	0.038	0.00762	U	U
Aroclor 1248	mg/kg	0.00879	0.0439	0.00879	U	U	0.00823	0.0411	0.00823	U	U	0.00783	0.0391	0.00783	U	U	0.00924	0.0461	0.00924	U	U	0.00762	0.038	0.00762	U	U
Aroclor 1254	mg/kg	0.00879	0.0439	0.00879	U	U	0.00823	0.0411	0.00823	U	U	0.00783	0.0391	0.00783	U	U	0.00924	0.0461	0.00924	U	U	0.00762	0.038	0.00762	U	U
Aroclor 1260	mg/kg	0.0265	0.0439	0.00879	P,J	J	0.268	0.0411	0.00823		J	0.00783	0.0391	0.00783	U	U	0.00924	0.0461	0.00924	U	U	0.00762	0.038	0.00762	U	U
SEMIVOLATILES																										
3-Methylphenol and 4-Methylphenol	mg/kg																									
Acenaphthene	mg/kg	0.00788	0.437	0.00788	U	U	0.0074	0.411	0.0074	U	U	0.00705	0.391	0.00705	U	U	0.00836	0.464	0.00836	U	U	0.00685	0.38	0.00685	U	U
Acenaphthylene	mg/kg	0.00525	0.437	0.00525	U	U	0.00494	0.411	0.00494	U	U	0.0047	0.391	0.0047	U	U	0.00558	0.464	0.00558	U	U	0.00457	0.38	0.00457	U	U
ACETOPHENONE	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		SL-SB07					SL-SB07					SL-SB07					SL-SB08					SL-SB08				
SAMPLE_NO		SL0075					SL0076					SL0078					SL0079					SL0080				
SAMPLE DATE		14-Jan-09					14-Jan-09					14-Jan-09					14-Jan-09					14-Jan-09				
DEPTH		0 - 1 Ft					0 - 1 Ft					5 - 6 Ft					0 - 1 Ft					7_1 - 9_1 Ft				
SAMPLE PURPOSE		REG					FD					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Anthracene	mg/kg	0.00945	0.437	0.00945	U	U	0.00888	0.411	0.00888	U	U	0.00846	0.391	0.00846	U	U	0.01	0.464	0.01	U	U	0.00822	0.38	0.00822	U	U
Atrazine	mg/kg																									
Benzaldehyde	mg/kg																									
Benzo(a)anthracene	mg/kg	0.0288	0.437	0.0288	U	U	0.027	0.411	0.027	U	U	0.0257	0.391	0.0257	U	U	0.0581	0.464	0.0305	J	J	0.025	0.38	0.025	U	U
Benzo(a)pyrene	mg/kg	0.0288	0.437	0.0288	U	U	0.027	0.411	0.027	U	U	0.0257	0.391	0.0257	U	U	0.053	0.464	0.0305	J	J	0.025	0.38	0.025	U	U
Benzo(b)fluoranthene	mg/kg	0.0729	0.437	0.0729	U	U	0.0685	0.411	0.0685	U	U	0.0652	0.391	0.0652	U	U	0.0962	0.464	0.0774	J	J	0.0634	0.38	0.0634	U	U
Benzo(ghi)perylene	mg/kg	0.107	0.437	0.107	U	U	0.1	0.411	0.1	U	U	0.0954	0.391	0.0954	U	U	0.113	0.464	0.113	U	U	0.0927	0.38	0.0927	U	U
Benzo(k)fluoranthene	mg/kg	0.133	0.437	0.133	U	U	0.125	0.411	0.125	U	U	0.119	0.391	0.119	U	U	0.141	0.464	0.141	U	U	0.115	0.38	0.115	U	U
Benzoic acid	mg/kg	0.107	0.437	0.107	U	U	0.1	0.411	0.1	U	U	0.0954	0.391	0.0954	U	U	0.113	0.464	0.113	U	U	0.0927	0.38	0.0927	U	U
Benzyl alcohol	mg/kg	0.107	0.437	0.107	U	U	0.1	0.411	0.1	U	U	0.0954	0.391	0.0954	U	U	0.113	0.464	0.113	U	U	0.0927	0.38	0.0927	U	U
BIBENZENE	mg/kg																									
Bis(2-chloroethoxy)methane	mg/kg	0.00919	0.437	0.00919	U	U	0.00864	0.411	0.00864	U	U	0.00822	0.391	0.00822	U	U	0.00976	0.464	0.00976	U	U	0.00799	0.38	0.00799	U	U
Bis(2-chloroethyl)ether	mg/kg	0.0112	0.437	0.0112	U	U	0.0105	0.411	0.0105	U	U	0.00998	0.391	0.00998	U	U	0.0118	0.464	0.0118	U	U	0.0097	0.38	0.0097	U	U
Bis(2-chloroisopropyl)ether	mg/kg	0.019	0.437	0.019	U	U	0.0179	0.411	0.0179	U	U	0.017	0.391	0.017	U	U	0.0202	0.464	0.0202	U	U	0.0166	0.38	0.0166	U	U
Bis(2-ethylhexyl)phthalate	mg/kg	0.0404	0.437	0.0404	U	U	0.038	0.411	0.038	U	U	0.0362	0.391	0.0362	U	U	0.0429	0.464	0.0429	U	U	0.0352	0.38	0.0352	U	U
Bromophenyl phenyl ether, 4-	mg/kg	0.0156	0.437	0.0156	U	U	0.0147	0.411	0.0147	U	U	0.014	0.391	0.014	U	U	0.0166	0.464	0.0166	U	U	0.0136	0.38	0.0136	U	U
Butyl benzyl phthalate	mg/kg	0.0177	0.437	0.0177	U	U	0.0167	0.411	0.0167	U	U	0.0159	0.391	0.0159	U	U	0.0188	0.464	0.0188	U	U	0.0154	0.38	0.0154	U	U
Caprolactam	mg/kg																									
Carbazole	mg/kg	0.0437	0.437	0.0437	U	U	0.0411	0.411	0.0411	U	U	0.0391	0.391	0.0391	U	U	0.0464	0.464	0.0464	U	U	0.038	0.38	0.038	U	U
Chloro-3-methylphenol, 4-	mg/kg	0.0108	0.437	0.0108	U	U	0.0101	0.411	0.0101	U	U	0.00963	0.391	0.00963	U	U	0.0114	0.464	0.0114	U	U	0.00936	0.38	0.00936	U	U
Chloroaniline, 4-	mg/kg	0.0379	0.437	0.0379	U	U	0.0357	0.411	0.0357	U	U	0.0339	0.391	0.0339	U	U	0.0403	0.464	0.0403	U	U	0.033	0.38	0.033	U	U
Chloronaphthalene, 2-	mg/kg	0.00696	0.437	0.00696	U	U	0.00654	0.411	0.00654	U	U	0.00623	0.391	0.00623	U	U	0.00739	0.464	0.00739	U	U	0.00605	0.38	0.00605	U	U
Chlorophenol, 2-	mg/kg	0.00538	0.437	0.00538	U	U	0.00506	0.411	0.00506	U	U	0.00482	0.391	0.00482	U	U	0.00571	0.464	0.00571	U	U	0.00468	0.38	0.00468	U	U
Chlorophenyl phenyl ether, 4-	mg/kg	0.0335	0.437	0.0335	U	U	0.0315	0.411	0.0315	U	U	0.03	0.391	0.03	U	U	0.0355	0.464	0.0355	U	U	0.0291	0.38	0.0291	U	U
Chrysene	mg/kg	0.0173	0.437	0.0173	U	U	0.0163	0.411	0.0163	U	U	0.0155	0.391	0.0155	U	U	0.0794	0.464	0.0184	J	J	0.0151	0.38	0.0151	U	U
Dibenz(a,h)anthracene	mg/kg	0.0989	0.437	0.0989	U	U	0.0929	0.411	0.0929	U	U	0.0884	0.391	0.0884	U	U	0.105	0.464	0.105	U	U	0.086	0.38	0.086	U	U
Dibenzofuran	mg/kg	0.00735	0.437	0.00735	U	U	0.00691	0.411	0.00691	U	U	0.00658	0.391	0.00658	U	U	0.00781	0.464	0.00781	U	U	0.00639	0.38	0.00639	U	U
Dichlorobenzene, 1,2-	mg/kg	0.0101	0.437	0.0101	U	U	0.0095	0.411	0.0095	U	U	0.00904	0.391	0.00904	U	U	0.0107	0.464	0.0107	U	U	0.00879	0.38	0.00879	U	U
Dichlorobenzene, 1,3-	mg/kg	0.0159	0.437	0.0159	U	U	0.0149	0.411	0.0149	U	U	0.0142	0.391	0.0142	U	U	0.0169	0.464	0.0169	U	U	0.0138	0.38	0.0138	U	U
Dichlorobenzene, 1,4-	mg/kg	0.00854	0.437	0.00854	U	U	0.00802	0.411	0.00802	U	U	0.00763	0.391	0.00763	U	U	0.00906	0.464	0.00906	U	U	0.00742	0.38	0.00742	U	U
Dichlorobenzidine, 3,3'-	mg/kg	0.0433	0.437	0.0433	U	U	0.0407	0.411	0.0407	U	U	0.0388	0.391	0.0388	U	U	0.046	0.464	0.046	U	U	0.0377	0.38	0.0377	U	U
Dichlorophenol, 2,4-	mg/kg	0.0156	0.437	0.0156	U	U	0.0147	0.411	0.0147	U	U	0.014	0.391	0.014	U	U	0.0166	0.464	0.0166	U	U	0.0136	0.38	0.0136	U	U
Diethyl phthalate	mg/kg	0.0177	0.437	0.0177	U	U	0.0167	0.411	0.0167	U	U	0.0159	0.391	0.0159	U	U	0.0188	0.464	0.0188	U	U	0.0154	0.38	0.0154	U	U
Dimethyl phthalate	mg/kg	0.0134	0.437	0.0134	U	U	0.0126	0.411	0.0126	U	U	0.012	0.391	0.012	U	U	0.0142	0.464	0.0142	U	U	0.0116	0.38	0.0116	U	U
Dimethylphenol, 2,4-	mg/kg	0.0116	0.437	0.0116	U	U	0.0109	0.411	0.0109	U	U	0.0103	0.391	0.0103	U	U	0.0123	0.464	0.0123	U	U	0.01	0.38	0.01	U	U
Di-n-butyl phthalate	mg/kg	0.00945	0.437	0.00945	U	U	0.00888	0.411	0.00888	U	U	0.00846	0.391	0.00846	U	U	0.01	0.464	0.01	U	U	0.00822	0.38	0.00822	U	U
Dinitro-2-methylphenol, 4,6-	mg/kg	0.044	0.437	0.044	U	U	0.0413	0.411	0.0413	U	U	0.0393	0.391	0.0393	U	U	0.0467	0.464	0.0467	U	U	0.0382	0.38	0.0382	U	U
Dinitrophenol, 2,4-	mg/kg	0.0697	0.875	0.0697	U	U	0.0655	0.822	0.0655	U	U	0.0624	0.782	0.0624	U	U	0.074	0.928	0.074	U	U	0.0606	0.76	0.0606	U	U
Dinitrotoluene, 2,4-	mg/kg	0.0154	0.437	0.0154	U	U	0.0144	0.411	0.0144	U	U	0.0818	0.391	0.0137	J	J	0.0163	0.464	0.0163	U	U	0.0134	0.38	0.0134	U	U
Dinitrotoluene, 2,6-	mg/kg	0.0105	0.437	0.0105	U	U	0.00987	0.411	0.00987	U	U	0.0411	0.391	0.0094	J	J	0.0112	0.464	0.0112	U	U	0.00913	0.38	0.00913	U	U
Di-n-octyl phthalate	mg/kg	0.0823	0.437	0.0823	U	U	0.0774	0.411	0.0774	U	U	0.0736	0.391	0.0736	U	U	0.0874	0.464	0.0874	U	U	0.0716	0.38	0.0716	U	U
DIPHENYLAMINE	mg/kg	0.0433	0.437	0.0433	U	U	0.0407	0.411	0.0407	U	U	0.0388	0.391	0.0388	U	U	0.046	0.464	0.046	U	U	0.0377	0.38	0.0377	U	U
Fluoranthene	mg/kg	0.0433	0.437	0.00945	J	J	0.00888	0.411	0.00888	U	U	0.00846	0.391	0.00846	U	U	0.163	0.464	0.01	J	J	0.00822	0.38	0.00822	U	U
Fluorene	mg/kg	0.0185	0.437	0.0185	U	U	0.0174	0.411	0.0174	U	U	0.0166	0.391	0.0166	U	U	0.0197	0.464	0.0197	U	U	0.0161	0.38	0.0161	U	U
Hexachlorobenzene	mg/kg	0.0272	0.437	0.0272	U	U	0.0255	0.411	0.0255	U	U	0.0243	0.391	0.0243	U	U	0.0289	0.464	0.0289	U	U	0.0236	0.38	0.0236	U	U
Hexachlorobutadiene	mg/kg	0.0415	0.437	0.0415	U	U	0.039	0.411	0.039	U	U	0.0371	0.391	0.0371	U	U	0.044	0.464	0.044	U	U	0.0361	0.38	0.0361	U	U
Hexachlorocyclopentadiene	mg/kg	0.0139	0.437	0.0139	U	U	0.0131	0.411	0.0131	U	U	0.0125	0.391	0.0125	U	U	0.0148	0.464	0.0148	U	U	0.0121	0.38	0.0121	U	U
Hexachloroethane	mg/kg	0.0134	0.437	0.0134	U	U	0.0126	0.411	0.0126	U	U	0.012	0.391	0.012	U	U	0.0142	0.464	0.0142	U	U	0.0116	0.38	0.0116	U	U
Indeno(1,2,3-cd)pyrene	mg/kg	0.142	0.437	0.142	U	U	0.133	0.411	0.133	U	U	0.127	0.391	0.127	U	U	0.151	0.464	0.151	U	U	0.123	0.38	0.123	U	U
Isophorone	mg/kg	0.00525	0.437	0.00525	U	U	0.00494	0.411	0.00494	U	U	0.0047	0.391	0.0047	U	U	0.00558	0.464	0.00558	U	U	0.00457	0.38	0.00457	U	U
Methylnaphthalene, 2-	mg/kg	0.115	0.437	0.115	U	U	0.108	0.411	0.108	U	U	0.103	0.391	0.103	U	U	0.122	0.464	0.122	U	U	0.0998	0.38	0.0998	U	U
Methylphenol, 2-	mg/kg	0.00657	0.437	0.00657	U	U	0.00617	0.411	0.00617	U	U	0.00587	0.391	0.00587	U	U	0.00697	0.464	0.00697	U	U	0.00571	0.38	0.00571	U	U

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		SL-SB07					SL-SB07					SL-SB07					SL-SB08					SL-SB08				
SAMPLE_NO		SL0075					SL0076					SL0078					SL0079					SL0080				
SAMPLE DATE		14-Jan-09					14-Jan-09					14-Jan-09					14-Jan-09					14-Jan-09				
DEPTH		0 - 1 Ft					0 - 1 Ft					5 - 6 Ft					0 - 1 Ft					7_1 - 9_1 Ft				
SAMPLE PURPOSE		REG					FD					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Methylphenol, 4-	mg/kg	0.0137	0.437	0.0137	U	U	0.0128	0.411	0.0128	U	U	0.0122	0.391	0.0122	U	U	0.0145	0.464	0.0145	U	U	0.0119	0.38	0.0119	U	U
Naphthalene	mg/kg	0.0104	0.437	0.0104	U	U	0.00975	0.411	0.00975	U	U	0.00928	0.391	0.00928	U	U	0.011	0.464	0.011	U	U	0.00902	0.38	0.00902	U	U
Nitroaniline, 2-	mg/kg	0.0189	0.437	0.0189	U	U	0.0178	0.411	0.0178	U	U	0.0169	0.391	0.0169	U	U	0.0201	0.464	0.0201	U	U	0.0164	0.38	0.0164	U	U
Nitroaniline, 3-	mg/kg	0.0148	0.437	0.0148	U	U	0.0139	0.411	0.0139	U	U	0.0133	0.391	0.0133	U	U	0.0157	0.464	0.0157	U	U	0.0129	0.38	0.0129	U	U
Nitroaniline, 4-	mg/kg	0.155	0.437	0.155	U	U	0.146	0.411	0.146	U	U	0.139	0.391	0.139	U	U	0.164	0.464	0.164	U	U	0.135	0.38	0.135	U	U
Nitrobenzene	mg/kg	0.0143	0.437	0.0143	U	U	0.0135	0.411	0.0135	U	U	0.0128	0.391	0.0128	U	U	0.0152	0.464	0.0152	U	U	0.0124	0.38	0.0124	U	U
Nitrophenol, 2-	mg/kg	0.0155	0.437	0.0155	U	U	0.0146	0.411	0.0146	U	U	0.0139	0.391	0.0139	U	U	0.0164	0.464	0.0164	U	U	0.0135	0.38	0.0135	U	U
Nitrophenol, 4-	mg/kg	0.0355	0.437	0.0355	U	U	0.0333	0.411	0.0333	U	U	0.0317	0.391	0.0317	U	U	0.0376	0.464	0.0376	U	U	0.0308	0.38	0.0308	U	U
n-Nitrosodimethylamine	mg/kg	0.0131	0.437	0.0131	U	U	0.0123	0.411	0.0123	U	U	0.0117	0.391	0.0117	U	U	0.0139	0.464	0.0139	U	U	0.0114	0.38	0.0114	U	U
n-Nitroso-di-n-propylamine	mg/kg	0.0156	0.437	0.0156	U	U	0.0147	0.411	0.0147	U	U	0.014	0.391	0.014	U	U	0.0166	0.464	0.0166	U	U	0.0136	0.38	0.0136	U	U
n-Nitrosodiphenylamine	mg/kg	0.00617	0.437	0.00617	U	U	0.0058	0.411	0.0058	U	U	0.00552	0.391	0.00552	U	U	0.00655	0.464	0.00655	U	U	0.00537	0.38	0.00537	U	U
Pentachlorophenol	mg/kg	0.0393	0.875	0.0393	U	U	0.0369	0.822	0.0369	U	U	0.0351	0.782	0.0351	U	U	0.0417	0.928	0.0417	U	U	0.0341	0.76	0.0341	U	U
Phenanthrene	mg/kg	0.0106	0.437	0.0106	U	U	0.01	0.411	0.01	U	U	0.00951	0.391	0.00951	U	U	0.102	0.464	0.0113	J	J	0.00925	0.38	0.00925	U	U
Phenol	mg/kg	0.00525	0.437	0.00525	U	U	0.00494	0.411	0.00494	U	U	0.0047	0.391	0.0047	U	U	0.00558	0.464	0.00558	U	U	0.00457	0.38	0.00457	U	U
Pyrene	mg/kg	0.0175	0.437	0.0175	U	U	0.0164	0.411	0.0164	U	U	0.0156	0.391	0.0156	U	U	0.12	0.464	0.0185	J	J	0.0152	0.38	0.0152	U	U
Trichlorobenzene, 1,2,4-	mg/kg	0.0108	0.437	0.0108	U	U	0.0101	0.411	0.0101	U	U	0.00963	0.391	0.00963	U	U	0.0114	0.464	0.0114	U	U	0.00936	0.38	0.00936	U	U
Trichlorophenol, 2,4,5-	mg/kg	0.0376	0.437	0.0376	U	U	0.0353	0.411	0.0353	U	U	0.0336	0.391	0.0336	U	U	0.0399	0.464	0.0399	U	U	0.0327	0.38	0.0327	U	U
Trichlorophenol, 2,4,6-	mg/kg	0.0295	0.437	0.0295	U	U	0.0278	0.411	0.0278	U	U	0.0264	0.391	0.0264	U	U	0.0314	0.464	0.0314	U	U	0.0257	0.38	0.0257	U	U
WATER QUALITY																										
% Solids	Percent																									
Total organic carbon	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		SL-SB09					SL-SB09					SL-SB10					SL-SB10					TNTA-45AL				
SAMPLE_NO		SL0081					SL0082					SL0083					SL0084					TNTA-45AL				
SAMPLE DATE		12-Jan-09					12-Jan-09					12-Jan-09					12-Jan-09					22-Oct-10				
DEPTH		5 - 6 Ft					8 - 10 Ft					5 - 6 Ft					8 - 10 Ft					4_3 - 4_8 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
EXPLOSIVES																										
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.147	0.294	0.147	U	U	0.15	0.3	0.15	U	U	0.149	0.297	0.149	U	U	0.149	0.297	0.149	U	U	0.059	0.15	0.059	U	U
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.147	0.294	0.147	U	U	0.15	0.3	0.15	U	U	0.149	0.297	0.149	U	U	0.149	0.297	0.149	U	U	0.157	0.15	0.059		
Dinitrobenzene, 1,3-	mg/kg	0.147	0.294	0.147	U	U	0.15	0.3	0.15	U	U	0.149	0.297	0.149	U	U	0.149	0.297	0.149	U	U	0.059	0.15	0.059	U	U
Dinitrotoluene, 2,4-	mg/kg	0.147	0.294	0.147	U	U	0.15	0.3	0.15	U	U	0.149	0.297	0.149	U	U	0.149	0.297	0.149	U	U	0.072	0.15	0.072	U	U
Dinitrotoluene, 2,6-	mg/kg	0.147	0.294	0.147	Q1,U	U	0.15	0.3	0.15	Q1,U	U	0.149	0.297	0.149	Q1,U	U	0.149	0.297	0.149	Q1,U	U	0.065	0.15	0.065	U	U
HMX	mg/kg	0.147	0.294	0.147	U	U	0.15	0.3	0.15	U	U	0.149	0.297	0.149	U	U	0.149	0.297	0.149	U	U	0.059	0.15	0.059	U	U
Nitrobenzene	mg/kg	0.147	0.294	0.147	U	U	0.15	0.3	0.15	U	U	0.149	0.297	0.149	U	U	0.149	0.297	0.149	U	U	0.069	0.15	0.069	U	U
Nitrotoluene, 2-	mg/kg	0.147	0.294	0.147	U	U	0.15	0.3	0.15	U	U	0.149	0.297	0.149	U	U	0.149	0.297	0.149	U	U	0.059	0.15	0.059	U	U
Nitrotoluene, 3-	mg/kg	0.147	0.294	0.147	U	U	0.15	0.3	0.15	U	U	0.149	0.297	0.149	U	U	0.149	0.297	0.149	U	U	0.059	0.15	0.059	U	U
Nitrotoluene, 4-	mg/kg	0.147	0.294	0.147	U	U	0.15	0.3	0.15	U	U	0.149	0.297	0.149	U	U	0.149	0.297	0.149	U	U	0.075	0.15	0.075	U	U
RDX	mg/kg	0.147	0.294	0.147	U	U	0.15	0.3	0.15	U	U	0.149	0.297	0.149	U	U	0.149	0.297	0.149	U	U	0.059	0.15	0.059	U	U
Tetryl	mg/kg	0.147	0.294	0.147	U	U	0.15	0.3	0.15	U	U	0.149	0.297	0.149	U	U	0.149	0.297	0.149	U	U	0.059	0.15	0.059	U	U
Trinitrobenzene, 1,3,5-	mg/kg	0.147	0.294	0.147	U	U	0.15	0.3	0.15	U	U	0.149	0.297	0.149	U	U	0.149	0.297	0.149	U	U	0.107	0.15	0.059	J	J
Trinitrotoluene, 2,4,6-	mg/kg	0.147	0.294	0.147	U	U	0.15	0.3	0.15	U	U	0.149	0.297	0.149	U	U	0.149	0.297	0.149	U	U	0.156	0.15	0.059		
METALS (UNFILTERED)																										
Aluminum	mg/kg	8870	3.73	1.86			10200	3.6	1.8			10300	3.98	1.99			7580	3.49	1.75							
Antimony	mg/kg	0.487	0.466	0.233		J	0.31	0.45	0.225	J	J	0.468	0.498	0.249	J	J	0.376	0.436	0.218	J	J					
Arsenic	mg/kg	20.3	0.932	0.466		J	11.2	0.9	0.45		J	16.8	0.996	0.498		J	12.7	0.873	0.436		J					
Barium	mg/kg	37.8	0.186	0.0932			36.2	0.18	0.09			58	0.199	0.0996			29.1	0.175	0.0873							
Beryllium	mg/kg	8.72	0.186	0.0932		J	7.03	0.18	0.09		J	9.71	0.199	0.0996		J	6.56	0.175	0.0873		J					
Cadmium	mg/kg	0.233	0.466	0.233	U	U	0.225	0.45	0.225	U	U	0.249	0.498	0.249	U	U	0.218	0.436	0.218	U	U					
Calcium	mg/kg	31500	9.32	4.66			43400	9	4.5			18800	9.96	4.98			41300	8.73	4.36							
Chromium	mg/kg	13.1	0.466	0.233			14.7	0.45	0.225			15.5	0.498	0.249			11.4	0.436	0.218							
Cobalt	mg/kg	11.2	0.186	0.0932			11.2	0.18	0.09			11.8	0.199	0.0996			9.8	0.175	0.087							
Copper	mg/kg	35.5	0.466	0.233			31.3	0.45	0.225			35.8	0.498	0.249			35.6	0.436	0.218							
Iron	mg/kg	33200	3.73	1.86			24000	1.8	0.9			37200	3.98	1.99			22600	1.75	0.873							
Lead	mg/kg	14.4	0.466	0.233			13.5	0.45	0.225			14.4	0.498	0.249			13.6	0.436	0.218							
Magnesium	mg/kg	9980	1.86	0.932		J	10700	1.8	0.9		J	5360	1.99	0.996		J	10500	1.75	0.873		J					
Manganese	mg/kg	285	0.186	0.0932			381	0.18	0.09			293	0.199	0.0996			391	0.175	0.0873							
Mercury	mg/kg	0.0154	0.0216	0.0108	J	J	0.0157	0.0223	0.0111	J	J	0.019	0.0235	0.0117	J	J	0.0145	0.019	0.00952	J	J					
Nickel	mg/kg	16	0.28	0.14		J	19.2	0.27	0.135		J	14.5	0.299	0.149		J	15.9	0.262	0.131		J					
Potassium	mg/kg	1080	23.3	11.7			1670	22.5	11.3			1060	24.9	12.4			1250	21.8	10.9							
Selenium	mg/kg	0.536	0.932	0.466	J	J	0.45	0.9	0.45	U	UJ	0.498	0.996	0.498	U	UJ	0.436	0.873	0.436	U	UJ					
Silver	mg/kg	0.233	0.466	0.233	U	U	0.225	0.45	0.225	U	U	0.249	0.498	0.249	U	U	0.218	0.436	0.218	U	U					
Sodium	mg/kg	94.7	18.6	9.32			162	18	9			68.3	19.9	9.96			145	17.5	8.73							
Thallium	mg/kg	0.378	0.466	0.233	J	J	0.294	0.45	0.225	J	J	0.292	0.498	0.249	J	J	0.319	0.436	0.218	J	J					
Vanadium	mg/kg	18.7	0.186	0.0932			18.4	0.18	0.09			20.7	0.199	0.0996			15.7	0.175	0.0873							
Zinc	mg/kg	67.3	2.33	1.17		J	53	2.25	1.13		J	75.7	2.49	1.24		J	62.8	2.18	1.09		J					
PESTICIDES/PCBS																										
Aroclor 1016	mg/kg	0.00788	0.0393	0.00788	U	U	0.00751	0.0375	0.00751	U	U	0.00806	0.0402	0.00806	U	U	0.00727	0.0363	0.00727	U	U					
Aroclor 1221	mg/kg	0.00788	0.0393	0.00788	U	U	0.0651	0.0375	0.00751		QJ	0.00806	0.0402	0.00806	U	U	0.00727	0.0363	0.00727	U	U					
Aroclor 1232	mg/kg	0.00788	0.0393	0.00788	U	U	0.00751	0.0375	0.00751	U	U	0.00806	0.0402	0.00806	U	U	0.00727	0.0363	0.00727	U	U					
Aroclor 1242	mg/kg	0.00788	0.0393	0.00788	U	U	0.00751	0.0375	0.00751	U	U	0.00806	0.0402	0.00806	U	U	0.00727	0.0363	0.00727	U	U					
Aroclor 1248	mg/kg	0.00788	0.0393	0.00788	U	U	0.00751	0.0375	0.00751	U	U	0.00806	0.0402	0.00806	U	U	0.00727	0.0363	0.00727	U	U					
Aroclor 1254	mg/kg	0.00788	0.0393	0.00788	U	U	0.00751	0.0375	0.00751	U	U	0.00806	0.0402	0.00806	U	U	0.00727	0.0363	0.00727	U	U					
Aroclor 1260	mg/kg	0.00788	0.0393	0.00788	U	U	0.00751	0.0375	0.00751	U	U	0.00806	0.0402	0.00806	U	U	0.00727	0.0363	0.00727	U	U					
SEMIVOLATILES																										
3-Methylphenol and 4-Methylphenol	mg/kg																									
Acenaphthene	mg/kg	0.00709	0.393	0.00709	U	U	0.00665	0.369	0.00665	U	U	0.00723	0.401	0.00723	U	U	0.00661	0.367	0.00661	U	U					
Acenaphthylene	mg/kg	0.00473	0.393	0.00473	U	U	0.00443	0.369	0.00443	U	U	0.00482	0.401	0.00482	U	U	0.0044	0.367	0.0044	U	U					
ACETOPHENONE	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		SL-SB09					SL-SB09					SL-SB10					SL-SB10					TNTA-45AL				
SAMPLE_NO		SL0081					SL0082					SL0083					SL0084					TNTA-45AL				
SAMPLE DATE		12-Jan-09					12-Jan-09					12-Jan-09					12-Jan-09					22-Oct-10				
DEPTH		5 - 6 Ft					8 - 10 Ft					5 - 6 Ft					8 - 10 Ft					4_3 - 4_8 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Anthracene	mg/kg	0.00851	0.393	0.00851	U	U	0.00798	0.369	0.00798	U	U	0.00867	0.401	0.00867	U	U	0.00793	0.367	0.00793	U	U					
Atrazine	mg/kg																									
Benzaldehyde	mg/kg																									
Benzo(a)anthracene	mg/kg	0.0259	0.393	0.0259	U	U	0.0243	0.369	0.0243	U	U	0.0264	0.401	0.0264	U	U	0.0241	0.367	0.0241	U	U					
Benzo(a)pyrene	mg/kg	0.0259	0.393	0.0259	U	U	0.0243	0.369	0.0243	U	U	0.0264	0.401	0.0264	U	U	0.0241	0.367	0.0241	U	U					
Benzo(b)fluoranthene	mg/kg	0.0656	0.393	0.0656	U	U	0.0615	0.369	0.0615	U	U	0.0669	0.401	0.0669	U	U	0.0611	0.367	0.0611	U	U					
Benzo(ghi)perylene	mg/kg	0.0959	0.393	0.0959	U	U	0.09	0.369	0.09	U	U	0.0978	0.401	0.0978	U	U	0.0894	0.367	0.0894	U	U					
Benzo(k)fluoranthene	mg/kg	0.119	0.393	0.119	U	U	0.112	0.369	0.112	U	U	0.122	0.401	0.122	U	U	0.111	0.367	0.111	U	U					
Benzoic acid	mg/kg	0.0959	0.393	0.0959	U	U	0.09	0.369	0.09	U	U	0.0978	0.401	0.0978	U	U	0.0894	0.367	0.0894	U	U					
Benzyl alcohol	mg/kg	0.0959	0.393	0.0959	U	U	0.09	0.369	0.09	U	U	0.0978	0.401	0.0978	U	U	0.0894	0.367	0.0894	U	U					
BIBENZENE	mg/kg																									
Bis(2-chloroethoxy)methane	mg/kg	0.00827	0.393	0.00827	U	U	0.00776	0.369	0.00776	U	U	0.00843	0.401	0.00843	U	U	0.00771	0.367	0.00771	U	U					
Bis(2-chloroethyl)ether	mg/kg	0.01	0.393	0.01	U	U	0.00942	0.369	0.00942	U	U	0.0102	0.401	0.0102	U	U	0.00936	0.367	0.00936	U	U					
Bis(2-chloroisopropyl)ether	mg/kg	0.0171	0.393	0.0171	U	U	0.0161	0.369	0.0161	U	U	0.0175	0.401	0.0175	U	U	0.016	0.367	0.016	U	U					
Bis(2-ethylhexyl)phthalate	mg/kg	0.0364	0.393	0.0364	U	U	0.0341	0.369	0.0341	U	U	0.0371	0.401	0.0371	U	U	0.0339	0.367	0.0339	U	U					
Bromophenyl phenyl ether, 4-	mg/kg	0.0141	0.393	0.0141	U	U	0.0132	0.369	0.0132	U	U	0.0143	0.401	0.0143	U	U	0.0131	0.367	0.0131	U	U					
Butyl benzyl phthalate	mg/kg	0.0159	0.393	0.0159	U	U	0.015	0.369	0.015	U	U	0.0163	0.401	0.0163	U	U	0.0149	0.367	0.0149	U	U					
Caprolactam	mg/kg																									
Carbazole	mg/kg	0.0393	0.393	0.0393	U	U	0.0369	0.369	0.0369	U	U	0.0401	0.401	0.0401	U	U	0.0367	0.367	0.0367	U	U					
Chloro-3-methylphenol, 4-	mg/kg	0.00969	0.393	0.00969	U	U	0.00909	0.369	0.00909	U	U	0.00988	0.401	0.00988	U	U	0.00903	0.367	0.00903	U	U					
Chloroaniline, 4-	mg/kg	0.0341	0.393	0.0341	Q1,U	UJ	0.032	0.369	0.032	Q1,U	UJ	0.0348	0.401	0.0348	Q1,U	UJ	0.0318	0.367	0.0318	Q1,U	UJ					
Chloronaphthalene, 2-	mg/kg	0.00626	0.393	0.00626	U	U	0.00587	0.369	0.00587	U	U	0.00638	0.401	0.00638	U	U	0.00584	0.367	0.00584	U	U					
Chlorophenol, 2-	mg/kg	0.00484	0.393	0.00484	U	U	0.00454	0.369	0.00454	U	U	0.00494	0.401	0.00494	U	U	0.00451	0.367	0.00451	U	U					
Chlorophenyl phenyl ether, 4-	mg/kg	0.0301	0.393	0.0301	U	U	0.0283	0.369	0.0283	U	U	0.0307	0.401	0.0307	U	U	0.0281	0.367	0.0281	U	U					
Chrysene	mg/kg	0.0156	0.393	0.0156	U	U	0.0146	0.369	0.0146	U	U	0.0159	0.401	0.0159	U	U	0.0145	0.367	0.0145	U	U					
Dibenz(a,h)anthracene	mg/kg	0.089	0.393	0.089	U	U	0.0834	0.369	0.0834	U	U	0.0907	0.401	0.0907	U	U	0.0829	0.367	0.0829	U	U					
Dibenzofuran	mg/kg	0.00662	0.393	0.00662	U	U	0.00621	0.369	0.00621	U	U	0.00675	0.401	0.00675	U	U	0.00617	0.367	0.00617	U	U					
Dichlorobenzene, 1,2-	mg/kg	0.0091	0.393	0.0091	U	U	0.00853	0.369	0.00853	U	U	0.00928	0.401	0.00928	U	U	0.00848	0.367	0.00848	U	U					
Dichlorobenzene, 1,3-	mg/kg	0.0143	0.393	0.0143	U	U	0.0134	0.369	0.0134	U	U	0.0146	0.401	0.0146	U	U	0.0133	0.367	0.0133	U	U					
Dichlorobenzene, 1,4-	mg/kg	0.00768	0.393	0.00768	U	U	0.0072	0.369	0.0072	U	U	0.00783	0.401	0.00783	U	U	0.00716	0.367	0.00716	U	U					
Dichlorobenzidine, 3,3'-	mg/kg	0.039	0.393	0.039	Q1,U	UJ	0.0366	0.369	0.0366	Q1,U	UJ	0.0398	0.401	0.0398	Q1,U	UJ	0.0363	0.367	0.0363	Q1,U	UJ					
Dichlorophenol, 2,4-	mg/kg	0.0141	0.393	0.0141	U	U	0.0132	0.369	0.0132	U	U	0.0143	0.401	0.0143	U	U	0.0131	0.367	0.0131	U	U					
Diethyl phthalate	mg/kg	0.0159	0.393	0.0159	U	U	0.015	0.369	0.015	U	U	0.0163	0.401	0.0163	U	U	0.0149	0.367	0.0149	U	U					
Dimethyl phthalate	mg/kg	0.012	0.393	0.012	U	U	0.0113	0.369	0.0113	U	U	0.0123	0.401	0.0123	U	U	0.0112	0.367	0.0112	U	U					
Dimethylphenol, 2,4-	mg/kg	0.0104	0.393	0.0104	U	U	0.00975	0.369	0.00975	U	U	0.0106	0.401	0.0106	U	U	0.00969	0.367	0.00969	U	U					
Di-n-butyl phthalate	mg/kg	0.00851	0.393	0.00851	U	U	0.00798	0.369	0.00798	U	U	0.00867	0.401	0.00867	U	U	0.00793	0.367	0.00793	U	U					
Dinitro-2-methylphenol, 4,6-	mg/kg	0.0396	0.393	0.0396	U	U	0.0371	0.369	0.0371	U	U	0.0404	0.401	0.0404	U	U	0.0369	0.367	0.0369	U	U					
Dinitrophenol, 2,4-	mg/kg	0.0627	0.393	0.0627	U	U	0.0588	0.369	0.0588	U	U	0.064	0.401	0.064	U	U	0.0585	0.367	0.0585	U	U					
Dinitrotoluene, 2,4-	mg/kg	0.0138	0.393	0.0138	U	U	0.013	0.369	0.013	U	U	0.0141	0.401	0.0141	U	U	0.0129	0.367	0.0129	U	U					
Dinitrotoluene, 2,6-	mg/kg	0.00945	0.393	0.00945	U	U	0.00887	0.369	0.00887	U	U	0.00964	0.401	0.00964	U	U	0.00881	0.367	0.00881	U	U					
Di-n-octyl phthalate	mg/kg	0.0741	0.393	0.0741	U	U	0.0695	0.369	0.0695	U	U	0.0755	0.401	0.0755	U	U	0.069	0.367	0.069	U	U					
DIPHENYLAMINE	mg/kg	0.039	0.393	0.039	U	U	0.0366	0.369	0.0366	U	U	0.0398	0.401	0.0398	U	U	0.0363	0.367	0.0363	U	U					
Fluoranthene	mg/kg	0.00851	0.393	0.00851	U	U	0.00798	0.369	0.00798	U	U	0.00867	0.401	0.00867	U	U	0.00793	0.367	0.00793	U	U					
Fluorene	mg/kg	0.0167	0.393	0.0167	U	U	0.0156	0.369	0.0156	U	U	0.017	0.401	0.017	U	U	0.0155	0.367	0.0155	U	U					
Hexachlorobenzene	mg/kg	0.0245	0.393	0.0245	U	U	0.0229	0.369	0.0229	U	U	0.0249	0.401	0.0249	U	U	0.0228	0.367	0.0228	U	U					
Hexachlorobutadiene	mg/kg	0.0373	0.393	0.0373	U	U	0.035	0.369	0.035	U	U	0.0381	0.401	0.0381	U	U	0.0348	0.367	0.0348	U	U					
Hexachlorocyclopentadiene	mg/kg	0.0125	0.393	0.0125	Q2,U	UJ	0.0117	0.369	0.0117	Q2,U	UJ	0.0128	0.401	0.0128	Q2,U	UJ	0.0117	0.367	0.0117	Q2,U	UJ					
Hexachloroethane	mg/kg	0.012	0.393	0.012	U	U	0.0113	0.369	0.0113	U	U	0.0123	0.401	0.0123	U	U	0.0112	0.367	0.0112	U	U					
Indeno(1,2,3-cd)pyrene	mg/kg	0.128	0.393	0.128	U	U	0.12	0.369	0.12	U	U	0.13	0.401	0.13	U	U	0.119	0.367	0.119	U	U					
Isophorone	mg/kg	0.00473	0.393	0.00473	U	U	0.00443	0.369	0.00443	U	U	0.00482	0.401	0.00482	U	U	0.0044	0.367	0.0044	U	U					
Methylnaphthalene, 2-	mg/kg	0.103	0.393	0.103	U	U	0.0969	0.369	0.0969	U	U	0.105	0.401	0.105	U	U	0.0962	0.367	0.0962	U	U					
Methylphenol, 2-	mg/kg	0.00591	0.393	0.00591	U	U	0.00554	0.369	0.00554	U	U	0.00602	0.401	0.00602	U	U	0.00551	0.367	0.00551	U	U					

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		SL-SB09					SL-SB09					SL-SB10					SL-SB10					TNTA-45AL				
SAMPLE_NO		SL0081					SL0082					SL0083					SL0084					TNTA-45AL				
SAMPLE DATE		12-Jan-09					12-Jan-09					12-Jan-09					12-Jan-09					22-Oct-10				
DEPTH		5 - 6 Ft					8 - 10 Ft					5 - 6 Ft					8 - 10 Ft					4_3 - 4_8 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Methylphenol, 4-	mg/kg	0.0123	0.393	0.0123	U	U	0.0115	0.369	0.0115	U	U	0.0125	0.401	0.0125	U	U	0.0115	0.367	0.0115	U	U					
Naphthalene	mg/kg	0.00933	0.393	0.00933	U	U	0.00875	0.369	0.00875	U	U	0.00952	0.401	0.00952	U	U	0.0087	0.367	0.0087	U	U					
Nitroaniline, 2-	mg/kg	0.017	0.393	0.017	U	U	0.016	0.369	0.016	U	U	0.0173	0.401	0.0173	U	U	0.0159	0.367	0.0159	U	U					
Nitroaniline, 3-	mg/kg	0.0133	0.393	0.0133	Q1,U	UJ	0.0125	0.369	0.0125	Q1,U	UJ	0.0136	0.401	0.0136	U	U	0.0124	0.367	0.0124	U	U					
Nitroaniline, 4-	mg/kg	0.139	0.393	0.139	U	U	0.131	0.369	0.131	U	U	0.142	0.401	0.142	U	U	0.13	0.367	0.13	U	U					
Nitrobenzene	mg/kg	0.0129	0.393	0.0129	U	U	0.0121	0.369	0.0121	U	U	0.0131	0.401	0.0131	U	U	0.012	0.367	0.012	U	U					
Nitrophenol, 2-	mg/kg	0.0139	0.393	0.0139	U	U	0.0131	0.369	0.0131	U	U	0.0142	0.401	0.0142	U	U	0.013	0.367	0.013	U	U					
Nitrophenol, 4-	mg/kg	0.0319	0.393	0.0319	U	U	0.0299	0.369	0.0299	U	U	0.0325	0.401	0.0325	U	U	0.0297	0.367	0.0297	U	U					
n-Nitrosodimethylamine	mg/kg	0.0118	0.393	0.0118	U	U	0.0111	0.369	0.0111	U	U	0.012	0.401	0.012	U	U	0.011	0.367	0.011	U	U					
n-Nitroso-di-n-propylamine	mg/kg	0.0141	0.393	0.0141	U	U	0.0132	0.369	0.0132	U	U	0.0143	0.401	0.0143	U	U	0.0131	0.367	0.0131	U	U					
n-Nitrosodiphenylamine	mg/kg	0.00555	0.393	0.00555	U	U	0.00521	0.369	0.00521	U	U	0.00566	0.401	0.00566	U	U	0.00518	0.367	0.00518	U	U					
Pentachlorophenol	mg/kg	0.0353	0.393	0.0353	U	U	0.0331	0.369	0.0331	U	U	0.036	0.401	0.036	U	U	0.0329	0.367	0.0329	U	U					
Phenanthrene	mg/kg	0.0504	0.393	0.00957	J	J	0.0898	0.369	0.00898	J	J	0.00976	0.401	0.00976	U	U	0.0749	0.367	0.00892	J	J					
Phenol	mg/kg	0.00473	0.393	0.00473	U	U	0.00443	0.369	0.00443	U	U	0.00482	0.401	0.00482	U	U	0.0044	0.367	0.0044	U	U					
Pyrene	mg/kg	0.0157	0.393	0.0157	U	U	0.0147	0.369	0.0147	U	U	0.016	0.401	0.016	U	U	0.0146	0.367	0.0146	U	U					
Trichlorobenzene, 1,2,4-	mg/kg	0.00969	0.393	0.00969	U	U	0.00909	0.369	0.00909	U	U	0.00988	0.401	0.00988	U	U	0.00903	0.367	0.00903	U	U					
Trichlorophenol, 2,4,5-	mg/kg	0.0338	0.393	0.0338	U	U	0.0317	0.369	0.0317	U	U	0.0345	0.401	0.0345	U	U	0.0315	0.367	0.0315	U	U					
Trichlorophenol, 2,4,6-	mg/kg	0.0266	0.393	0.0266	U	U	0.0249	0.369	0.0249	U	U	0.0271	0.401	0.0271	U	U	0.0248	0.367	0.0248	U	U					
WATER QUALITY																										
% Solids	Percent																					83.4	0			
Total organic carbon	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTA-46BL					TNTA-48AL					TNTA-53BL					TNTA-SL-SB02					TNTA-SL-SB02				
SAMPLE_NO		TNTA-46BL					TNTA-48AL					TNTA-53BL					SL0063					SL0064				
SAMPLE DATE		21-Oct-10					21-Oct-10					22-Oct-10					12-Jan-09					12-Jan-09				
DEPTH		4 - 4_5 Ft					4_5 - 5 Ft					3_6 - 4_1 Ft					0 - 1 Ft					8 - 10 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
EXPLOSIVES																										
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.378	0.19	0.075		J	0.064	0.16	0.064	U	U	1.04	0.18	0.071			0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.753	0.19	0.075			0.064	0.16	0.064	U	U	4.73	0.18	0.071			0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U
Dinitrobenzene, 1,3-	mg/kg	0.075	0.19	0.075	U	U	0.064	0.16	0.064	U	U	0.142	0.18	0.071	J	J	0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U
Dinitrotoluene, 2,4-	mg/kg	2.12	0.19	0.092		J	0.078	0.16	0.078	U	U	2.39	0.18	0.087			0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U
Dinitrotoluene, 2,6-	mg/kg	0.667	0.19	0.082			0.07	0.16	0.07	U	U	0.494	0.18	0.078			0.149	0.299	0.149	Q1,U	U	0.15	0.3	0.15	Q1,U	U
HMX	mg/kg	0.075	0.19	0.075	U	U	0.064	0.16	0.064	U	U	0.071	0.18	0.071	U	U	0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U
Nitrobenzene	mg/kg	0.088	0.19	0.088	U	U	0.074	0.16	0.074	U	U	0.083	0.18	0.083	U	U	0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U
Nitrotoluene, 2-	mg/kg	0.075	0.19	0.075	U	U	0.064	0.16	0.064	U	U	0.071	0.18	0.071	U	U	0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U
Nitrotoluene, 3-	mg/kg	0.075	0.19	0.075	U	U	0.064	0.16	0.064	U	U	0.071	0.18	0.071	U	U	0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U
Nitrotoluene, 4-	mg/kg	0.095	0.19	0.095	U	U	0.081	0.16	0.081	U	U	0.09	0.18	0.09	U	U	0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U
RDX	mg/kg	0.075	0.19	0.075	U	U	0.064	0.16	0.064	U	U	0.071	0.18	0.071	U	U	0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U
Tetryl	mg/kg	0.075	0.19	0.075	U	U	0.064	0.16	0.064	U	U	0.071	0.18	0.071	U	U	0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U
Trinitrobenzene, 1,3,5-	mg/kg	0.455	0.19	0.075			0.064	0.16	0.064	U	U	2.72	0.18	0.071			0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U
Trinitrotoluene, 2,4,6-	mg/kg	10.3	0.19	0.075		J	0.064	0.16	0.064	U	U	9.67	0.18	0.071			0.149	0.299	0.149	U	U	0.15	0.3	0.15	U	U
METALS (UNFILTERED)																										
Aluminum	mg/kg																12400	4.38	2.19			7070	3.62	1.81		
Antimony	mg/kg																0.274	0.548	0.274	U	UJ	0.311	0.453	0.227	J	J
Arsenic	mg/kg																5.93	1.1	0.548		J	12.8	0.906	0.453		J
Barium	mg/kg																84	0.219	0.11			35	0.181	0.0906		
Beryllium	mg/kg																6.82	0.219	0.11		J	6.79	0.181	0.0906		J
Cadmium	mg/kg																0.274	0.548	0.274	U	U	0.227	0.453	0.227	U	U
Calcium	mg/kg																6360	11	5.48			45100	9.06	4.53		
Chromium	mg/kg																16.5	0.548	0.274			10.3	0.453	0.227		
Cobalt	mg/kg																5.97	0.219	0.11			8.55	0.181	0.0906		
Copper	mg/kg																25.6	0.548	0.274			35.3	0.453	0.227		
Iron	mg/kg																19500	2.19	1.1			23600	1.81	0.906		
Lead	mg/kg																20.2	0.548	0.274			12.5	0.453	0.227		
Magnesium	mg/kg																2840	2.19	1.1		J	10900	1.81	0.906		J
Manganese	mg/kg																137	0.219	0.11			426	0.181	0.0906		
Mercury	mg/kg																0.0483	0.0259	0.0129			0.017	0.0196	0.00982	J	J
Nickel	mg/kg																9.06	0.329	0.164		J	11.4	0.272	0.136		J
Potassium	mg/kg																718	27.4	13.7			1050	22.7	11.3		
Selenium	mg/kg																0.608	1.1	0.548	J	J	0.453	0.906	0.453	U	UJ
Silver	mg/kg																0.274	0.548	0.274	U	U	0.227	0.453	0.227	U	U
Sodium	mg/kg																68.7	21.9	11			143	18.1	9.06		
Thallium	mg/kg																0.274	0.548	0.274	U	U	0.271	0.453	0.227	J	J
Vanadium	mg/kg																26.3	0.219	0.11			15.7	0.181	0.0906		
Zinc	mg/kg																50.9	2.74	1.37		J	54.5	2.27	1.13		J
PESTICIDES/PCBS																										
Aroclor 1016	mg/kg																0.125	0.046	0.00922	P	J	0.00742	0.037	0.00742	U	U
Aroclor 1221	mg/kg																0.00922	0.046	0.00922	U	U	0.00742	0.037	0.00742	U	U
Aroclor 1232	mg/kg																0.00922	0.046	0.00922	U	U	0.00742	0.037	0.00742	U	U
Aroclor 1242	mg/kg																0.00922	0.046	0.00922	U	U	0.00742	0.037	0.00742	U	U
Aroclor 1248	mg/kg																0.00922	0.046	0.00922	U	U	0.00742	0.037	0.00742	U	U
Aroclor 1254	mg/kg																0.00922	0.046	0.00922	U	U	0.00742	0.037	0.00742	U	U
Aroclor 1260	mg/kg																0.00922	0.046	0.00922	U	U	0.00742	0.037	0.00742	U	U
SEMIVOLATILES																										
3-Methylphenol and 4-Methylphenol	mg/kg																									
Acenaphthene	mg/kg																0.00832	0.462	0.00832	U	U	0.00657	0.364	0.00657	U	U
Acenaphthylene	mg/kg																0.111	0.462	0.00555	J	J	0.00438	0.364	0.00438	U	U
ACETOPHENONE	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTA-46BL					TNTA-48AL					TNTA-53BL					TNTA-SL-SB02					TNTA-SL-SB02				
SAMPLE_NO		TNTA-46BL					TNTA-48AL					TNTA-53BL					SL0063					SL0064				
SAMPLE DATE		21-Oct-10					21-Oct-10					22-Oct-10					12-Jan-09					12-Jan-09				
DEPTH		4 - 4_5 Ft					4_5 - 5 Ft					3_6 - 4_1 Ft					0 - 1 Ft					8 - 10 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Anthracene	mg/kg																0.299	0.462	0.00999	J	J	0.00788	0.364	0.00788	U	U
Atrazine	mg/kg																									
Benzaldehyde	mg/kg																									
Benzo(a)anthracene	mg/kg																1.54	0.462	0.0304			0.024	0.364	0.024	U	U
Benzo(a)pyrene	mg/kg																1.18	0.462	0.0304			0.024	0.364	0.024	U	U
Benzo(b)fluoranthene	mg/kg																2	0.462	0.077			0.0607	0.364	0.0607	U	U
Benzo(ghi)perylene	mg/kg																0.69	0.462	0.113			0.0889	0.364	0.0889	U	U
Benzo(k)fluoranthene	mg/kg																0.54	0.462	0.14			0.111	0.364	0.111	U	U
Benzoic acid	mg/kg																0.537	0.462	0.113			0.0889	0.364	0.0889	U	U
Benzyl alcohol	mg/kg																0.113	0.462	0.113	U	U	0.0889	0.364	0.0889	U	U
BIBENZENE	mg/kg																									
Bis(2-chloroethoxy)methane	mg/kg																0.00971	0.462	0.00971	U	U	0.00766	0.364	0.00766	U	U
Bis(2-chloroethyl)ether	mg/kg																0.0118	0.462	0.0118	U	U	0.0093	0.364	0.0093	U	U
Bis(2-chloroisopropyl)ether	mg/kg																0.0201	0.462	0.0201	U	U	0.0159	0.364	0.0159	U	U
Bis(2-ethylhexyl)phthalate	mg/kg																0.0869	0.462	0.0427	J	J	0.0337	0.364	0.0337	U	U
Bromophenyl phenyl ether, 4-	mg/kg																0.0165	0.462	0.0165	U	U	0.013	0.364	0.013	U	U
Butyl benzyl phthalate	mg/kg																0.0187	0.462	0.0187	U	U	0.0148	0.364	0.0148	U	U
Caprolactam	mg/kg																									
Carbazole	mg/kg																0.0462	0.462	0.0462	U	U	0.0364	0.364	0.0364	U	U
Chloro-3-methylphenol, 4-	mg/kg																0.0114	0.462	0.0114	U	U	0.00897	0.364	0.00897	U	U
Chloroaniline, 4-	mg/kg																0.0401	0.462	0.0401	Q1,U	UJ	0.0316	0.364	0.0316	Q1,U	UJ
Chloronaphthalene, 2-	mg/kg																0.00735	0.462	0.00735	U	U	0.0058	0.364	0.0058	U	U
Chlorophenol, 2-	mg/kg																0.00569	0.462	0.00569	U	U	0.00449	0.364	0.00449	U	U
Chlorophenyl phenyl ether, 4-	mg/kg																0.0354	0.462	0.0354	U	U	0.0279	0.364	0.0279	U	U
Chrysene	mg/kg																1.36	0.462	0.0183			0.0144	0.364	0.0144	U	U
Dibenz(a,h)anthracene	mg/kg																0.196	0.462	0.104	J	J	0.0824	0.364	0.0824	U	U
Dibenzofuran	mg/kg																0.00777	0.462	0.00777	U	U	0.00613	0.364	0.00613	U	U
Dichlorobenzene, 1,2-	mg/kg																0.0107	0.462	0.0107	U	U	0.00843	0.364	0.00843	U	U
Dichlorobenzene, 1,3-	mg/kg																0.0168	0.462	0.0168	U	U	0.0132	0.364	0.0132	U	U
Dichlorobenzene, 1,4-	mg/kg																0.00902	0.462	0.00902	U	U	0.00711	0.364	0.00711	U	U
Dichlorobenzidine, 3,3'-	mg/kg																0.0458	0.462	0.0458	Q1,U	UJ	0.0361	0.364	0.0361	Q1,U	UJ
Dichlorophenol, 2,4-	mg/kg																0.0165	0.462	0.0165	U	U	0.013	0.364	0.013	U	U
Diethyl phthalate	mg/kg																0.0187	0.462	0.0187	U	U	0.0148	0.364	0.0148	U	U
Dimethyl phthalate	mg/kg																0.0141	0.462	0.0141	U	U	0.0112	0.364	0.0112	U	U
Dimethylphenol, 2,4-	mg/kg																0.0122	0.462	0.0122	U	U	0.00963	0.364	0.00963	U	U
Di-n-butyl phthalate	mg/kg																0.00999	0.462	0.00999	U	U	0.00788	0.364	0.00788	U	U
Dinitro-2-methylphenol, 4,6-	mg/kg																0.0465	0.462	0.0465	U	U	0.0367	0.364	0.0367	U	U
Dinitrophenol, 2,4-	mg/kg																0.0736	0.462	0.0736	U	U	0.0581	0.364	0.0581	U	U
Dinitrotoluene, 2,4-	mg/kg																0.0615	0.462	0.0162	J	J	0.0128	0.364	0.0128	U	U
Dinitrotoluene, 2,6-	mg/kg																0.0111	0.462	0.0111	U	U	0.00876	0.364	0.00876	U	U
Di-n-octyl phthalate	mg/kg																0.087	0.462	0.087	U	U	0.0686	0.364	0.0686	U	U
DIPHENYLAMINE	mg/kg																0.0458	0.462	0.0458	U	U	0.0361	0.364	0.0361	U	U
Fluoranthene	mg/kg																3.05	0.462	0.00999			0.00788	0.364	0.00788	U	U
Fluorene	mg/kg																0.0196	0.462	0.0196	U	U	0.0154	0.364	0.0154	U	U
Hexachlorobenzene	mg/kg																0.0287	0.462	0.0287	U	U	0.0227	0.364	0.0227	U	U
Hexachlorobutadiene	mg/kg																0.0438	0.462	0.0438	U	U	0.0346	0.364	0.0346	U	U
Hexachlorocyclopentadiene	mg/kg																0.0147	0.462	0.0147	Q2,U	UJ	0.0116	0.364	0.0116	Q2,U	UJ
Hexachloroethane	mg/kg																0.0141	0.462	0.0141	U	U	0.0112	0.364	0.0112	U	U
Indeno(1,2,3-cd)pyrene	mg/kg																1.06	0.462	0.15			0.118	0.364	0.118	U	U
Isophorone	mg/kg																0.00555	0.462	0.00555	U	U	0.00438	0.364	0.00438	U	U
Methylnaphthalene, 2-	mg/kg																0.121	0.462	0.121	U	U	0.0957	0.364	0.0957	U	U
Methylphenol, 2-	mg/kg																0.00693	0.462	0.00693	U	U	0.00547	0.364	0.00547	U	U

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTA-46BL					TNTA-48AL					TNTA-53BL					TNTA-SL-SB02					TNTA-SL-SB02				
SAMPLE_NO		TNTA-46BL					TNTA-48AL					TNTA-53BL					SL0063					SL0064				
SAMPLE DATE		21-Oct-10					21-Oct-10					22-Oct-10					12-Jan-09					12-Jan-09				
DEPTH		4 - 4_5 Ft					4_5 - 5 Ft					3_6 - 4_1 Ft					0 - 1 Ft					8 - 10 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Methylphenol, 4-	mg/kg																0.0144	0.462	0.0144	U	U	0.0114	0.364	0.0114	U	U
Naphthalene	mg/kg																0.011	0.462	0.011	U	U	0.00865	0.364	0.00865	U	U
Nitroaniline, 2-	mg/kg																0.02	0.462	0.02	U	U	0.0158	0.364	0.0158	U	U
Nitroaniline, 3-	mg/kg																0.0157	0.462	0.0157	Q1,U	UJ	0.0124	0.364	0.0124	Q1,U	UJ
Nitroaniline, 4-	mg/kg																0.164	0.462	0.164	U	U	0.129	0.364	0.129	U	U
Nitrobenzene	mg/kg																0.0151	0.462	0.0151	U	U	0.0119	0.364	0.0119	U	U
Nitrophenol, 2-	mg/kg																0.0164	0.462	0.0164	U	U	0.0129	0.364	0.0129	U	U
Nitrophenol, 4-	mg/kg																0.0374	0.462	0.0374	U	U	0.0295	0.364	0.0295	U	U
n-Nitrosodimethylamine	mg/kg																0.0139	0.462	0.0139	U	U	0.0109	0.364	0.0109	U	U
n-Nitroso-di-n-propylamine	mg/kg																0.0165	0.462	0.0165	U	U	0.013	0.364	0.013	U	U
n-Nitrosodiphenylamine	mg/kg																0.00652	0.462	0.00652	U	U	0.00514	0.364	0.00514	U	U
Pentachlorophenol	mg/kg																0.0415	0.462	0.0415	U	U	0.0327	0.364	0.0327	U	U
Phenanthrene	mg/kg																0.392	0.462	0.0112	J	J	0.0854	0.364	0.00886	J	J
Phenol	mg/kg																0.00555	0.462	0.00555	U	U	0.00438	0.364	0.00438	U	U
Pyrene	mg/kg																2.22	0.462	0.0184			0.0146	0.364	0.0146	U	U
Trichlorobenzene, 1,2,4-	mg/kg																0.0114	0.462	0.0114	U	U	0.00897	0.364	0.00897	U	U
Trichlorophenol, 2,4,5-	mg/kg																0.0397	0.462	0.0397	U	U	0.0313	0.364	0.0313	U	U
Trichlorophenol, 2,4,6-	mg/kg																0.0312	0.462	0.0312	U	U	0.0246	0.364	0.0246	U	U
WATER QUALITY																										
% Solids	Percent	84.7	0				77.5	0				82.5	0													
Total organic carbon	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTA-SL-SB02					TNTA-SL-SB02					TNTA-SL-SB05					TNTA-SL-SB05					TNTA-SL-SB05				
SAMPLE_NO		SL0065					SL0232					SL0071					SL0072					SL0233				
SAMPLE DATE		12-Jan-09					22-Aug-11					13-Jan-09					13-Jan-09					23-Aug-11				
DEPTH		8 - 10 Ft					5 - 7 Ft					0 - 1 Ft					8 - 10 Ft					0 - 1 Ft				
SAMPLE PURPOSE		FD					REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
EXPLOSIVES																										
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.148	0.296	0.148	U	U	0.07	0.18	0.07	U	U	18.5	2.97	1.49			0.149	0.299	0.149	U	U	15.9	5	2		
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.148	0.296	0.148	U	U	0.07	0.18	0.07	U	U	16.4	2.97	1.49			0.149	0.299	0.149	U	U	15.6	5	2		
Dinitrobenzene, 1,3-	mg/kg	0.148	0.296	0.148	U	U	0.07	0.18	0.07	U	U	0.149	0.297	0.149	U	U	0.149	0.299	0.149	U	U	2	5	2	U	U
Dinitrotoluene, 2,4-	mg/kg	0.148	0.296	0.148	U	U	0.085	0.18	0.085	U	U	1.46	0.297	0.149			0.149	0.299	0.149	U	U	2.4	5	2.4	U	U
Dinitrotoluene, 2,6-	mg/kg	0.148	0.296	0.148	Q1,U	U	0.077	0.18	0.077	U	U	0.75	0.297	0.149			0.149	0.299	0.149	Q1,U	U	2.2	5	2.2	U	U
HMX	mg/kg	0.148	0.296	0.148	U	U	0.07	0.18	0.07	U	U	0.149	0.297	0.149	U	U	0.149	0.299	0.149	U	U	2	5	2	U	U
Nitrobenzene	mg/kg	0.148	0.296	0.148	U	U	0.082	0.18	0.082	U	U	0.149	0.297	0.149	U	U	0.149	0.299	0.149	U	U	2.3	5	2.3	U	U
Nitrotoluene, 2-	mg/kg	0.148	0.296	0.148	U	U	0.07	0.18	0.07	U	U	0.149	0.297	0.149	U	U	0.149	0.299	0.149	U	U	2	5	2	U	U
Nitrotoluene, 3-	mg/kg	0.148	0.296	0.148	U	U	0.07	0.18	0.07	U	U	0.149	0.297	0.149	U	U	0.149	0.299	0.149	U	U	2	5	2	U	U
Nitrotoluene, 4-	mg/kg	0.148	0.296	0.148	U	U	0.089	0.18	0.089	U	U	0.149	0.297	0.149	U	U	0.149	0.299	0.149	U	U	2.5	5	2.5	U	U
RDX	mg/kg	0.148	0.296	0.148	U	U	0.07	0.18	0.07	U	U	0.149	0.297	0.149	U	U	0.149	0.299	0.149	U	U	2	5	2	U	U
Tetryl	mg/kg	0.148	0.296	0.148	U	U	0.07	0.18	0.07	U	U	0.149	0.297	0.149	U	U	0.149	0.299	0.149	U	U	2	5	2	U	U
Trinitrobenzene, 1,3,5-	mg/kg	0.148	0.296	0.148	U	U	0.07	0.18	0.07	U	U	0.149	0.297	0.149	U	U	0.149	0.299	0.149	U	U	2	5	2	U	U
Trinitrotoluene, 2,4,6-	mg/kg	0.148	0.296	0.148	U	U	0.0793	0.18	0.07	J	J	138	14.9	7.43			0.371	0.299	0.149			287	5	2		
METALS (UNFILTERED)																										
Aluminum	mg/kg	8490	3.57	1.79								8810	4.11	2.05			10300	3.61	1.8							
Antimony	mg/kg	0.259	0.446	0.223	J	J						0.257	0.514	0.257	U	UJ	0.252	0.451	0.226	J	J					
Arsenic	mg/kg	14.6	0.893	0.446		J						6.15	1.03	0.514		J	12.7	0.902	0.451		J					
Barium	mg/kg	26.3	0.179	0.0893								52.3	0.205	0.103			16.2	0.18	0.0902							
Beryllium	mg/kg	6.87	0.179	0.0893		J						6.43	0.205	0.103		J	7.29	0.18	0.0902		J					
Cadmium	mg/kg	0.306	0.446	0.223	J	J						0.257	0.514	0.257	U	U	0.559	0.451	0.226							
Calcium	mg/kg	43400	8.93	4.46								4030	10.3	5.14			45100	9.02	4.51							
Chromium	mg/kg	12	0.446	0.223								1.7	0.514	0.257			15.9	0.451	0.226							
Cobalt	mg/kg	10.6	0.179	0.089								7.1	0.205	0.103			14.5	0.18	0.0902							
Copper	mg/kg	33.7	0.446	0.223								21.9	0.514	0.257			37	0.451	0.226							
Iron	mg/kg	23800	1.79	0.893								19000	2.05	1.03			29500	3.61	1.8							
Lead	mg/kg	13.8	0.446	0.223								11.4	0.514	0.257			12.7	0.451	0.226							
Magnesium	mg/kg	10600	1.79	0.893		J						2270	2.05	1.03		J	9530	1.8	0.902		J					
Manganese	mg/kg	386	0.179	0.0893								211	0.205	0.103			443	0.18	0.0902							
Mercury	mg/kg	0.0186	0.0196	0.0098	J	J						0.0441	0.0244	0.0122			0.0127	0.0222	0.0111	J	J					
Nickel	mg/kg	17.6	0.268	0.134		J						8.35	0.308	0.154		J	29.1	0.271	0.135		J					
Potassium	mg/kg	1280	22.3	11.2								616	25.7	12.8			1480	22.6	11.3							
Selenium	mg/kg	0.446	0.893	0.446	U	UJ						0.514	1.03	0.514	U	UJ	0.451	0.902	0.451	U	UJ					
Silver	mg/kg	0.223	0.446	0.223	U	U						0.257	0.514	0.257	U	U	0.226	0.451	0.226	U	U					
Sodium	mg/kg	154	17.9	8.93								51.9	20.5	10.3			188	18	9.02							
Thallium	mg/kg	0.315	0.446	0.223	J	J						0.257	0.514	0.257	U	U	0.226	0.451	0.226	U	U					
Vanadium	mg/kg	17.1	0.179	0.0893								23	0.205	0.103			17.2	0.18	0.0902							
Zinc	mg/kg	131	2.23	1.12		J						48.7	2.57	1.28		J	261	2.26	1.13		J					
PESTICIDES/PCBS																										
Aroclor 1016	mg/kg	0.00734	0.0367	0.00734	U	U						1.16	0.0434	0.0087	P	J	0.0077	0.0384	0.0077	U	U					
Aroclor 1221	mg/kg	0.199	0.0367	0.00734		QJ						0.0087	0.0434	0.0087	U	U	0.0175	0.0384	0.0077	J	QJ					
Aroclor 1232	mg/kg	0.00734	0.0367	0.00734	U	U						0.0087	0.0434	0.0087	U	U	0.0077	0.0384	0.0077	U	U					
Aroclor 1242	mg/kg	0.00734	0.0367	0.00734	U	U						0.0087	0.0434	0.0087	U	U	0.0077	0.0384	0.0077	U	U					
Aroclor 1248	mg/kg	0.00734	0.0367	0.00734	U	U						0.0087	0.0434	0.0087	U	U	0.0077	0.0384	0.0077	U	U					
Aroclor 1254	mg/kg	0.00734	0.0367	0.00734	U	U						0.0087	0.0434	0.0087	U	U	0.0077	0.0384	0.0077	U	U					
Aroclor 1260	mg/kg	0.00734	0.0367	0.00734	U	U						0.0087	0.0434	0.0087	U	U	0.0077	0.0384	0.0077	U	U					
SEMIVOLATILES																										
3-Methylphenol and 4-Methylphenol	mg/kg																									
Acenaphthene	mg/kg	0.00674	0.374	0.00674	U	U						0.0388	2.15	0.0388	U	U	0.00697	0.387	0.00697	U	U					
Acenaphthylene	mg/kg	0.00449	0.374	0.00449	U	U						0.0258	2.15	0.0258	U	U	0.00465	0.387	0.00465	U	U					
ACETOPHENONE	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTA-SL-SB02					TNTA-SL-SB02					TNTA-SL-SB05					TNTA-SL-SB05					TNTA-SL-SB05				
SAMPLE_NO		SL0065					SL0232					SL0071					SL0072					SL0233				
SAMPLE DATE		12-Jan-09					22-Aug-11					13-Jan-09					13-Jan-09					23-Aug-11				
DEPTH		8 - 10 Ft					5 - 7 Ft					0 - 1 Ft					8 - 10 Ft					0 - 1 Ft				
SAMPLE PURPOSE		FD					REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Anthracene	mg/kg	0.00808	0.374	0.00808	U	U						0.0465	2.15	0.0465	U	U	0.00836	0.387	0.00836	U	U					
Atrazine	mg/kg																									
Benzaldehyde	mg/kg																									
Benzo(a)anthracene	mg/kg	0.0246	0.374	0.0246	U	U						0.141	2.15	0.141	U	U	0.0254	0.387	0.0254	U	U					
Benzo(a)pyrene	mg/kg	0.0246	0.374	0.0246	U	U						0.141	2.15	0.141	U	U	0.0254	0.387	0.0254	U	U					
Benzo(b)fluoranthene	mg/kg	0.0623	0.374	0.0623	U	U						0.358	2.15	0.358	U	U	0.0645	0.387	0.0645	U	U					
Benzo(ghi)perylene	mg/kg	0.0912	0.374	0.0912	U	U						0.524	2.15	0.524	U	U	0.0943	0.387	0.0943	U	U					
Benzo(k)fluoranthene	mg/kg	0.113	0.374	0.113	U	U						0.652	2.15	0.652	U	U	0.117	0.387	0.117	U	U					
Benzoic acid	mg/kg	0.0912	0.374	0.0912	U	U						0.524	2.15	0.524	U	U	0.0943	0.387	0.0943	U	U					
Benzyl alcohol	mg/kg	0.0912	0.374	0.0912	U	U						0.524	2.15	0.524	U	U	0.0943	0.387	0.0943	U	U					
BIBENZENE	mg/kg																									
Bis(2-chloroethoxy)methane	mg/kg	0.00786	0.374	0.00786	U	U						0.0452	2.15	0.0452	U	U	0.00813	0.387	0.00813	U	U					
Bis(2-chloroethyl)ether	mg/kg	0.00954	0.374	0.00954	U	U						0.0549	2.15	0.0549	U	U	0.00987	0.387	0.00987	U	U					
Bis(2-chloroisopropyl)ether	mg/kg	0.0163	0.374	0.0163	U	U						0.0936	2.15	0.0936	U	U	0.0168	0.387	0.0168	U	U					
Bis(2-ethylhexyl)phthalate	mg/kg	0.0346	0.374	0.0346	U	U						0.199	2.15	0.199	U	U	0.0358	0.387	0.0358	U	U					
Bromophenyl phenyl ether, 4-	mg/kg	0.0134	0.374	0.0134	U	U						0.0769	2.15	0.0769	U	U	0.0138	0.387	0.0138	U	U					
Butyl benzyl phthalate	mg/kg	0.0152	0.374	0.0152	U	U						0.0872	2.15	0.0872	U	U	0.0157	0.387	0.0157	U	U					
Caprolactam	mg/kg																									
Carbazole	mg/kg	0.0374	0.374	0.0374	U	U						0.215	2.15	0.215	U	U	0.0387	0.387	0.0387	U	U					
Chloro-3-methylphenol, 4-	mg/kg	0.00921	0.374	0.00921	U	U						0.053	2.15	0.053	U	U	0.00952	0.387	0.00952	U	U					
Chloroaniline, 4-	mg/kg	0.0324	0.374	0.0324	Q1,U	UJ						0.187	2.15	0.187	Q1,U	UJ	0.0336	0.387	0.0336	Q1,U	UJ					
Chloronaphthalene, 2-	mg/kg	0.00595	0.374	0.00595	U	U						0.0342	2.15	0.0342	U	U	0.00616	0.387	0.00616	U	U					
Chlorophenol, 2-	mg/kg	0.0046	0.374	0.0046	U	U						0.0265	2.15	0.0265	U	U	0.00476	0.387	0.00476	U	U					
Chlorophenyl phenyl ether, 4-	mg/kg	0.0286	0.374	0.0286	U	U						0.165	2.15	0.165	U	U	0.0296	0.387	0.0296	U	U					
Chrysene	mg/kg	0.0148	0.374	0.0148	U	U						0.0853	2.15	0.0853	U	U	0.0153	0.387	0.0153	U	U					
Dibenz(a,h)anthracene	mg/kg	0.0845	0.374	0.0845	U	U						0.486	2.15	0.486	U	U	0.0875	0.387	0.0875	U	U					
Dibenzofuran	mg/kg	0.00629	0.374	0.00629	U	U						0.0362	2.15	0.0362	U	U	0.0065	0.387	0.0065	U	U					
Dichlorobenzene, 1,2-	mg/kg	0.00864	0.374	0.00864	U	U						0.0497	2.15	0.0497	U	U	0.00894	0.387	0.00894	U	U					
Dichlorobenzene, 1,3-	mg/kg	0.0136	0.374	0.0136	U	U						0.0781	2.15	0.0781	U	U	0.0141	0.387	0.0141	U	U					
Dichlorobenzene, 1,4-	mg/kg	0.0073	0.374	0.0073	U	U						0.042	2.15	0.042	U	U	0.00755	0.387	0.00755	U	U					
Dichlorobenzidine, 3,3'-	mg/kg	0.037	0.374	0.037	Q1,U	UJ						0.213	2.15	0.213	Q1,U	UJ	0.0383	0.387	0.0383	Q1,U	UJ					
Dichlorophenol, 2,4-	mg/kg	0.0134	0.374	0.0134	U	U						0.0769	2.15	0.0769	U	U	0.0138	0.387	0.0138	U	U					
Diethyl phthalate	mg/kg	0.0152	0.374	0.0152	U	U						0.0872	2.15	0.0872	U	U	0.0157	0.387	0.0157	U	U					
Dimethyl phthalate	mg/kg	0.0115	0.374	0.0115	U	U						0.0659	2.15	0.0659	U	U	0.0118	0.387	0.0118	U	U					
Dimethylphenol, 2,4-	mg/kg	0.00988	0.374	0.00988	U	U						0.0568	2.15	0.0568	U	U	0.0102	0.387	0.0102	U	U					
Di-n-butyl phthalate	mg/kg	0.00808	0.374	0.00808	U	U						0.0465	2.15	0.0465	U	U	0.00836	0.387	0.00836	U	U					
Dinitro-2-methylphenol, 4,6-	mg/kg	0.0376	0.374	0.0376	U	U						0.216	2.15	0.216	U	U	0.0389	0.387	0.0389	U	U					
Dinitrophenol, 2,4-	mg/kg	0.0596	0.374	0.0596	U	U						0.343	2.15	0.343	U	U	0.0617	0.387	0.0617	U	U					
Dinitrotoluene, 2,4-	mg/kg	0.0131	0.374	0.0131	U	U						4.42	2.15	0.0756			0.0136	0.387	0.0136	U	U					
Dinitrotoluene, 2,6-	mg/kg	0.00898	0.374	0.00898	U	U						2.18	2.15	0.0517			0.00929	0.387	0.00929	U	U					
Di-n-octyl phthalate	mg/kg	0.0704	0.374	0.0704	U	U						0.405	2.15	0.405	U	U	0.0728	0.387	0.0728	U	U					
DIPHENYLAMINE	mg/kg	0.037	0.374	0.037	U	U						0.213	2.15	0.213	U	U	0.0383	0.387	0.0383	U	U					
Fluoranthene	mg/kg	0.00808	0.374	0.00808	U	U						0.0465	2.15	0.0465	U	U	0.00836	0.387	0.00836	U	U					
Fluorene	mg/kg	0.0158	0.374	0.0158	U	U						0.0911	2.15	0.0911	U	U	0.0164	0.387	0.0164	U	U					
Hexachlorobenzene	mg/kg	0.0232	0.374	0.0232	U	U						0.134	2.15	0.134	U	U	0.024	0.387	0.024	U	U					
Hexachlorobutadiene	mg/kg	0.0355	0.374	0.0355	U	U						0.204	2.15	0.204	U	U	0.0367	0.387	0.0367	U	U					
Hexachlorocyclopentadiene	mg/kg	0.0119	0.374	0.0119	Q2,U	UJ						0.0685	2.15	0.0685	Q2,U	UJ	0.0123	0.387	0.0123	Q2,U	UJ					
Hexachloroethane	mg/kg	0.0115	0.374	0.0115	U	U						0.0659	2.15	0.0659	U	U	0.0118	0.387	0.0118	U	U					
Indeno(1,2,3-cd)pyrene	mg/kg	0.121	0.374	0.121	U	U						0.698	2.15	0.698	U	U	0.125	0.387	0.125	U	U					
Isophorone	mg/kg	0.00449	0.374	0.00449	U	U						0.0258	2.15	0.0258	U	U	0.00465	0.387	0.00465	U	U					
Methylnaphthalene, 2-	mg/kg	0.0981	0.374	0.0981	U	U						0.564	2.15	0.564	U	U	0.102	0.387	0.102	U	U					
Methylphenol, 2-	mg/kg	0.00561	0.374	0.00561	U	U						0.0323	2.15	0.0323	U	U	0.00581	0.387	0.00581	U	U					

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTA-SL-SB02					TNTA-SL-SB02					TNTA-SL-SB05					TNTA-SL-SB05					TNTA-SL-SB05				
SAMPLE_NO		SL0065					SL0232					SL0071					SL0072					SL0233				
SAMPLE DATE		12-Jan-09					22-Aug-11					13-Jan-09					13-Jan-09					23-Aug-11				
DEPTH		8 - 10 Ft					5 - 7 Ft					0 - 1 Ft					8 - 10 Ft					0 - 1 Ft				
SAMPLE PURPOSE		FD					REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Methylphenol, 4-	mg/kg	0.0117	0.374	0.0117	U	U						0.0672	2.15	0.0672	U	U	0.0121	0.387	0.0121	U	U					
Naphthalene	mg/kg	0.00887	0.374	0.00887	U	U						0.051	2.15	0.051	U	U	0.00918	0.387	0.00918	U	U					
Nitroaniline, 2-	mg/kg	0.0162	0.374	0.0162	U	U						0.093	2.15	0.093	U	U	0.0167	0.387	0.0167	U	U					
Nitroaniline, 3-	mg/kg	0.0127	0.374	0.0127	Q1,U	UJ						0.299	2.15	0.073	J	J	0.0131	0.387	0.0131	U	U					
Nitroaniline, 4-	mg/kg	0.132	0.374	0.132	U	U						0.762	2.15	0.762	U	U	0.137	0.387	0.137	U	U					
Nitrobenzene	mg/kg	0.0122	0.374	0.0122	U	U						0.0704	2.15	0.0704	U	U	0.0127	0.387	0.0127	U	U					
Nitrophenol, 2-	mg/kg	0.0132	0.374	0.0132	U	U						0.0762	2.15	0.0762	U	U	0.0137	0.387	0.0137	U	U					
Nitrophenol, 4-	mg/kg	0.0303	0.374	0.0303	U	U						0.174	2.15	0.174	U	U	0.0314	0.387	0.0314	U	U					
n-Nitrosodimethylamine	mg/kg	0.0112	0.374	0.0112	U	U						0.0646	2.15	0.0646	U	U	0.0116	0.387	0.0116	U	U					
n-Nitroso-di-n-propylamine	mg/kg	0.0134	0.374	0.0134	U	U						0.0769	2.15	0.0769	U	U	0.0138	0.387	0.0138	U	U					
n-Nitrosodiphenylamine	mg/kg	0.00528	0.374	0.00528	U	U						0.0304	2.15	0.0304	U	U	0.00546	0.387	0.00546	U	U					
Pentachlorophenol	mg/kg	0.0336	0.374	0.0336	U	U						0.193	2.15	0.193	U	U	0.0347	0.387	0.0347	U	U					
Phenanthrene	mg/kg	0.0408	0.374	0.00909	J	J						0.0523	2.15	0.0523	U	U	0.0515	0.387	0.00941	J	J					
Phenol	mg/kg	0.00449	0.374	0.00449	U	U						0.0258	2.15	0.0258	U	U	0.00465	0.387	0.00465	U	U					
Pyrene	mg/kg	0.0149	0.374	0.0149	U	U						0.0859	2.15	0.0859	U	U	0.0154	0.387	0.0154	U	U					
Trichlorobenzene, 1,2,4-	mg/kg	0.00921	0.374	0.00921	U	U						0.053	2.15	0.053	U	U	0.00952	0.387	0.00952	U	U					
Trichlorophenol, 2,4,5-	mg/kg	0.0321	0.374	0.0321	U	U						0.185	2.15	0.185	U	U	0.0332	0.387	0.0332	U	U					
Trichlorophenol, 2,4,6-	mg/kg	0.0253	0.374	0.0253	U	U						0.145	2.15	0.145	U	U	0.0261	0.387	0.0261	U	U					
WATER QUALITY																										
% Solids	Percent																									
Total organic carbon	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTA-SL-TP03					TNTA-SL-TP04					TNTA-SL-TP21					TNTA-SL-TP22					TNTA-SL-TP22				
SAMPLE_NO		SL0003					SL0004					SL0025					SL0026					SL0027				
SAMPLE DATE		4-Dec-08					4-Dec-08					5-Dec-08					5-Dec-08					5-Dec-08				
DEPTH		5 - 5_5 Ft					4 - 4_5 Ft					4 - 4_5 Ft					4 - 4_5 Ft					4 - 4_5 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					FD				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
EXPLOSIVES																										
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.267	0.294	0.147	J	J	0.153	0.306	0.153	U	U	0.147	0.294	0.147	U	U	0.143	0.286	0.143	U	U	0.152	0.303	0.152	U	U
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.401	0.294	0.147			0.153	0.306	0.153	U	U	0.147	0.294	0.147	U	U	0.143	0.286	0.143	U	U	0.152	0.303	0.152	U	U
Dinitrobenzene, 1,3-	mg/kg	0.147	0.294	0.147	U	U	0.153	0.306	0.153	U	U	0.147	0.294	0.147	U	U	0.143	0.286	0.143	U	U	0.152	0.303	0.152	U	U
Dinitrotoluene, 2,4-	mg/kg	0.624	0.294	0.147			0.153	0.306	0.153	U	U	0.147	0.294	0.147	U	U	0.143	0.286	0.143	U	U	0.152	0.303	0.152	U	U
Dinitrotoluene, 2,6-	mg/kg	0.217	0.294	0.147	J	J	0.153	0.306	0.153	U	U	0.147	0.294	0.147	U	U	0.143	0.286	0.143	U	U	0.152	0.303	0.152	U	U
HMX	mg/kg	0.147	0.294	0.147	U	U	0.153	0.306	0.153	U	U	0.147	0.294	0.147	U	U	0.143	0.286	0.143	U	U	0.152	0.303	0.152	U	U
Nitrobenzene	mg/kg	0.147	0.294	0.147	U	U	0.153	0.306	0.153	U	U	0.147	0.294	0.147	U	U	0.143	0.286	0.143	U	U	0.152	0.303	0.152	U	U
Nitrotoluene, 2-	mg/kg	0.147	0.294	0.147	U	U	0.153	0.306	0.153	U	U	0.147	0.294	0.147	U	U	0.143	0.286	0.143	U	U	0.152	0.303	0.152	U	U
Nitrotoluene, 3-	mg/kg	0.147	0.294	0.147	U	U	0.153	0.306	0.153	U	U	0.147	0.294	0.147	U	U	0.143	0.286	0.143	U	U	0.152	0.303	0.152	U	U
Nitrotoluene, 4-	mg/kg	0.147	0.294	0.147	U		0.153	0.306	0.153	U	U	0.147	0.294	0.147	U	U	0.143	0.286	0.143	U	U	0.152	0.303	0.152	U	U
RDX	mg/kg	0.147	0.294	0.147	U	U	0.153	0.306	0.153	U	U	0.147	0.294	0.147	U	U	0.143	0.286	0.143	U	U	0.152	0.303	0.152	U	U
Tetryl	mg/kg	0.147	0.294	0.147	U	U	0.153	0.306	0.153	U	U	0.147	0.294	0.147	U	U	0.143	0.286	0.143	U	U	0.152	0.303	0.152	U	U
Trinitrobenzene, 1,3,5-	mg/kg	0.567	0.294	0.147			0.153	0.306	0.153	U	U	0.147	0.294	0.147	U	U	0.143	0.286	0.143	U	U	0.152	0.303	0.152	U	U
Trinitrotoluene, 2,4,6-	mg/kg	0.68	0.294	0.147			0.153	0.306	0.153	U	U	0.147	0.294	0.147	U	U	0.143	0.286	0.143	U	U	0.152	0.303	0.152	U	U
METALS (UNFILTERED)																										
Aluminum	mg/kg																									
Antimony	mg/kg																									
Arsenic	mg/kg																									
Barium	mg/kg																									
Beryllium	mg/kg																									
Cadmium	mg/kg																									
Calcium	mg/kg																									
Chromium	mg/kg																									
Cobalt	mg/kg																									
Copper	mg/kg																									
Iron	mg/kg																									
Lead	mg/kg																									
Magnesium	mg/kg																									
Manganese	mg/kg																									
Mercury	mg/kg																									
Nickel	mg/kg																									
Potassium	mg/kg																									
Selenium	mg/kg																									
Silver	mg/kg																									
Sodium	mg/kg																									
Thallium	mg/kg																									
Vanadium	mg/kg																									
Zinc	mg/kg																									
PESTICIDES/PCBS																										
Aroclor 1016	mg/kg																									
Aroclor 1221	mg/kg																									
Aroclor 1232	mg/kg																									
Aroclor 1242	mg/kg																									
Aroclor 1248	mg/kg																									
Aroclor 1254	mg/kg																									
Aroclor 1260	mg/kg																									
SEMIVOLATILES																										
3-Methylphenol and 4-Methylphenol	mg/kg																									
Acenaphthene	mg/kg																									
Acenaphthylene	mg/kg																									
ACETOPHENONE	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTA-SL-TP03					TNTA-SL-TP04					TNTA-SL-TP21					TNTA-SL-TP22					TNTA-SL-TP22				
SAMPLE_NO		SL0003					SL0004					SL0025					SL0026					SL0027				
SAMPLE DATE		4-Dec-08					4-Dec-08					5-Dec-08					5-Dec-08					5-Dec-08				
DEPTH		5 - 5_5 Ft					4 - 4_5 Ft					4 - 4_5 Ft					4 - 4_5 Ft					4 - 4_5 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					FD				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Anthracene	mg/kg																									
Atrazine	mg/kg																									
Benzaldehyde	mg/kg																									
Benzo(a)anthracene	mg/kg																									
Benzo(a)pyrene	mg/kg																									
Benzo(b)fluoranthene	mg/kg																									
Benzo(ghi)perylene	mg/kg																									
Benzo(k)fluoranthene	mg/kg																									
Benzoic acid	mg/kg																									
Benzyl alcohol	mg/kg																									
BIBENZENE	mg/kg																									
Bis(2-chloroethoxy)methane	mg/kg																									
Bis(2-chloroethyl)ether	mg/kg																									
Bis(2-chloroisopropyl)ether	mg/kg																									
Bis(2-ethylhexyl)phthalate	mg/kg																									
Bromophenyl phenyl ether, 4-	mg/kg																									
Butyl benzyl phthalate	mg/kg																									
Caprolactam	mg/kg																									
Carbazole	mg/kg																									
Chloro-3-methylphenol, 4-	mg/kg																									
Chloroaniline, 4-	mg/kg																									
Chloronaphthalene, 2-	mg/kg																									
Chlorophenol, 2-	mg/kg																									
Chlorophenyl phenyl ether, 4-	mg/kg																									
Chrysene	mg/kg																									
Dibenz(a,h)anthracene	mg/kg																									
Dibenzofuran	mg/kg																									
Dichlorobenzene, 1,2-	mg/kg																									
Dichlorobenzene, 1,3-	mg/kg																									
Dichlorobenzene, 1,4-	mg/kg																									
Dichlorobenzidine, 3,3'-	mg/kg																									
Dichlorophenol, 2,4-	mg/kg																									
Diethyl phthalate	mg/kg																									
Dimethyl phthalate	mg/kg																									
Dimethylphenol, 2,4-	mg/kg																									
Di-n-butyl phthalate	mg/kg																									
Dinitro-2-methylphenol, 4,6-	mg/kg																									
Dinitrophenol, 2,4-	mg/kg																									
Dinitrotoluene, 2,4-	mg/kg																									
Dinitrotoluene, 2,6-	mg/kg																									
Di-n-octyl phthalate	mg/kg																									
DIPHENYLAMINE	mg/kg																									
Fluoranthene	mg/kg																									
Fluorene	mg/kg																									
Hexachlorobenzene	mg/kg																									
Hexachlorobutadiene	mg/kg																									
Hexachlorocyclopentadiene	mg/kg																									
Hexachloroethane	mg/kg																									
Indeno(1,2,3-cd)pyrene	mg/kg																									
Isophorone	mg/kg																									
Methylnaphthalene, 2-	mg/kg																									
Methylphenol, 2-	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTA-SL-TP03					TNTA-SL-TP04					TNTA-SL-TP21					TNTA-SL-TP22					TNTA-SL-TP22				
SAMPLE_NO		SL0003					SL0004					SL0025					SL0026					SL0027				
SAMPLE DATE		4-Dec-08					4-Dec-08					5-Dec-08					5-Dec-08					5-Dec-08				
DEPTH		5 - 5_5 Ft					4 - 4_5 Ft					4 - 4_5 Ft					4 - 4_5 Ft					4 - 4_5 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					FD				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Methylphenol, 4-	mg/kg																									
Naphthalene	mg/kg																									
Nitroaniline, 2-	mg/kg																									
Nitroaniline, 3-	mg/kg																									
Nitroaniline, 4-	mg/kg																									
Nitrobenzene	mg/kg																									
Nitrophenol, 2-	mg/kg																									
Nitrophenol, 4-	mg/kg																									
n-Nitrosodimethylamine	mg/kg																									
n-Nitroso-di-n-propylamine	mg/kg																									
n-Nitrosodiphenylamine	mg/kg																									
Pentachlorophenol	mg/kg																									
Phenanthrene	mg/kg																									
Phenol	mg/kg																									
Pyrene	mg/kg																									
Trichlorobenzene, 1,2,4-	mg/kg																									
Trichlorophenol, 2,4,5-	mg/kg																									
Trichlorophenol, 2,4,6-	mg/kg																									
WATER QUALITY																										
% Solids	Percent																									
Total organic carbon	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTA-SL-TP23					TNTA-SL-TP24					TNTA-SL-TP25					TNTA-SL-TP26				
SAMPLE_NO		SL0029					SL0030					SL0031					SL0032				
SAMPLE DATE		5-Dec-08					5-Dec-08					5-Dec-08					4-Dec-08				
DEPTH		4 - 4_5 Ft					4 - 4_25 Ft					4 - 4_25 Ft					4 - 4_3 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
EXPLOSIVES																					
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.139	0.278	0.139	U	U	0.15	0.3	0.15	U	U	0.268	0.274	0.137	J	J	0.14	0.28	0.14	U	U
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.139	0.278	0.139	U	U	0.15	0.3	0.15	U	U	0.476	0.274	0.137			0.14	0.28	0.14	U	U
Dinitrobenzene, 1,3-	mg/kg	0.139	0.278	0.139	U	U	0.15	0.3	0.15	U	U	0.137	0.274	0.137	U	U	0.14	0.28	0.14	U	U
Dinitrotoluene, 2,4-	mg/kg	0.139	0.278	0.139	U	U	0.15	0.3	0.15	U	U	0.137	0.274	0.137	U	U	0.14	0.28	0.14	U	U
Dinitrotoluene, 2,6-	mg/kg	0.139	0.278	0.139	U	U	0.15	0.3	0.15	U	U	0.137	0.274	0.137	U	U	0.14	0.28	0.14	U	U
HMX	mg/kg	0.139	0.278	0.139	U	U	0.15	0.3	0.15	U	U	0.137	0.274	0.137	U	U	0.14	0.28	0.14	U	U
Nitrobenzene	mg/kg	0.139	0.278	0.139	U	U	0.15	0.3	0.15	U	U	0.137	0.274	0.137	U	U	0.14	0.28	0.14	U	U
Nitrotoluene, 2-	mg/kg	0.139	0.278	0.139	U	U	0.15	0.3	0.15	U	U	0.137	0.274	0.137	U	U	0.14	0.28	0.14	U	U
Nitrotoluene, 3-	mg/kg	0.139	0.278	0.139	U	U	0.15	0.3	0.15	U	U	0.137	0.274	0.137	U	U	0.14	0.28	0.14	U	U
Nitrotoluene, 4-	mg/kg	0.139	0.278	0.139	U	U	0.15	0.3	0.15	U	U	0.137	0.274	0.137	U	U	0.14	0.28	0.14	U	U
RDX	mg/kg	0.139	0.278	0.139	U	U	0.15	0.3	0.15	U	U	0.137	0.274	0.137	U	U	0.14	0.28	0.14	U	U
Tetryl	mg/kg	0.139	0.278	0.139	U	U	0.15	0.3	0.15	U	U	0.137	0.274	0.137	U	U	0.14	0.28	0.14	U	U
Trinitrobenzene, 1,3,5-	mg/kg	0.139	0.278	0.139	U	U	0.15	0.3	0.15	U	U	0.137	0.274	0.137	U	U	0.14	0.28	0.14	U	U
Trinitrotoluene, 2,4,6-	mg/kg	0.139	0.278	0.139	U	U	0.15	0.3	0.15	U	U	0.137	0.274	0.137	U	U	0.14	0.28	0.14	U	U
METALS (UNFILTERED)																					
Aluminum	mg/kg																				
Antimony	mg/kg																				
Arsenic	mg/kg																				
Barium	mg/kg																				
Beryllium	mg/kg																				
Cadmium	mg/kg																				
Calcium	mg/kg																				
Chromium	mg/kg																				
Cobalt	mg/kg																				
Copper	mg/kg																				
Iron	mg/kg																				
Lead	mg/kg																				
Magnesium	mg/kg																				
Manganese	mg/kg																				
Mercury	mg/kg																				
Nickel	mg/kg																				
Potassium	mg/kg																				
Selenium	mg/kg																				
Silver	mg/kg																				
Sodium	mg/kg																				
Thallium	mg/kg																				
Vanadium	mg/kg																				
Zinc	mg/kg																				
PESTICIDES/PCBS																					
Aroclor 1016	mg/kg																				
Aroclor 1221	mg/kg																				
Aroclor 1232	mg/kg																				
Aroclor 1242	mg/kg																				
Aroclor 1248	mg/kg																				
Aroclor 1254	mg/kg																				
Aroclor 1260	mg/kg																				
SEMIVOLATILES																					
3-Methylphenol and 4-Methylphenol	mg/kg																				
Acenaphthene	mg/kg																				
Acenaphthylene	mg/kg																				
ACETOPHENONE	mg/kg																				

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTA-SL-TP23					TNTA-SL-TP24					TNTA-SL-TP25					TNTA-SL-TP26				
SAMPLE_NO		SL0029					SL0030					SL0031					SL0032				
SAMPLE DATE		5-Dec-08					5-Dec-08					5-Dec-08					4-Dec-08				
DEPTH		4 - 4_5 Ft					4 - 4_25 Ft					4 - 4_25 Ft					4 - 4_3 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Anthracene	mg/kg																				
Atrazine	mg/kg																				
Benzaldehyde	mg/kg																				
Benzo(a)anthracene	mg/kg																				
Benzo(a)pyrene	mg/kg																				
Benzo(b)fluoranthene	mg/kg																				
Benzo(ghi)perylene	mg/kg																				
Benzo(k)fluoranthene	mg/kg																				
Benzoic acid	mg/kg																				
Benzyl alcohol	mg/kg																				
BIBENZENE	mg/kg																				
Bis(2-chloroethoxy)methane	mg/kg																				
Bis(2-chloroethyl)ether	mg/kg																				
Bis(2-chloroisopropyl)ether	mg/kg																				
Bis(2-ethylhexyl)phthalate	mg/kg																				
Bromophenyl phenyl ether, 4-	mg/kg																				
Butyl benzyl phthalate	mg/kg																				
Caprolactam	mg/kg																				
Carbazole	mg/kg																				
Chloro-3-methylphenol, 4-	mg/kg																				
Chloroaniline, 4-	mg/kg																				
Chloronaphthalene, 2-	mg/kg																				
Chlorophenol, 2-	mg/kg																				
Chlorophenyl phenyl ether, 4-	mg/kg																				
Chrysene	mg/kg																				
Dibenz(a,h)anthracene	mg/kg																				
Dibenzofuran	mg/kg																				
Dichlorobenzene, 1,2-	mg/kg																				
Dichlorobenzene, 1,3-	mg/kg																				
Dichlorobenzene, 1,4-	mg/kg																				
Dichlorobenzidine, 3,3'-	mg/kg																				
Dichlorophenol, 2,4-	mg/kg																				
Diethyl phthalate	mg/kg																				
Dimethyl phthalate	mg/kg																				
Dimethylphenol, 2,4-	mg/kg																				
Di-n-butyl phthalate	mg/kg																				
Dinitro-2-methylphenol, 4,6-	mg/kg																				
Dinitrophenol, 2,4-	mg/kg																				
Dinitrotoluene, 2,4-	mg/kg																				
Dinitrotoluene, 2,6-	mg/kg																				
Di-n-octyl phthalate	mg/kg																				
DIPHENYLAMINE	mg/kg																				
Fluoranthene	mg/kg																				
Fluorene	mg/kg																				
Hexachlorobenzene	mg/kg																				
Hexachlorobutadiene	mg/kg																				
Hexachlorocyclopentadiene	mg/kg																				
Hexachloroethane	mg/kg																				
Indeno(1,2,3-cd)pyrene	mg/kg																				
Isophorone	mg/kg																				
Methylnaphthalene, 2-	mg/kg																				
Methylphenol, 2-	mg/kg																				

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTA-SL-TP23					TNTA-SL-TP24					TNTA-SL-TP25					TNTA-SL-TP26				
SAMPLE_NO		SL0029					SL0030					SL0031					SL0032				
SAMPLE DATE		5-Dec-08					5-Dec-08					5-Dec-08					4-Dec-08				
DEPTH		4 - 4_5 Ft					4 - 4_25 Ft					4 - 4_25 Ft					4 - 4_3 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Methylphenol, 4-	mg/kg																				
Naphthalene	mg/kg																				
Nitroaniline, 2-	mg/kg																				
Nitroaniline, 3-	mg/kg																				
Nitroaniline, 4-	mg/kg																				
Nitrobenzene	mg/kg																				
Nitrophenol, 2-	mg/kg																				
Nitrophenol, 4-	mg/kg																				
n-Nitrosodimethylamine	mg/kg																				
n-Nitroso-di-n-propylamine	mg/kg																				
n-Nitrosodiphenylamine	mg/kg																				
Pentachlorophenol	mg/kg																				
Phenanthrene	mg/kg																				
Phenol	mg/kg																				
Pyrene	mg/kg																				
Trichlorobenzene, 1,2,4-	mg/kg																				
Trichlorophenol, 2,4,5-	mg/kg																				
Trichlorophenol, 2,4,6-	mg/kg																				
WATER QUALITY																					
% Solids	Percent																				
Total organic carbon	mg/kg																				

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTA-SL-TP27					TNTA-SL-TP28					TNTA-SL-TP28					TNTA-SL-TP29					TNTA-SL-TP30					TNTA-SL-TP32				
SAMPLE NO		SL0033					SL0034					SL0035					SL0037					SL0038					SL0040				
SAMPLE DATE		4-Dec-08					4-Dec-08					4-Dec-08					4-Dec-08					4-Dec-08					4-Dec-08				
DEPTH		3 - 3_5 Ft					3 - 3_25 Ft					3 - 3_25 Ft					5 - 5_5 Ft					5 - 5_25 Ft					5 - 5_5 Ft				
SAMPLE PURPOSE		REG					REG					FD					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
EXPLOSIVES																															
Amino-2,6-dinitrotoluene, 4-	mg/kg	3.78	0.287	0.144			0.151	0.302	0.151	U	U	0.149	0.299	0.149	U	U	0.142	0.283	0.142	U	U	1.67	0.305	0.152			0.147	0.294	0.147	U	U
Amino-4,6-dinitrotoluene, 2-	mg/kg	9.98	1.44	0.718			0.151	0.302	0.151	U	U	0.149	0.299	0.149	U	U	0.142	0.283	0.142	U	U	3.16	0.305	0.152			0.147	0.294	0.147	U	U
Dinitrobenzene, 1,3-	mg/kg	0.144	0.287	0.144	U	U	0.151	0.302	0.151	U	U	0.149	0.299	0.149	U	U	0.142	0.283	0.142	U	U	0.152	0.305	0.152	U	U	0.147	0.294	0.147	U	U
Dinitrotoluene, 2,4-	mg/kg	3.25	0.287	0.144			0.151	0.302	0.151	U	U	0.149	0.299	0.149	U	U	0.142	0.283	0.142	U	U	0.896	0.305	0.152			0.147	0.294	0.147	U	U
Dinitrotoluene, 2,6-	mg/kg	0.526	0.287	0.144			0.151	0.302	0.151	U	U	0.149	0.299	0.149	U	U	0.142	0.283	0.142	U	U	0.529	0.305	0.152			0.147	0.294	0.147	U	U
HMX	mg/kg	0.144	0.287	0.144	U	U	0.151	0.302	0.151	U	U	0.149	0.299	0.149	U	U	0.142	0.283	0.142	U	U	0.152	0.305	0.152	U	U	0.147	0.294	0.147	U	U
Nitrobenzene	mg/kg	0.144	0.287	0.144	U	U	0.151	0.302	0.151	U	U	0.149	0.299	0.149	U	U	0.142	0.283	0.142	U	U	0.152	0.305	0.152	U	U	0.147	0.294	0.147	U	U
Nitrotoluene, 2-	mg/kg	0.144	0.287	0.144	U	U	0.151	0.302	0.151	U	U	0.149	0.299	0.149	U	U	0.142	0.283	0.142	U	U	0.152	0.305	0.152	U	U	0.147	0.294	0.147	U	U
Nitrotoluene, 3-	mg/kg	0.144	0.287	0.144	U	U	0.151	0.302	0.151	U	U	0.149	0.299	0.149	U	U	0.142	0.283	0.142	U	U	0.152	0.305	0.152	U	U	0.147	0.294	0.147	U	U
Nitrotoluene, 4-	mg/kg	0.144	0.287	0.144	U	U	0.151	0.302	0.151	U	U	0.149	0.299	0.149	U	U	0.142	0.283	0.142	U	U	0.152	0.305	0.152	U	U	0.147	0.294	0.147	U	U
RDX	mg/kg	0.144	0.287	0.144	U	U	0.151	0.302	0.151	U	U	0.149	0.299	0.149	U	U	0.142	0.283	0.142	U	U	0.152	0.305	0.152	U	U	0.147	0.294	0.147	U	U
Tetryl	mg/kg	0.144	0.287	0.144	U	U	0.151	0.302	0.151	U	U	0.149	0.299	0.149	U	U	0.142	0.283	0.142	U	U	0.152	0.305	0.152	U	U	0.147	0.294	0.147	U	U
Trinitrobenzene, 1,3,5-	mg/kg	0.144	0.287	0.144	U	U	0.151	0.302	0.151	U	U	0.149	0.299	0.149	U	U	0.142	0.283	0.142	U	U	0.978	0.305	0.152			0.147	0.294	0.147	U	U
Trinitrotoluene, 2,4,6-	mg/kg	3.35	1.44	0.718			0.151	0.302	0.151	U	U	0.251	0.299	0.149	J	J	0.142	0.283	0.142	U	U	77.8	15.2	7.61			0.147	0.294	0.147	U	U
METALS (UNFILTERED)																															
Aluminum	mg/kg																														
Antimony	mg/kg																														
Arsenic	mg/kg																														
Barium	mg/kg																														
Beryllium	mg/kg																														
Cadmium	mg/kg																														
Calcium	mg/kg																														
Chromium	mg/kg																														
Cobalt	mg/kg																														
Copper	mg/kg																														
Iron	mg/kg																														
Lead	mg/kg																														
Magnesium	mg/kg																														
Manganese	mg/kg																														
Mercury	mg/kg																														
Nickel	mg/kg																														
Potassium	mg/kg																														
Selenium	mg/kg																														
Silver	mg/kg																														
Sodium	mg/kg																														
Thallium	mg/kg																														
Vanadium	mg/kg																														
Zinc	mg/kg																														
PESTICIDES/PCBS																															
Aroclor 1016	mg/kg																														
Aroclor 1221	mg/kg																														
Aroclor 1232	mg/kg																														
Aroclor 1242	mg/kg																														
Aroclor 1248	mg/kg																														
Aroclor 1254	mg/kg																														
Aroclor 1260	mg/kg																														
SEMIVOLATILES																															
3-Methylphenol and 4-Methylphenol	mg/kg																														
Acenaphthene	mg/kg																														
Acenaphthylene	mg/kg																														
ACETOPHENONE	mg/kg																														

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTA-SL-TP27					TNTA-SL-TP28					TNTA-SL-TP28					TNTA-SL-TP29					TNTA-SL-TP30					TNTA-SL-TP32				
SAMPLE NO		SL0033					SL0034					SL0035					SL0037					SL0038					SL0040				
SAMPLE DATE		4-Dec-08					4-Dec-08					4-Dec-08					4-Dec-08					4-Dec-08					4-Dec-08				
DEPTH		3 - 3_5 Ft					3 - 3_25 Ft					3 - 3_25 Ft					5 - 5_5 Ft					5 - 5_25 Ft					5 - 5_5 Ft				
SAMPLE PURPOSE		REG					REG					FD					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Anthracene	mg/kg																														
Atrazine	mg/kg																														
Benzaldehyde	mg/kg																														
Benzo(a)anthracene	mg/kg																														
Benzo(a)pyrene	mg/kg																														
Benzo(b)fluoranthene	mg/kg																														
Benzo(ghi)perylene	mg/kg																														
Benzo(k)fluoranthene	mg/kg																														
Benzoic acid	mg/kg																														
Benzyl alcohol	mg/kg																														
BIBENZENE	mg/kg																														
Bis(2-chloroethoxy)methane	mg/kg																														
Bis(2-chloroethyl)ether	mg/kg																														
Bis(2-chloroisopropyl)ether	mg/kg																														
Bis(2-ethylhexyl)phthalate	mg/kg																														
Bromophenyl phenyl ether, 4-	mg/kg																														
Butyl benzyl phthalate	mg/kg																														
Caprolactam	mg/kg																														
Carbazole	mg/kg																														
Chloro-3-methylphenol, 4-	mg/kg																														
Chloroaniline, 4-	mg/kg																														
Chloronaphthalene, 2-	mg/kg																														
Chlorophenol, 2-	mg/kg																														
Chlorophenyl phenyl ether, 4-	mg/kg																														
Chrysene	mg/kg																														
Dibenz(a,h)anthracene	mg/kg																														
Dibenzofuran	mg/kg																														
Dichlorobenzene, 1,2-	mg/kg																														
Dichlorobenzene, 1,3-	mg/kg																														
Dichlorobenzene, 1,4-	mg/kg																														
Dichlorobenzidine, 3,3'-	mg/kg																														
Dichlorophenol, 2,4-	mg/kg																														
Diethyl phthalate	mg/kg																														
Dimethyl phthalate	mg/kg																														
Dimethylphenol, 2,4-	mg/kg																														
Di-n-butyl phthalate	mg/kg																														
Dinitro-2-methylphenol, 4,6-	mg/kg																														
Dinitrophenol, 2,4-	mg/kg																														
Dinitrotoluene, 2,4-	mg/kg																														
Dinitrotoluene, 2,6-	mg/kg																														
Di-n-octyl phthalate	mg/kg																														
DIPHENYLAMINE	mg/kg																														
Fluoranthene	mg/kg																														
Fluorene	mg/kg																														
Hexachlorobenzene	mg/kg																														
Hexachlorobutadiene	mg/kg																														
Hexachlorocyclopentadiene	mg/kg																														
Hexachloroethane	mg/kg																														
Indeno(1,2,3-cd)pyrene	mg/kg																														
Isophorone	mg/kg																														
Methylnaphthalene, 2-	mg/kg																														
Methylphenol, 2-	mg/kg																														

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTA-SL-TP27					TNTA-SL-TP28					TNTA-SL-TP28					TNTA-SL-TP29					TNTA-SL-TP30					TNTA-SL-TP32				
SAMPLE NO		SL0033					SL0034					SL0035					SL0037					SL0038					SL0040				
SAMPLE DATE		4-Dec-08					4-Dec-08					4-Dec-08					4-Dec-08					4-Dec-08					4-Dec-08				
DEPTH		3 - 3_5 Ft					3 - 3_25 Ft					3 - 3_25 Ft					5 - 5_5 Ft					5 - 5_25 Ft					5 - 5_5 Ft				
SAMPLE PURPOSE		REG					REG					FD					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Methylphenol, 4-	mg/kg																														
Naphthalene	mg/kg																														
Nitroaniline, 2-	mg/kg																														
Nitroaniline, 3-	mg/kg																														
Nitroaniline, 4-	mg/kg																														
Nitrobenzene	mg/kg																														
Nitrophenol, 2-	mg/kg																														
Nitrophenol, 4-	mg/kg																														
n-Nitrosodimethylamine	mg/kg																														
n-Nitroso-di-n-propylamine	mg/kg																														
n-Nitrosodiphenylamine	mg/kg																														
Pentachlorophenol	mg/kg																														
Phenanthrene	mg/kg																														
Phenol	mg/kg																														
Pyrene	mg/kg																														
Trichlorobenzene, 1,2,4-	mg/kg																														
Trichlorophenol, 2,4,5-	mg/kg																														
Trichlorophenol, 2,4,6-	mg/kg																														
WATER QUALITY																															
% Solids	Percent																														
Total organic carbon	mg/kg																														

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTA-SL-TP33					TNTA-SL-TP34					TNTA-SL-TP35					TNTA-SL-TP36					TNTA-SL-TP37				
SAMPLE NO		SL0041					SL0042					SL0043					SL0044					SL0045				
SAMPLE DATE		4-Dec-08					4-Dec-08					4-Dec-08					4-Dec-08					4-Dec-08				
DEPTH		5 - 5_5 Ft					5 - 5_5 Ft					5 - 5_25 Ft					5 - 5_5 Ft					4 - 4_25 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
EXPLOSIVES																										
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.155	0.311	0.155	U	U	0.141	0.282	0.141	U	U	0.155	0.309	0.155	U	U	0.146	0.293	0.146	U	U	0.145	0.29	0.145	U	U
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.155	0.311	0.155	U	U	0.141	0.282	0.141	U	U	0.155	0.309	0.155	U	U	0.146	0.293	0.146	U	U	0.145	0.29	0.145	U	U
Dinitrobenzene, 1,3-	mg/kg	0.155	0.311	0.155	U	U	0.141	0.282	0.141	U	U	0.155	0.309	0.155	U	U	0.146	0.293	0.146	U	U	0.145	0.29	0.145	U	U
Dinitrotoluene, 2,4-	mg/kg	1.76	0.311	0.155			0.141	0.282	0.141	U	U	0.155	0.309	0.155	U	U	0.146	0.293	0.146	U	U	0.145	0.29	0.145	U	U
Dinitrotoluene, 2,6-	mg/kg	0.584	0.311	0.155			0.141	0.282	0.141	U	U	0.155	0.309	0.155	U	U	0.146	0.293	0.146	U	U	0.145	0.29	0.145	U	U
HMX	mg/kg	0.155	0.311	0.155	U	U	0.141	0.282	0.141	U	U	0.155	0.309	0.155	U	U	0.146	0.293	0.146	U	U	0.145	0.29	0.145	U	U
Nitrobenzene	mg/kg	0.155	0.311	0.155	U	U	0.141	0.282	0.141	U	U	0.155	0.309	0.155	U	U	0.146	0.293	0.146	U	U	0.145	0.29	0.145	U	U
Nitrotoluene, 2-	mg/kg	0.155	0.311	0.155	U	U	0.141	0.282	0.141	U	U	0.155	0.309	0.155	U	U	0.146	0.293	0.146	U	U	0.145	0.29	0.145	U	U
Nitrotoluene, 3-	mg/kg	0.155	0.311	0.155	U	U	0.141	0.282	0.141	U	U	0.155	0.309	0.155	U	U	0.146	0.293	0.146	U	U	0.145	0.29	0.145	U	U
Nitrotoluene, 4-	mg/kg	0.155	0.311	0.155	U	U	0.141	0.282	0.141	U	U	0.155	0.309	0.155	U	U	0.146	0.293	0.146	U	U	0.145	0.29	0.145	U	U
RDX	mg/kg	0.155	0.311	0.155	U	U	0.141	0.282	0.141	U	U	0.155	0.309	0.155	U	U	0.146	0.293	0.146	U	U	0.145	0.29	0.145	U	U
Tetryl	mg/kg	0.155	0.311	0.155	U	U	0.141	0.282	0.141	U	U	0.155	0.309	0.155	U	U	0.146	0.293	0.146	U	U	0.145	0.29	0.145	U	U
Trinitrobenzene, 1,3,5-	mg/kg	1.51	0.311	0.155			0.141	0.282	0.141	U	U	0.155	0.309	0.155	U	U	0.146	0.293	0.146	U	U	0.145	0.29	0.145	U	U
Trinitrotoluene, 2,4,6-	mg/kg	1380	155	77.7			0.149	0.282	0.141	J	J	0.155	0.309	0.155	U	U	0.146	0.293	0.146	U	U	1.09	0.29	0.145		
METALS (UNFILTERED)																										
Aluminum	mg/kg																									
Antimony	mg/kg																									
Arsenic	mg/kg																									
Barium	mg/kg																									
Beryllium	mg/kg																									
Cadmium	mg/kg																									
Calcium	mg/kg																									
Chromium	mg/kg																									
Cobalt	mg/kg																									
Copper	mg/kg																									
Iron	mg/kg																									
Lead	mg/kg																									
Magnesium	mg/kg																									
Manganese	mg/kg																									
Mercury	mg/kg																									
Nickel	mg/kg																									
Potassium	mg/kg																									
Selenium	mg/kg																									
Silver	mg/kg																									
Sodium	mg/kg																									
Thallium	mg/kg																									
Vanadium	mg/kg																									
Zinc	mg/kg																									
PESTICIDES/PCBS																										
Aroclor 1016	mg/kg																									
Aroclor 1221	mg/kg																									
Aroclor 1232	mg/kg																									
Aroclor 1242	mg/kg																									
Aroclor 1248	mg/kg																									
Aroclor 1254	mg/kg																									
Aroclor 1260	mg/kg																									
SEMIVOLATILES																										
3-Methylphenol and 4-Methylphenol	mg/kg																									
Acenaphthene	mg/kg																									
Acenaphthylene	mg/kg																									
ACETOPHENONE	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTA-SL-TP33					TNTA-SL-TP34					TNTA-SL-TP35					TNTA-SL-TP36					TNTA-SL-TP37				
SAMPLE NO		SL0041					SL0042					SL0043					SL0044					SL0045				
SAMPLE DATE		4-Dec-08					4-Dec-08					4-Dec-08					4-Dec-08					4-Dec-08				
DEPTH		5 - 5_5 Ft					5 - 5_5 Ft					5 - 5_25 Ft					5 - 5_5 Ft					4 - 4_25 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Anthracene	mg/kg																									
Atrazine	mg/kg																									
Benzaldehyde	mg/kg																									
Benzo(a)anthracene	mg/kg																									
Benzo(a)pyrene	mg/kg																									
Benzo(b)fluoranthene	mg/kg																									
Benzo(ghi)perylene	mg/kg																									
Benzo(k)fluoranthene	mg/kg																									
Benzoic acid	mg/kg																									
Benzyl alcohol	mg/kg																									
BIBENZENE	mg/kg																									
Bis(2-chloroethoxy)methane	mg/kg																									
Bis(2-chloroethyl)ether	mg/kg																									
Bis(2-chloroisopropyl)ether	mg/kg																									
Bis(2-ethylhexyl)phthalate	mg/kg																									
Bromophenyl phenyl ether, 4-	mg/kg																									
Butyl benzyl phthalate	mg/kg																									
Caprolactam	mg/kg																									
Carbazole	mg/kg																									
Chloro-3-methylphenol, 4-	mg/kg																									
Chloroaniline, 4-	mg/kg																									
Chloronaphthalene, 2-	mg/kg																									
Chlorophenol, 2-	mg/kg																									
Chlorophenyl phenyl ether, 4-	mg/kg																									
Chrysene	mg/kg																									
Dibenz(a,h)anthracene	mg/kg																									
Dibenzofuran	mg/kg																									
Dichlorobenzene, 1,2-	mg/kg																									
Dichlorobenzene, 1,3-	mg/kg																									
Dichlorobenzene, 1,4-	mg/kg																									
Dichlorobenzidine, 3,3'-	mg/kg																									
Dichlorophenol, 2,4-	mg/kg																									
Diethyl phthalate	mg/kg																									
Dimethyl phthalate	mg/kg																									
Dimethylphenol, 2,4-	mg/kg																									
Di-n-butyl phthalate	mg/kg																									
Dinitro-2-methylphenol, 4,6-	mg/kg																									
Dinitrophenol, 2,4-	mg/kg																									
Dinitrotoluene, 2,4-	mg/kg																									
Dinitrotoluene, 2,6-	mg/kg																									
Di-n-octyl phthalate	mg/kg																									
DIPHENYLAMINE	mg/kg																									
Fluoranthene	mg/kg																									
Fluorene	mg/kg																									
Hexachlorobenzene	mg/kg																									
Hexachlorobutadiene	mg/kg																									
Hexachlorocyclopentadiene	mg/kg																									
Hexachloroethane	mg/kg																									
Indeno(1,2,3-cd)pyrene	mg/kg																									
Isophorone	mg/kg																									
Methylnaphthalene, 2-	mg/kg																									
Methylphenol, 2-	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTA-SL-TP33					TNTA-SL-TP34					TNTA-SL-TP35					TNTA-SL-TP36					TNTA-SL-TP37				
SAMPLE NO		SL0041					SL0042					SL0043					SL0044					SL0045				
SAMPLE DATE		4-Dec-08					4-Dec-08					4-Dec-08					4-Dec-08					4-Dec-08				
DEPTH		5 - 5_5 Ft					5 - 5_5 Ft					5 - 5_25 Ft					5 - 5_5 Ft					4 - 4_25 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Methylphenol, 4-	mg/kg																									
Naphthalene	mg/kg																									
Nitroaniline, 2-	mg/kg																									
Nitroaniline, 3-	mg/kg																									
Nitroaniline, 4-	mg/kg																									
Nitrobenzene	mg/kg																									
Nitrophenol, 2-	mg/kg																									
Nitrophenol, 4-	mg/kg																									
n-Nitrosodimethylamine	mg/kg																									
n-Nitroso-di-n-propylamine	mg/kg																									
n-Nitrosodiphenylamine	mg/kg																									
Pentachlorophenol	mg/kg																									
Phenanthrene	mg/kg																									
Phenol	mg/kg																									
Pyrene	mg/kg																									
Trichlorobenzene, 1,2,4-	mg/kg																									
Trichlorophenol, 2,4,5-	mg/kg																									
Trichlorophenol, 2,4,6-	mg/kg																									
WATER QUALITY																										
% Solids	Percent																									
Total organic carbon	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-DP01					TNTB-SL-DP01					TNTB-SL-DP01					TNTB-SL-DP02					TNTB-SL-DP02				
SAMPLE NO		DP0100					DP0101					DP0103					DP0104					DP0105				
SAMPLE DATE		20-Aug-09					20-Aug-09					20-Aug-09					20-Aug-09					20-Aug-09				
DEPTH		0 - 1 Ft					0 - 1 Ft					8 - 10 Ft					0 - 1 Ft					8 - 10 Ft				
SAMPLE PURPOSE		REG					FD					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
EXPLOSIVES																										
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.041	0.16	0.041	U	U	0.043	0.17	0.043	U	U	0.042	0.17	0.042	U	U	0.041	0.16	0.041	U	U	0.041	0.16	0.041	U	U
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.09	0.16	0.09	U	U	0.093	0.17	0.093	U	U	0.092	0.17	0.092	U	U	0.089	0.16	0.089	U	U	0.089	0.16	0.089	U	U
Dinitrobenzene, 1,3-	mg/kg	0.044	0.16	0.044	U	U	0.045	0.17	0.045	U	U	0.045	0.17	0.045	U	U	0.043	0.16	0.043	U	U	0.043	0.16	0.043	U	U
Dinitrotoluene, 2,4-	mg/kg	0.049	0.16	0.049	U	U	0.051	0.17	0.051	U	U	0.051	0.17	0.051	U	U	0.049	0.16	0.049	U	U	0.049	0.16	0.049	U	U
Dinitrotoluene, 2,6-	mg/kg	0.044	0.16	0.044	U	U	0.045	0.17	0.045	U	U	0.045	0.17	0.045	U	U	0.043	0.16	0.043	U	U	0.043	0.16	0.043	U	U
HMX	mg/kg	0.071	0.16	0.071	U	U	0.073	0.17	0.073	U	U	0.073	0.17	0.073	U	U	0.07	0.16	0.07	U	U	0.07	0.16	0.07	U	U
Nitrobenzene	mg/kg	0.054	0.16	0.054	U	U	0.056	0.17	0.056	U	U	0.056	0.17	0.056	U	U	0.054	0.16	0.054	U	U	0.054	0.16	0.054	U	U
Nitrotoluene, 2-	mg/kg	0.041	0.16	0.041	U	U	0.043	0.17	0.043	U	U	0.042	0.17	0.042	U	U	0.041	0.16	0.041	U	U	0.041	0.16	0.041	U	U
Nitrotoluene, 3-	mg/kg	0.069	0.16	0.069	U	U	0.071	0.17	0.071	U	U	0.071	0.17	0.071	U	U	0.069	0.16	0.069	U	U	0.068	0.16	0.068	U	U
Nitrotoluene, 4-	mg/kg	0.051	0.16	0.051	U	U	0.053	0.17	0.053	U	U	0.053	0.17	0.053	U	U	0.051	0.16	0.051	U	U	0.05	0.16	0.05	U	U
RDX	mg/kg	0.07	0.16	0.07	U	U	0.072	0.17	0.072	U	U	0.072	0.17	0.072	U	U	0.069	0.16	0.069	U	U	0.069	0.16	0.069	U	U
Tetryl	mg/kg	0.042	0.16	0.042	U	U	0.043	0.17	0.043	U	U	0.043	0.17	0.043	U	U	0.042	0.16	0.042	U	U	0.041	0.16	0.041	U	U
Trinitrobenzene, 1,3,5-	mg/kg	0.041	0.16	0.041	U	U	0.043	0.17	0.043	U	U	0.042	0.17	0.042	U	U	0.041	0.16	0.041	U	U	0.0534	0.16	0.041	J	J
Trinitrotoluene, 2,4,6-	mg/kg	0.041	0.16	0.041	U	U	0.043	0.17	0.043	U	U	0.042	0.17	0.042	U	U	0.041	0.16	0.041	U	U	0.041	0.16	0.041	U	U
METALS (UNFILTERED)																										
Aluminum	mg/kg	5130	11	0.63		J	5780	11	0.6		J	3160	12	0.64		J	5470	11	0.58		J	2130	12	0.63		J
Antimony	mg/kg	0.51	6.9	0.51	U	UJ	0.39	3.3	0.25	B	J	0.39	3.5	0.26	B	J	0.27	3.2	0.24	B	J	0.52	6.9	0.52	U	UJ
Arsenic	mg/kg	3.4	0.92	0.41			2.9	0.44	0.2			3.9	0.47	0.21			5	0.42	0.19			1.1	0.92	0.42		
Barium	mg/kg	22.3	11	0.29		J	24.7	11	0.27		J	13.3	12	0.29		J	29.5	11	0.26		J	7.4	12	0.29	B	J
Beryllium	mg/kg	0.34	0.29	0.057			0.36	0.27	0.054			0.23	0.29	0.059	B	J	0.4	0.26	0.053			0.19	0.29	0.058	B	J
Cadmium	mg/kg	0.057	0.23	0.057	U	UJ	0.054	0.22	0.054	U	UJ	0.059	0.23	0.059	U	UJ	0.265	0.84	0.265	U	UJ	0.058	0.23	0.058	U	UJ
Calcium	mg/kg	38700	570	11		J	5510	270	5.4		J	26200	290	5.9		J	1170	260	5.3		J	35700	580	12		J
Chromium	mg/kg	6.5	1.1	0.184			7.3	1.1	0.174			5.4	1.2	0.188			8.1	1.1	0.168			4.7	1.2	0.184		
Cobalt	mg/kg	2.2	2.9	0.047	B	J	2.3	2.7	0.045	B	J	3.2	2.9	0.049			4.2	2.6	0.044			2.3	2.9	0.048	B	J
Copper	mg/kg	4.5	1.4	0.12			3.9	1.4	0.11			6.3	1.5	0.12			11.3	1.3	0.11			3.8	1.4	0.12		
Iron	mg/kg	7110	5.7	1.3		J	7820	5.4	1.3		J	5950	5.9	1.3		J	12300	5.3	1.2		J	4220	5.8	1.3		J
Lead	mg/kg	6.9	11	0.23	B	J	6.2	5.4	0.11			3.1	5.9	0.12	B	J	7.7	5.3	0.11			2.3	12	0.23	B	J
Magnesium	mg/kg	4980	290	5.7		J	1050	270	5.4		J	7980	290	5.9		J	728	260	5.3		J	8870	290	5.8		J
Manganese	mg/kg	142	0.86	0.029		J	127	0.82	0.027		J	140	0.88	0.029		J	113	0.79	0.026		J	136	0.86	0.029		J
Mercury	mg/kg	0.031	0.091	0.013	B	J	0.02	0.083	0.012	B	J	0.014	0.1	0.014	U	U	0.031	0.081	0.012	B	J	0.014	0.098	0.014	U	U
Nickel	mg/kg	5	2.3	0.13			5.1	2.2	0.13			8.2	2.3	0.13			9.2	2.1	0.12			5.1	2.3	0.13		
Potassium	mg/kg	441	570	5.7	B	J	343	540	5.4	B	J	861	590	5.9		J	420	530	5.3	B	J	523	580	5.8	B	J
Selenium	mg/kg	0.8	11	0.35	B	J	0.46	5.4	0.17	B	J	0.51	5.9	0.18	B	J	0.68	5.3	0.16	B	J	0.67	12	0.36	B	J
Silver	mg/kg	0.069	0.57	0.069	U	U	0.065	0.54	0.065	U	U	0.07	0.59	0.07	U	U	0.063	0.53	0.063	U	U	0.069	0.58	0.069	U	U
Sodium	mg/kg	139	570	29	B	J	162	540	27	B	J	195	590	29	B	J	155	530	26	B	J	254	580	29	B	J
Thallium	mg/kg	0.95	2.3	0.95	U	U	0.19	0.54	0.19	U	U	0.2	0.59	0.2	U	U	0.24	0.53	0.18	B	J	0.8	2.3	0.8	U	U
Vanadium	mg/kg	12.8	2.9	0.038		J	15.4	2.7	0.036		J	10.5	2.9	0.039		J	16.7	2.6	0.035		J	7.9	2.9	0.038		J
Zinc	mg/kg	21.6	1.1	0.22		J	23.1	1.1	0.21		J	20.9	1.2	0.22		J	19	1.1	0.2		J	14.4	1.2	0.22		J
PESTICIDES/PCBS																										
Aroclor 1016	mg/kg	0.0095	0.019	0.0095	U	U	0.0092	0.018	0.0092	U	U	0.01	0.02	0.01	U	U	0.0092	0.018	0.0092	U	U	0.0099	0.02	0.0099	U	U
Aroclor 1221	mg/kg	0.015	0.019	0.015	U	U	0.015	0.018	0.015	U	U	0.016	0.02	0.016	U	U	0.015	0.018	0.015	U	U	0.016	0.02	0.016	U	U
Aroclor 1232	mg/kg	0.015	0.019	0.015	U	U	0.015	0.018	0.015	U	U	0.016	0.02	0.016	U	U	0.015	0.018	0.015	U	U	0.016	0.02	0.016	U	U
Aroclor 1242	mg/kg	0.0095	0.019	0.0095	U	U	0.0092	0.018	0.0092	U	U	0.01	0.02	0.01	U	U	0.0092	0.018	0.0092	U	U	0.0099	0.02	0.0099	U	U
Aroclor 1248	mg/kg	0.0095	0.019	0.0095	U	U	0.0092	0.018	0.0092	U	U	0.01	0.02	0.01	U	U	0.0092	0.018	0.0092	U	U	0.0099	0.02	0.0099	U	U
Aroclor 1254	mg/kg	0.0095	0.019	0.0095	U	U	0.0092	0.018	0.0092	U	U	0.01	0.02	0.01	U	U	0.0092	0.018	0.0092	U	U	0.0099	0.02	0.0099	U	U
Aroclor 1260	mg/kg	0.0295	0.019	0.0095		J	0.0092	0.018	0.0092	U	U	0.01	0.02	0.01	U	U	0.0092	0.018	0.0092	U	U	0.0099	0.02	0.0099	U	U
SEMIVOLATILES																										
3-Methylphenol and 4-Methylphenol	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Acenaphthene	mg/kg	0.12	0.19	0.038	J	J	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Acenaphthylene	mg/kg	0.829	0.19	0.038		J	0.325	0.18	0.037		J	0.0491	0.2	0.04	J	J	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
ACETOPHENONE	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-DP01					TNTB-SL-DP01					TNTB-SL-DP01					TNTB-SL-DP02					TNTB-SL-DP02				
SAMPLE NO		DP0100					DP0101					DP0103					DP0104					DP0105				
SAMPLE DATE		20-Aug-09					20-Aug-09					20-Aug-09					20-Aug-09					20-Aug-09				
DEPTH		0 - 1 Ft					0 - 1 Ft					8 - 10 Ft					0 - 1 Ft					8 - 10 Ft				
SAMPLE PURPOSE		REG					FD					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Anthracene	mg/kg	1.2	0.19	0.038		J	0.227	0.18	0.037		J	0.044	0.2	0.04	J	J	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Atrazine	mg/kg																									
Benzaldehyde	mg/kg																									
Benzo(a)anthracene	mg/kg	2.43	0.19	0.038		J	0.804	0.18	0.037		J	0.151	0.2	0.04	J	J	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Benzo(a)pyrene	mg/kg	1.96	0.19	0.038		J	0.785	0.18	0.037		J	0.13	0.2	0.04	J	J	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Benzo(b)fluoranthene	mg/kg	2.8	0.19	0.038		J	1.09	0.18	0.037		J	0.183	0.2	0.04	J	J	0.0528	0.19	0.037	J	J	0.04	0.2	0.04	U	U
Benzo(ghi)perylene	mg/kg	0.94	0.19	0.038		J	0.357	0.18	0.037		J	0.0568	0.2	0.04	J	J	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Benzo(k)fluoranthene	mg/kg	1.07	0.19	0.038		J	0.383	0.18	0.037		J	0.07	0.2	0.04	J	J	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Benzoic acid	mg/kg	0.38	0.95	0.38	U	U	0.37	0.92	0.37	U	U	0.4	1	0.4	U	U	0.37	0.93	0.37	U	U	0.4	1	0.4	U	U
Benzyl alcohol	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
BIBENZENE	mg/kg																									
Bis(2-chloroethoxy)methane	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Bis(2-chloroethyl)ether	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Bis(2-chloroisopropyl)ether	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Bis(2-ethylhexyl)phthalate	mg/kg	0.19	0.38	0.19	U	U	0.18	0.37	0.18	U	U	0.2	0.4	0.2	U	U	0.19	0.37	0.19	U	U	0.2	0.4	0.2	U	U
Bromophenyl phenyl ether, 4-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Butyl benzyl phthalate	mg/kg	0.076	0.38	0.076	U	U	0.074	0.37	0.074	U	U	0.081	0.4	0.081	U	U	0.074	0.37	0.074	U	U	0.08	0.4	0.08	U	U
Caprolactam	mg/kg																									
Carbazole	mg/kg	0.603	0.19	0.038		J	0.0872	0.18	0.037	J	J	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Chloro-3-methylphenol, 4-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Chloroaniline, 4-	mg/kg	0.076	0.19	0.076	U	U	0.074	0.18	0.074	U	U	0.081	0.2	0.081	U	U	0.074	0.19	0.074	U	U	0.08	0.2	0.08	U	U
Chloronaphthalene, 2-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Chlorophenol, 2-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Chlorophenyl phenyl ether, 4-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Chrysene	mg/kg	2.25	0.19	0.038		J	0.744	0.18	0.037		J	0.132	0.2	0.04	J	J	0.0403	0.19	0.037	J	J	0.04	0.2	0.04	U	U
Dibenz(a,h)anthracene	mg/kg	0.247	0.19	0.038		J	0.0917	0.18	0.037	J	J	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Dibenzofuran	mg/kg	0.376	0.19	0.038		J	0.0407	0.18	0.037	J	J	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Dichlorobenzene, 1,2-	mg/kg	0.049	0.19	0.049	U	U	0.048	0.18	0.048	U	U	0.053	0.2	0.053	U	U	0.048	0.19	0.048	U	U	0.052	0.2	0.052	U	U
Dichlorobenzene, 1,3-	mg/kg	0.049	0.19	0.049	U	U	0.048	0.18	0.048	U	U	0.053	0.2	0.053	U	U	0.048	0.19	0.048	U	U	0.052	0.2	0.052	U	U
Dichlorobenzene, 1,4-	mg/kg	0.046	0.19	0.046	U	U	0.044	0.18	0.044	U	U	0.049	0.2	0.049	U	U	0.044	0.19	0.044	U	U	0.048	0.2	0.048	U	U
Dichlorobenzidine, 3,3'-	mg/kg	0.076	0.38	0.076	U	U	0.074	0.37	0.074	U	U	0.081	0.4	0.081	U	U	0.074	0.37	0.074	U	U	0.08	0.4	0.08	U	U
Dichlorophenol, 2,4-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Diethyl phthalate	mg/kg	0.19	0.38	0.19	U	U	0.18	0.37	0.18	U	U	0.2	0.4	0.2	U	U	0.19	0.37	0.19	U	U	0.2	0.4	0.2	U	U
Dimethyl phthalate	mg/kg	0.076	0.38	0.076	U	U	0.074	0.37	0.074	U	U	0.081	0.4	0.081	U	U	0.074	0.37	0.074	U	U	0.08	0.4	0.08	U	U
Dimethylphenol, 2,4-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Di-n-butyl phthalate	mg/kg	0.076	0.38	0.076	U	U	0.074	0.37	0.074	U	U	0.081	0.4	0.081	U	U	0.074	0.37	0.074	U	U	0.08	0.4	0.08	U	U
Dinitro-2-methylphenol, 4,6-	mg/kg	0.12	0.38	0.12	U	U	0.12	0.37	0.12	U	U	0.13	0.4	0.13	U	U	0.12	0.37	0.12	U	U	0.13	0.4	0.13	U	U
Dinitrophenol, 2,4-	mg/kg	0.38	0.95	0.38	U	U	0.37	0.92	0.37	U	U	0.4	1	0.4	U	U	0.37	0.93	0.37	U	U	0.4	1	0.4	U	U
Dinitrotoluene, 2,4-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Dinitrotoluene, 2,6-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Di-n-octyl phthalate	mg/kg	0.076	0.38	0.076	U	U	0.074	0.37	0.074	U	U	0.081	0.4	0.081	U	U	0.074	0.37	0.074	U	U	0.08	0.4	0.08	U	U
DIPHENYLAMINE	mg/kg																									
Fluoranthene	mg/kg	6.57	0.38	0.076		J	1.76	0.18	0.037		J	0.351	0.2	0.04			0.0763	0.19	0.037	J	J	0.04	0.2	0.04	U	U
Fluorene	mg/kg	0.755	0.19	0.038		J	0.0937	0.18	0.037	J	J	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Hexachlorobenzene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Hexachlorobutadiene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Hexachlorocyclopentadiene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Hexachloroethane	mg/kg	0.046	0.19	0.046	U	U	0.044	0.18	0.044	U	U	0.049	0.2	0.049	U	U	0.044	0.19	0.044	U	U	0.048	0.2	0.048	U	U
Indeno(1,2,3-cd)pyrene	mg/kg	1.12	0.19	0.038		J	0.431	0.18	0.037		J	0.0668	0.2	0.04	J	J	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Isophorone	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Methylnaphthalene, 2-	mg/kg	0.0487	0.19	0.038	J	J	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Methylphenol, 2-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-DP01					TNTB-SL-DP01					TNTB-SL-DP01					TNTB-SL-DP02					TNTB-SL-DP02				
SAMPLE NO		DP0100					DP0101					DP0103					DP0104					DP0105				
SAMPLE DATE		20-Aug-09					20-Aug-09					20-Aug-09					20-Aug-09					20-Aug-09				
DEPTH		0 - 1 Ft					0 - 1 Ft					8 - 10 Ft					0 - 1 Ft					8 - 10 Ft				
SAMPLE PURPOSE		REG					FD					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Methylphenol, 4-	mg/kg																									
Naphthalene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Nitroaniline, 2-	mg/kg	0.076	0.38	0.076	U	U	0.074	0.37	0.074	U	U	0.081	0.4	0.081	U	U	0.074	0.37	0.074	U	U	0.08	0.4	0.08	U	U
Nitroaniline, 3-	mg/kg	0.076	0.38	0.076	U	U	0.074	0.37	0.074	U	U	0.081	0.4	0.081	U	U	0.074	0.37	0.074	U	U	0.08	0.4	0.08	U	U
Nitroaniline, 4-	mg/kg	0.076	0.38	0.076	U	U	0.074	0.37	0.074	U	U	0.081	0.4	0.081	U	U	0.074	0.37	0.074	U	U	0.08	0.4	0.08	U	U
Nitrobenzene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Nitrophenol, 2-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Nitrophenol, 4-	mg/kg	0.38	0.95	0.38	U	U	0.37	0.92	0.37	U	U	0.4	1	0.4	U	U	0.37	0.93	0.37	U	U	0.4	1	0.4	U	U
n-Nitrosodimethylamine	mg/kg																									
n-Nitroso-di-n-propylamine	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
n-Nitrosodiphenylamine	mg/kg	0.076	0.19	0.076	U	U	0.074	0.18	0.074	U	U	0.081	0.2	0.081	U	U	0.074	0.19	0.074	U	U	0.08	0.2	0.08	U	U
Pentachlorophenol	mg/kg	0.38	0.95	0.38	U	U	0.37	0.92	0.37	U	U	0.4	1	0.4	U	U	0.37	0.93	0.37	U	U	0.4	1	0.4	U	U
Phenanthrene	mg/kg	5.62	0.38	0.076		J	0.833	0.18	0.037		J	0.105	0.2	0.04	J	J	0.0504	0.19	0.037	J	J	0.04	0.2	0.04	U	U
Phenol	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Pyrene	mg/kg	4.35	0.19	0.038		J	1.33	0.18	0.037		J	0.257	0.2	0.04			0.0569	0.19	0.037	J	J	0.04	0.2	0.04	U	U
Trichlorobenzene, 1,2,4-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Trichlorophenol, 2,4,5-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
Trichlorophenol, 2,4,6-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.18	0.037	U	U	0.04	0.2	0.04	U	U	0.037	0.19	0.037	U	U	0.04	0.2	0.04	U	U
WATER QUALITY																										
% Solids	Percent	87.4	0				89.1	0				82.9	0				90.6	0				82.6	0			
Total organic carbon	mg/kg	0.29	0.4	0.4	B	J																				

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-DP03					TNTB-SL-DP03					TNTB-SL-DP04					TNTB-SL-DP04					TNTB-SL-DP05				
SAMPLE NO		DP0106					DP0107					DP0108					DP0109					DP0110				
SAMPLE DATE		21-Aug-09					21-Aug-09					24-Aug-09					24-Aug-09					24-Aug-09				
DEPTH		0 - 1 Ft					8 - 10 Ft					0 - 1 Ft					8 - 10 Ft					0 - 1 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
EXPLOSIVES																										
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.04	0.16	0.04	U	U	0.104	0.17	0.043	J	J	0.048	0.19	0.048	U	U	0.047	0.19	0.047	U	U	0.042	0.17	0.042	U	U
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.087	0.16	0.087	U	U	0.145	0.17	0.095	J	J	0.1	0.19	0.1	U	U	0.1	0.19	0.1	U	U	0.091	0.17	0.091	U	U
Dinitrobenzene, 1,3-	mg/kg	0.042	0.16	0.042	U	U	0.046	0.17	0.046	U	U	0.05	0.19	0.05	U	U	0.049	0.19	0.049	U	U	0.044	0.17	0.044	U	U
Dinitrotoluene, 2,4-	mg/kg	0.048	0.16	0.048	U	U	0.052	0.17	0.052	U	U	0.057	0.19	0.057	U	U	0.056	0.19	0.056	U	U	0.05	0.17	0.05	U	U
Dinitrotoluene, 2,6-	mg/kg	0.042	0.16	0.042	U	U	0.046	0.17	0.046	U	U	0.05	0.19	0.05	U	U	0.049	0.19	0.049	U	U	0.044	0.17	0.044	U	U
HMX	mg/kg	0.069	0.16	0.069	U	U	0.075	0.17	0.075	U	U	0.082	0.19	0.082	U	U	0.08	0.19	0.08	U	U	0.072	0.17	0.072	U	U
Nitrobenzene	mg/kg	0.053	0.16	0.053	U	U	0.057	0.17	0.057	U	U	0.063	0.19	0.063	U	U	0.061	0.19	0.061	U	U	0.055	0.17	0.055	U	U
Nitrotoluene, 2-	mg/kg	0.04	0.16	0.04	U	U	0.043	0.17	0.043	U	U	0.048	0.19	0.048	U	U	0.047	0.19	0.047	U	U	0.042	0.17	0.042	U	U
Nitrotoluene, 3-	mg/kg	0.067	0.16	0.067	U	U	0.073	0.17	0.073	U	U	0.08	0.19	0.08	U	U	0.078	0.19	0.078	U	U	0.07	0.17	0.07	U	U
Nitrotoluene, 4-	mg/kg	0.05	0.16	0.05	U	U	0.054	0.17	0.054	U	U	0.059	0.19	0.059	U	U	0.058	0.19	0.058	U	U	0.052	0.17	0.052	U	U
RDX	mg/kg	0.068	0.16	0.068	U	U	0.074	0.17	0.074	U	U	0.081	0.19	0.081	U	U	0.079	0.19	0.079	U	U	0.071	0.17	0.071	U	U
Tetryl	mg/kg	0.041	0.16	0.041	U	U	0.044	0.17	0.044	U	U	0.049	0.19	0.049	U	U	0.047	0.19	0.047	U	U	0.043	0.17	0.043	U	U
Trinitrobenzene, 1,3,5-	mg/kg	0.04	0.16	0.04	U	U	0.043	0.17	0.043	U	U	0.048	0.19	0.048	U	U	0.047	0.19	0.047	U	U	0.042	0.17	0.042	U	U
Trinitrotoluene, 2,4,6-	mg/kg	0.04	0.16	0.04	U	U	0.192	0.17	0.043			0.048	0.19	0.048	U	U	0.047	0.19	0.047	U	U	0.042	0.17	0.042	U	U
METALS (UNFILTERED)																										
Aluminum	mg/kg	3880	45	2.4		J	3210	13	0.69		J	6370	12	0.64		J	8570	10	0.57		J	4910	9.8	0.54		J
Antimony	mg/kg	1	13	1	U	UJ	0.56	7.5	0.56	U	UJ	0.37	3.5	0.26	B	J	0.51	3.1	0.23	B	J	0.22	2.9	0.22	U	UJ
Arsenic	mg/kg	3.7	1.8	0.8			3.9	1	0.45			3.7	0.46	0.21		J	11.8	0.42	0.19		J	3	0.39	0.18		J
Barium	mg/kg	11.1	45	1.1	B	J	16	13	0.31		J	39	12	0.29		J	23.7	10	0.26		J	26.2	9.8	0.25		J
Beryllium	mg/kg	0.47	1.1	0.22	B	J	0.24	0.31	0.063	B	J	0.68	0.29	0.058			0.51	0.26	0.052			0.49	0.25	0.049		
Cadmium	mg/kg	0.22	0.89	0.22	U	UJ	0.063	0.25	0.063	U	UJ	0.16	0.23	0.058	B	J	0.24	0.21	0.052		J	0.17	0.2	0.049	B	J
Calcium	mg/kg	2050	1100	22		J	47200	630	13		J	3610	290	5.8		J	25300	260	5.2		J	3720	250	4.9		J
Chromium	mg/kg	6.2	2.2	0.36			5.6	1.3	0.2			10.2	0.58	0.092		J	13.8	0.52	0.083		J	8.5	0.49	0.079		J
Cobalt	mg/kg	4.1	11	0.18	B	J	3	3.1	0.052	B	J	5.8	2.9	0.048		J	13.1	2.6	0.043		J	4.8	2.5	0.041		J
Copper	mg/kg	4.3	5.6	0.47	B	J	6.1	1.6	0.13			9.6	1.4	0.12		J	30.2	1.3	0.11		J	8.2	1.2	0.1		J
Iron	mg/kg	10900	22	5.1		J	6720	6.3	1.4		J	11200	5.8	1.3		J	23300	5.2	1.2		J	9890	4.9	1.1		J
Lead	mg/kg	4.3	22	0.45	B	J	3.9	13	0.25	B	J	9.8	5.8	0.12		J	17.7	5.2	0.1		J	7.6	4.9	0.098		J
Magnesium	mg/kg	832	1100	22	B	J	13300	310	6.3		J	1160	290	5.8		J	8200	260	5.2		J	1050	250	4.9		J
Manganese	mg/kg	206	3.3	0.11		J	172	0.94	0.031		J	130	0.87	0.029		J	371	3.1	0.1		J	102	0.74	0.025		J
Mercury	mg/kg	0.022	0.09	0.013	B	J	0.015	0.11	0.015	U	U	0.035	0.097	0.014	B	J	0.013	0.091	0.013	U	U	0.037	0.086	0.012	B	J
Nickel	mg/kg	7.6	8.9	0.51	B	J	7.7	2.5	0.14			16.2	2.3	0.13		J	34.4	2.1	0.12		J	9.9	2	0.11		J
Potassium	mg/kg	382	2200	22	B	J	999	630	6.3		J	549	580	5.8	B	J	1790	520	5.2		J	421	490	4.9	B	J
Selenium	mg/kg	0.69	22	0.69	U	U	0.59	13	0.39	B	J	0.39	5.8	0.18	B	J	0.16	5.2	0.16	U	UJ	0.28	4.9	0.15	B	J
Silver	mg/kg	0.27	2.2	0.27	U	U	0.075	0.63	0.075	U	U	0.069	0.58	0.069	U	UJ	0.063	0.52	0.063	U	UJ	0.059	0.49	0.059	U	UJ
Sodium	mg/kg	110	2200	110	U	U	227	630	31	B	J	29	580	29	U	U	125	520	26	B	J	25	490	25	U	U
Thallium	mg/kg	0.76	2.2	0.76	U	U	0.21	0.63	0.21	U	U	0.2	0.58	0.2	U	UJ	0.42	0.52	0.18	B	J	0.85	2	0.85	U	UJ
Vanadium	mg/kg	19.1	11	0.15		J	10.1	3.1	0.041		J	16.4	2.9	0.038		J	14.1	2.6	0.034		J	15.4	2.5	0.032		J
Zinc	mg/kg	20.3	4.5	0.85		J	21.5	1.3	0.24		J	40.2	1.2	0.22		J	65.2	1	0.2		J	38.2	0.98	0.19		J
PESTICIDES/PCBS																										
Aroclor 1016	mg/kg	0.0093	0.019	0.0093	U	U	0.01	0.021	0.01	U	U	0.01	0.02	0.01	U	U	0.0097	0.019	0.0097	U	U	0.0099	0.02	0.0099	U	U
Aroclor 1221	mg/kg	0.015	0.019	0.015	U	U	0.017	0.021	0.017	U	U	0.016	0.02	0.016	U	U	0.015	0.019	0.015	U	U	0.016	0.02	0.016	U	U
Aroclor 1232	mg/kg	0.015	0.019	0.015	U	U	0.017	0.021	0.017	U	U	0.016	0.02	0.016	U	U	0.015	0.019	0.015	U	U	0.016	0.02	0.016	U	U
Aroclor 1242	mg/kg	0.0093	0.019	0.0093	U	U	0.01	0.021	0.01	U	U	0.01	0.02	0.01	U	U	0.0097	0.019	0.0097	U	U	0.0099	0.02	0.0099	U	U
Aroclor 1248	mg/kg	0.0093	0.019	0.0093	U	U	0.01	0.021	0.01	U	U	0.01	0.02	0.01	U	U	0.0097	0.019	0.0097	U	U	0.0099	0.02	0.0099	U	U
Aroclor 1254	mg/kg	0.0093	0.019	0.0093	U	U	0.01	0.021	0.01	U	U	0.01	0.02	0.01	U	U	0.0097	0.019	0.0097	U	U	0.0099	0.02	0.0099	U	U
Aroclor 1260	mg/kg	0.0093	0.019	0.0093	U	U	0.01	0.021	0.01	U	U	0.01	0.02	0.01	U	U	0.0097	0.019	0.0097	U	U	0.0099	0.02	0.0099	U	U
SEMIVOLATILES																										
3-Methylphenol and 4-Methylphenol	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Acenaphthene	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Acenaphthylene	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
ACETOPHENONE	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-DP03					TNTB-SL-DP03					TNTB-SL-DP04					TNTB-SL-DP04					TNTB-SL-DP05				
SAMPLE NO		DP0106					DP0107					DP0108					DP0109					DP0110				
SAMPLE DATE		21-Aug-09					21-Aug-09					24-Aug-09					24-Aug-09					24-Aug-09				
DEPTH		0 - 1 Ft					8 - 10 Ft					0 - 1 Ft					8 - 10 Ft					0 - 1 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Anthracene	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Atrazine	mg/kg																									
Benzaldehyde	mg/kg																									
Benzo(a)anthracene	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Benzo(a)pyrene	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Benzo(b)fluoranthene	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Benzo(ghi)perylene	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Benzo(k)fluoranthene	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Benzoic acid	mg/kg	0.37	0.93	0.37	U	U	0.42	1.1	0.42	U	U	0.4	0.99	0.4	U	U	0.39	0.97	0.39	U	U	0.39	0.97	0.39	U	U
Benzyl alcohol	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
BIBENZENE	mg/kg																									
Bis(2-chloroethoxy)methane	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Bis(2-chloroethyl)ether	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Bis(2-chloroisopropyl)ether	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Bis(2-ethylhexyl)phthalate	mg/kg	0.19	0.37	0.19	U	U	0.21	0.42	0.21	U	U	0.2	0.4	0.2	U	U	0.19	0.39	0.19	U	U	0.19	0.39	0.19	U	U
Bromophenyl phenyl ether, 4-	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Butyl benzyl phthalate	mg/kg	0.074	0.37	0.074	U	U	0.085	0.42	0.085	U	U	0.079	0.4	0.079	U	U	0.077	0.39	0.077	U	U	0.078	0.39	0.078	U	U
Caprolactam	mg/kg																									
Carbazole	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Chloro-3-methylphenol, 4-	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Chloroaniline, 4-	mg/kg	0.074	0.19	0.074	U	U	0.085	0.21	0.085	U	U	0.079	0.2	0.079	U	U	0.077	0.19	0.077	U	U	0.078	0.19	0.078	U	U
Chloronaphthalene, 2-	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Chlorophenol, 2-	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Chlorophenyl phenyl ether, 4-	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Chrysene	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Dibenz(a,h)anthracene	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Dibenzofuran	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Dichlorobenzene, 1,2-	mg/kg	0.048	0.19	0.048	U	U	0.055	0.21	0.055	U	U	0.052	0.2	0.052	U	U	0.05	0.19	0.05	U	U	0.051	0.19	0.051	U	U
Dichlorobenzene, 1,3-	mg/kg	0.048	0.19	0.048	U	U	0.055	0.21	0.055	U	U	0.052	0.2	0.052	U	U	0.05	0.19	0.05	U	U	0.051	0.19	0.051	U	U
Dichlorobenzene, 1,4-	mg/kg	0.045	0.19	0.045	U	U	0.051	0.21	0.051	U	U	0.048	0.2	0.048	U	U	0.046	0.19	0.046	U	U	0.047	0.19	0.047	U	U
Dichlorobenzidine, 3,3'-	mg/kg	0.074	0.37	0.074	U	U	0.085	0.42	0.085	U	U	0.079	0.4	0.079	U	U	0.077	0.39	0.077	U	U	0.078	0.39	0.078	U	U
Dichlorophenol, 2,4-	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Diethyl phthalate	mg/kg	0.19	0.37	0.19	U	U	0.21	0.42	0.21	U	U	0.2	0.4	0.2	U	U	0.19	0.39	0.19	U	U	0.19	0.39	0.19	U	U
Dimethyl phthalate	mg/kg	0.074	0.37	0.074	U	U	0.085	0.42	0.085	U	U	0.079	0.4	0.079	U	U	0.077	0.39	0.077	U	U	0.078	0.39	0.078	U	U
Dimethylphenol, 2,4-	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Di-n-butyl phthalate	mg/kg	0.074	0.37	0.074	U	U	0.085	0.42	0.085	U	U	0.15	0.4	0.079	J	J	0.077	0.39	0.077	U	U	0.078	0.39	0.078	U	U
Dinitro-2-methylphenol, 4,6-	mg/kg	0.12	0.37	0.12	U	U	0.14	0.42	0.14	U	U	0.13	0.4	0.13	U	U	0.12	0.39	0.12	U	U	0.12	0.39	0.12	U	U
Dinitrophenol, 2,4-	mg/kg	0.37	0.93	0.37	U	U	0.42	1.1	0.42	U	U	0.4	0.99	0.4	U	U	0.39	0.97	0.39	U	U	0.39	0.97	0.39	U	U
Dinitrotoluene, 2,4-	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Dinitrotoluene, 2,6-	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Di-n-octyl phthalate	mg/kg	0.074	0.37	0.074	U	U	0.085	0.42	0.085	U	U	0.079	0.4	0.079	U	U	0.077	0.39	0.077	U	U	0.078	0.39	0.078	U	U
DIPHENYLAMINE	mg/kg																									
Fluoranthene	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.044	0.19	0.039	J	J
Fluorene	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Hexachlorobenzene	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Hexachlorobutadiene	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Hexachlorocyclopentadiene	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Hexachloroethane	mg/kg	0.045	0.19	0.045	U	U	0.051	0.21	0.051	U	U	0.048	0.2	0.048	U	U	0.046	0.19	0.046	U	U	0.047	0.19	0.047	U	U
Indeno(1,2,3-cd)pyrene	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Isophorone	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Methylnaphthalene, 2-	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Methylphenol, 2-	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-DP03					TNTB-SL-DP03					TNTB-SL-DP04					TNTB-SL-DP04					TNTB-SL-DP05				
SAMPLE NO		DP0106					DP0107					DP0108					DP0109					DP0110				
SAMPLE DATE		21-Aug-09					21-Aug-09					24-Aug-09					24-Aug-09					24-Aug-09				
DEPTH		0 - 1 Ft					8 - 10 Ft					0 - 1 Ft					8 - 10 Ft					0 - 1 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Methylphenol, 4-	mg/kg																									
Naphthalene	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Nitroaniline, 2-	mg/kg	0.074	0.37	0.074	U	U	0.085	0.42	0.085	U	U	0.079	0.4	0.079	U	U	0.077	0.39	0.077	U	U	0.078	0.39	0.078	U	U
Nitroaniline, 3-	mg/kg	0.074	0.37	0.074	U	U	0.085	0.42	0.085	U	U	0.079	0.4	0.079	U	U	0.077	0.39	0.077	U	U	0.078	0.39	0.078	U	U
Nitroaniline, 4-	mg/kg	0.074	0.37	0.074	U	U	0.085	0.42	0.085	U	U	0.079	0.4	0.079	U	U	0.077	0.39	0.077	U	U	0.078	0.39	0.078	U	U
Nitrobenzene	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Nitrophenol, 2-	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Nitrophenol, 4-	mg/kg	0.37	0.93	0.37	U	U	0.42	1.1	0.42	U	U	0.4	0.99	0.4	U	U	0.39	0.97	0.39	U	U	0.39	0.97	0.39	U	U
n-Nitrosodimethylamine	mg/kg																									
n-Nitroso-di-n-propylamine	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
n-Nitrosodiphenylamine	mg/kg	0.074	0.19	0.074	U	U	0.085	0.21	0.085	U	U	0.079	0.2	0.079	U	U	0.077	0.19	0.077	U	U	0.078	0.19	0.078	U	U
Pentachlorophenol	mg/kg	0.37	0.93	0.37	U	U	0.42	1.1	0.42	U	U	0.4	0.99	0.4	U	U	0.39	0.97	0.39	U	U	0.39	0.97	0.39	U	U
Phenanthrene	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Phenol	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Pyrene	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Trichlorobenzene, 1,2,4-	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Trichlorophenol, 2,4,5-	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
Trichlorophenol, 2,4,6-	mg/kg	0.037	0.19	0.037	U	U	0.042	0.21	0.042	U	U	0.04	0.2	0.04	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U
WATER QUALITY																										
% Solids	Percent	89.8	0				78.9	0				84.9	0				87.1	0				85.6	0			
Total organic carbon	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-DP05					TNTB-SL-DP06					TNTB-SL-DP06					TNTB-SL-DP06					TNTB-SL-DP07				
SAMPLE NO		DP0111					DP0112					DP0113					DP0115					DP0116				
SAMPLE DATE		24-Aug-09					24-Aug-09					24-Aug-09					24-Aug-09					24-Aug-09				
DEPTH		8 - 10 Ft					0 - 1 Ft					0 - 1 Ft					9 - 10 Ft					0 - 1 Ft				
SAMPLE PURPOSE		REG					REG					FD					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
EXPLOSIVES																										
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.038	0.15	0.038	U	U	0.045	0.18	0.045	U	U	0.039	0.16	0.039	U	U	0.038	0.15	0.038	U	U	0.043	0.17	0.043	U	U
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.083	0.15	0.083	U	U	0.098	0.18	0.098	U	U	0.085	0.16	0.085	U	U	0.083	0.15	0.083	U	U	0.094	0.17	0.094	U	U
Dinitrobenzene, 1,3-	mg/kg	0.04	0.15	0.04	U	U	0.048	0.18	0.048	U	U	0.042	0.16	0.042	U	U	0.04	0.15	0.04	U	U	0.045	0.17	0.045	U	U
Dinitrotoluene, 2,4-	mg/kg	0.046	0.15	0.046	U	U	0.054	0.18	0.054	U	U	0.047	0.16	0.047	U	U	0.045	0.15	0.045	U	U	0.052	0.17	0.052	U	U
Dinitrotoluene, 2,6-	mg/kg	0.04	0.15	0.04	U	U	0.048	0.18	0.048	U	U	0.042	0.16	0.042	U	U	0.04	0.15	0.04	U	U	0.045	0.17	0.045	U	U
HMX	mg/kg	0.066	0.15	0.066	U	U	0.077	0.18	0.077	U	U	0.067	0.16	0.067	U	U	0.065	0.15	0.065	U	U	0.074	0.17	0.074	U	U
Nitrobenzene	mg/kg	0.05	0.15	0.05	U	U	0.059	0.18	0.059	U	U	0.052	0.16	0.052	U	U	0.05	0.15	0.05	U	U	0.057	0.17	0.057	U	U
Nitrotoluene, 2-	mg/kg	0.038	0.15	0.038	U	U	0.045	0.18	0.045	U	U	0.039	0.16	0.039	U	U	0.038	0.15	0.038	U	U	0.043	0.17	0.043	U	U
Nitrotoluene, 3-	mg/kg	0.064	0.15	0.064	U	U	0.076	0.18	0.076	U	U	0.066	0.16	0.066	U	U	0.064	0.15	0.064	U	U	0.072	0.17	0.072	U	U
Nitrotoluene, 4-	mg/kg	0.047	0.15	0.047	U	U	0.056	0.18	0.056	U	U	0.049	0.16	0.049	U	U	0.047	0.15	0.047	U	U	0.053	0.17	0.053	U	U
RDX	mg/kg	0.065	0.15	0.065	U	U	0.077	0.18	0.077	U	U	0.067	0.16	0.067	U	U	0.064	0.15	0.064	U	U	0.073	0.17	0.073	U	U
Tetryl	mg/kg	0.039	0.15	0.039	U	U	0.046	0.18	0.046	U	U	0.04	0.16	0.04	U	U	0.039	0.15	0.039	U	U	0.044	0.17	0.044	U	U
Trinitrobenzene, 1,3,5-	mg/kg	0.038	0.15	0.038	U	U	0.045	0.18	0.045	U	U	0.039	0.16	0.039	U	U	0.038	0.15	0.038	U	U	0.043	0.17	0.043	U	U
Trinitrotoluene, 2,4,6-	mg/kg	0.038	0.15	0.038	U	U	0.045	0.18	0.045	U	U	0.039	0.16	0.039	U	U	0.038	0.15	0.038	U	U	0.043	0.17	0.043	U	U
METALS (UNFILTERED)																										
Aluminum	mg/kg	7820	9.3	0.51		J	4390	10	0.57		J	4610	11	0.62		J	2090	12	0.63		J	3260	10	0.57		J
Antimony	mg/kg	0.59	5.6	0.42	B	J	0.23	3.1	0.23	U	UJ	0.25	3.4	0.25	U	UJ	0.52	6.9	0.52	U	UJ	0.23	3.1	0.23	U	UJ
Arsenic	mg/kg	12	0.74	0.34		J	2.9	0.42	0.19		J	3	0.45	0.2		J	3.3	0.92	0.42		J	2.3	0.42	0.19		J
Barium	mg/kg	31.3	9.3	0.23		J	16.7	10	0.26		J	17.1	11	0.28		J	6.3	12	0.29	B	J	28.5	10	0.26		J
Beryllium	mg/kg	0.48	0.23	0.047			0.29	0.26	0.052			0.3	0.28	0.056			0.18	0.29	0.058	B	J	0.33	0.26	0.052		
Cadmium	mg/kg	0.19	0.19	0.047		J	0.18	0.21	0.052	B	J	0.19	0.22	0.056	B	J	0.085	0.23	0.058	B	J	0.11	0.21	0.052	B	J
Calcium	mg/kg	45100	470	9.3		J	1680	260	5.2		J	1580	280	5.6		J	43200	580	12		J	1930	260	5.2		J
Chromium	mg/kg	13.1	0.47	0.074		J	6.4	0.52	0.083		J	6.7	0.56	0.09		J	4.4	0.58	0.092		J	4.4	0.52	0.083		J
Cobalt	mg/kg	11.5	2.3	0.039		J	2.8	2.6	0.043		J	3	2.8	0.047		J	3.3	2.9	0.048		J	3	2.6	0.043		J
Copper	mg/kg	21	1.2	0.098		J	4.2	1.3	0.11		J	4.2	1.4	0.12		J	4.5	1.4	0.12		J	5.1	1.3	0.11		J
Iron	mg/kg	22300	4.7	1.1		J	7900	5.2	1.2		J	8290	5.6	1.3		J	4590	5.8	1.3		J	9040	5.2	1.2		J
Lead	mg/kg	11.6	9.3	0.19		J	12.2	5.2	0.1		J	12	5.6	0.11		J	3.2	12	0.23	B	J	7.2	5.2	0.1		J
Magnesium	mg/kg	7800	230	4.7		J	683	260	5.2		J	708	280	5.6		J	8240	290	5.8		J	831	260	5.2		J
Manganese	mg/kg	458	2.8	0.093		J	140	0.78	0.026		J	141	0.84	0.028		J	139	0.86	0.029		J	673	3.9	0.13		J
Mercury	mg/kg	0.013	0.091	0.013	U	U	0.038	0.095	0.014	B	J	0.046	0.093	0.013	B	J	0.013	0.093	0.013	U	U	0.018	0.078	0.011	B	J
Nickel	mg/kg	29	1.9	0.11		J	5.5	2.1	0.12		J	5.7	2.2	0.13		J	7.5	2.3	0.13		J	8.5	2.1	0.12		J
Potassium	mg/kg	1980	470	4.7		J	347	520	5.2	B	J	354	560	5.6	B	J	678	580	5.8		J	242	520	5.2	B	J
Selenium	mg/kg	0.29	9.3	0.29	U	UJ	0.16	5.2	0.16	U	UJ	0.35	5.6	0.17	B	J	0.36	12	0.36	U	UJ	0.16	5.2	0.16	U	UJ
Silver	mg/kg	0.056	0.47	0.056	U	UJ	0.063	0.52	0.063	U	UJ	0.067	0.56	0.067	U	UJ	0.069	0.58	0.069	U	UJ	0.062	0.52	0.062	U	UJ
Sodium	mg/kg	166	470	23	B	J	26	520	26	U	U	28	560	28	U	U	119	580	29	B	J	26	520	26	U	U
Thallium	mg/kg	0.51	0.47	0.16		J	3.6	5.2	3.6	U	UJ	3.8	5.6	3.8	U	UJ	2	5.8	2	U	UJ	0.9	2.1	0.9	U	UJ
Vanadium	mg/kg	12.3	2.3	0.031		J	12.9	2.6	0.034		J	13.8	2.8	0.037		J	6.4	2.9	0.038		J	7.8	2.6	0.034		J
Zinc	mg/kg	45.5	0.93	0.18		J	58.8	1	0.2		J	62.9	1.1	0.21		J	17.1	1.2	0.22		J	30.5	1	0.2		J
PESTICIDES/PCBS																										
Aroclor 1016	mg/kg	0.0094	0.019	0.0094	U	U	0.0094	0.019	0.0094	U	U	0.0094	0.019	0.0094	U	U	0.01	0.021	0.01	U	U	0.009	0.018	0.009	U	U
Aroclor 1221	mg/kg	0.015	0.019	0.015	U	U	0.015	0.019	0.015	U	U	0.015	0.019	0.015	U	U	0.017	0.021	0.017	U	U	0.014	0.018	0.014	U	U
Aroclor 1232	mg/kg	0.015	0.019	0.015	U	U	0.015	0.019	0.015	U	U	0.015	0.019	0.015	U	U	0.017	0.021	0.017	U	U	0.014	0.018	0.014	U	U
Aroclor 1242	mg/kg	0.0094	0.019	0.0094	U	U	0.0094	0.019	0.0094	U	U	0.0094	0.019	0.0094	U	U	0.01	0.021	0.01	U	U	0.009	0.018	0.009	U	U
Aroclor 1248	mg/kg	0.0094	0.019	0.0094	U	U	0.0094	0.019	0.0094	U	U	0.0094	0.019	0.0094	U	U	0.01	0.021	0.01	U	U	0.009	0.018	0.009	U	U
Aroclor 1254	mg/kg	0.0094	0.019	0.0094	U	U	0.0094	0.019	0.0094	U	U	0.0094	0.019	0.0094	U	U	0.01	0.021	0.01	U	U	0.009	0.018	0.009	U	U
Aroclor 1260	mg/kg	0.0094	0.019	0.0094	U	U	0.0094	0.019	0.0094	U	U	0.0094	0.019	0.0094	U	U	0.01	0.021	0.01	U	U	0.009	0.018	0.009	U	U
SEMIVOLATILES																										
3-Methylphenol and 4-Methylphenol	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Acenaphthene	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Acenaphthylene	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
ACETOPHENONE	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-DP05					TNTB-SL-DP06					TNTB-SL-DP06					TNTB-SL-DP06					TNTB-SL-DP07				
SAMPLE NO		DP0111					DP0112					DP0113					DP0115					DP0116				
SAMPLE DATE		24-Aug-09					24-Aug-09					24-Aug-09					24-Aug-09					24-Aug-09				
DEPTH		8 - 10 Ft					0 - 1 Ft					0 - 1 Ft					9 - 10 Ft					0 - 1 Ft				
SAMPLE PURPOSE		REG					REG					FD					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Anthracene	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Atrazine	mg/kg																									
Benzaldehyde	mg/kg																									
Benzo(a)anthracene	mg/kg	0.037	0.18	0.037	U	U	0.0534	0.19	0.038	J	J	0.041	0.19	0.038	J	J	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Benzo(a)pyrene	mg/kg	0.037	0.18	0.037	U	U	0.0524	0.19	0.038	J	J	0.0428	0.19	0.038	J	J	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Benzo(b)fluoranthene	mg/kg	0.037	0.18	0.037	U	U	0.0739	0.19	0.038	J	J	0.0622	0.19	0.038	J	J	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Benzo(ghi)perylene	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Benzo(k)fluoranthene	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Benzoic acid	mg/kg	0.37	0.92	0.37	U	U	0.38	0.94	0.38	U	U	0.38	0.96	0.38	U	U	0.42	1	0.42	U	UJ	0.36	0.9	0.36	U	U
Benzyl alcohol	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
BIBENZENE	mg/kg																									
Bis(2-chloroethoxy)methane	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Bis(2-chloroethyl)ether	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Bis(2-chloroisopropyl)ether	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Bis(2-ethylhexyl)phthalate	mg/kg	0.18	0.37	0.18	U	U	0.19	0.38	0.19	U	U	0.19	0.38	0.19	U	U	0.21	0.42	0.21	U	U	0.18	0.36	0.18	U	U
Bromophenyl phenyl ether, 4-	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Butyl benzyl phthalate	mg/kg	0.074	0.37	0.074	U	U	0.076	0.38	0.076	U	U	0.077	0.38	0.077	U	U	0.083	0.42	0.083	U	U	0.072	0.36	0.072	U	U
Caprolactam	mg/kg																									
Carbazole	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Chloro-3-methylphenol, 4-	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Chloroaniline, 4-	mg/kg	0.074	0.18	0.074	U	U	0.076	0.19	0.076	U	U	0.077	0.19	0.077	U	U	0.083	0.21	0.083	U	U	0.072	0.18	0.072	U	U
Chloronaphthalene, 2-	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Chlorophenol, 2-	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Chlorophenyl phenyl ether, 4-	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Chrysene	mg/kg	0.037	0.18	0.037	U	U	0.0568	0.19	0.038	J	J	0.0407	0.19	0.038	J	J	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Dibenz(a,h)anthracene	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Dibenzofuran	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Dichlorobenzene, 1,2-	mg/kg	0.048	0.18	0.048	U	U	0.049	0.19	0.049	U	U	0.05	0.19	0.05	U	U	0.054	0.21	0.054	U	U	0.047	0.18	0.047	U	U
Dichlorobenzene, 1,3-	mg/kg	0.048	0.18	0.048	U	U	0.049	0.19	0.049	U	U	0.05	0.19	0.05	U	U	0.054	0.21	0.054	U	U	0.047	0.18	0.047	U	U
Dichlorobenzene, 1,4-	mg/kg	0.044	0.18	0.044	U	U	0.045	0.19	0.045	U	U	0.046	0.19	0.046	U	U	0.05	0.21	0.05	U	U	0.043	0.18	0.043	U	U
Dichlorobenzidine, 3,3'-	mg/kg	0.074	0.37	0.074	U	U	0.076	0.38	0.076	U	U	0.077	0.38	0.077	U	U	0.083	0.42	0.083	U	U	0.072	0.36	0.072	U	U
Dichlorophenol, 2,4-	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Diethyl phthalate	mg/kg	0.18	0.37	0.18	U	U	0.19	0.38	0.19	U	U	0.19	0.38	0.19	U	U	0.21	0.42	0.21	U	U	0.18	0.36	0.18	U	U
Dimethyl phthalate	mg/kg	0.074	0.37	0.074	U	U	0.076	0.38	0.076	U	U	0.077	0.38	0.077	U	U	0.083	0.42	0.083	U	U	0.072	0.36	0.072	U	U
Dimethylphenol, 2,4-	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Di-n-butyl phthalate	mg/kg	0.074	0.37	0.074	U	U	0.076	0.38	0.076	U	U	0.077	0.38	0.077	U	U	0.083	0.42	0.083	U	U	0.072	0.36	0.072	U	U
Dinitro-2-methylphenol, 4,6-	mg/kg	0.12	0.37	0.12	U	U	0.12	0.38	0.12	U	U	0.12	0.38	0.12	U	U	0.13	0.42	0.13	U	UJ	0.12	0.36	0.12	U	U
Dinitrophenol, 2,4-	mg/kg	0.37	0.92	0.37	U	U	0.38	0.94	0.38	U	U	0.38	0.96	0.38	U	U	0.42	1	0.42	U	UJ	0.36	0.9	0.36	U	U
Dinitrotoluene, 2,4-	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Dinitrotoluene, 2,6-	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Di-n-octyl phthalate	mg/kg	0.074	0.37	0.074	U	U	0.076	0.38	0.076	U	U	0.077	0.38	0.077	U	U	0.083	0.42	0.083	U	U	0.072	0.36	0.072	U	U
DIPHENYLAMINE	mg/kg																									
Fluoranthene	mg/kg	0.037	0.18	0.037	U	U	0.11	0.19	0.038	J	J	0.0718	0.19	0.038	J	J	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Fluorene	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Hexachlorobenzene	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Hexachlorobutadiene	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Hexachlorocyclopentadiene	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Hexachloroethane	mg/kg	0.044	0.18	0.044	U	U	0.045	0.19	0.045	U	U	0.046	0.19	0.046	U	U	0.05	0.21	0.05	U	U	0.043	0.18	0.043	U	U
Indeno(1,2,3-cd)pyrene	mg/kg	0.037	0.18	0.037	U	U	0.0392	0.19	0.038	J	J	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Isophorone	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Methylnaphthalene, 2-	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Methylphenol, 2-	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-DP05					TNTB-SL-DP06					TNTB-SL-DP06					TNTB-SL-DP06					TNTB-SL-DP07				
SAMPLE NO		DP0111					DP0112					DP0113					DP0115					DP0116				
SAMPLE DATE		24-Aug-09					24-Aug-09					24-Aug-09					24-Aug-09					24-Aug-09				
DEPTH		8 - 10 Ft					0 - 1 Ft					0 - 1 Ft					9 - 10 Ft					0 - 1 Ft				
SAMPLE PURPOSE		REG					REG					FD					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Methylphenol, 4-	mg/kg																									
Naphthalene	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Nitroaniline, 2-	mg/kg	0.074	0.37	0.074	U	U	0.076	0.38	0.076	U	U	0.077	0.38	0.077	U	U	0.083	0.42	0.083	U	U	0.072	0.36	0.072	U	U
Nitroaniline, 3-	mg/kg	0.074	0.37	0.074	U	U	0.076	0.38	0.076	U	U	0.077	0.38	0.077	U	U	0.083	0.42	0.083	U	U	0.072	0.36	0.072	U	U
Nitroaniline, 4-	mg/kg	0.074	0.37	0.074	U	U	0.076	0.38	0.076	U	U	0.077	0.38	0.077	U	U	0.083	0.42	0.083	U	U	0.072	0.36	0.072	U	U
Nitrobenzene	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Nitrophenol, 2-	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Nitrophenol, 4-	mg/kg	0.37	0.92	0.37	U	U	0.38	0.94	0.38	U	U	0.38	0.96	0.38	U	U	0.42	1	0.42	U	U	0.36	0.9	0.36	U	U
n-Nitrosodimethylamine	mg/kg																									
n-Nitroso-di-n-propylamine	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
n-Nitrosodiphenylamine	mg/kg	0.074	0.18	0.074	U	U	0.076	0.19	0.076	U	U	0.077	0.19	0.077	U	U	0.083	0.21	0.083	U	U	0.072	0.18	0.072	U	U
Pentachlorophenol	mg/kg	0.37	0.92	0.37	U	U	0.38	0.94	0.38	U	U	0.38	0.96	0.38	U	U	0.42	1	0.42	U	UJ	0.36	0.9	0.36	U	U
Phenanthrene	mg/kg	0.0424	0.18	0.037	J	J	0.0404	0.19	0.038	J	J	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Phenol	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Pyrene	mg/kg	0.037	0.18	0.037	U	U	0.0825	0.19	0.038	J	J	0.0565	0.19	0.038	J	J	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Trichlorobenzene, 1,2,4-	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Trichlorophenol, 2,4,5-	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
Trichlorophenol, 2,4,6-	mg/kg	0.037	0.18	0.037	U	U	0.038	0.19	0.038	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.036	0.18	0.036	U	U
WATER QUALITY																										
% Solids	Percent	88.8	0				88	0				88.3	0				80.3	0				94.3	0			
Total organic carbon	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-DP07					TNTB-SL-DP08					TNTB-SL-DP08					TNTB-SL-DP09					TNTB-SL-DP09				
SAMPLE NO		DP0117					DP0118					DP0119					DP0120					DP0121				
SAMPLE DATE		24-Aug-09					25-Aug-09					25-Aug-09					25-Aug-09					25-Aug-09				
DEPTH		4 - 6 Ft					0 - 1 Ft					2 - 4 Ft					0 - 1 Ft					2 - 4 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
EXPLOSIVES																										
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.04	0.16	0.04	U	U	0.04	0.16	0.04	U	U	0.045	0.18	0.045	U	U	0.224	0.17	0.042			0.278	0.17	0.041		
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.088	0.16	0.088	U	U	0.087	0.16	0.087	U	U	0.097	0.18	0.097	U	U	0.222	0.17	0.091			0.336	0.17	0.09		
Dinitrobenzene, 1,3-	mg/kg	0.043	0.16	0.043	U	U	0.042	0.16	0.042	U	U	0.047	0.18	0.047	U	U	0.044	0.17	0.044	U	U	0.044	0.17	0.044	U	U
Dinitrotoluene, 2,4-	mg/kg	0.048	0.16	0.048	U	U	0.048	0.16	0.048	U	U	0.054	0.18	0.054	U	U	0.0517	0.17	0.05	J	J	0.0827	0.17	0.05	J	J
Dinitrotoluene, 2,6-	mg/kg	0.043	0.16	0.043	U	U	0.042	0.16	0.042	U	U	0.047	0.18	0.047	U	U	0.044	0.17	0.044	U	U	0.044	0.17	0.044	U	U
HMX	mg/kg	0.069	0.16	0.069	U	U	0.069	0.16	0.069	U	U	0.077	0.18	0.077	U	U	0.072	0.17	0.072	U	U	0.071	0.17	0.071	U	U
Nitrobenzene	mg/kg	0.053	0.16	0.053	U	U	0.053	0.16	0.053	U	U	0.059	0.18	0.059	U	U	0.055	0.17	0.055	U	U	0.055	0.17	0.055	U	U
Nitrotoluene, 2-	mg/kg	0.04	0.16	0.04	U	U	0.04	0.16	0.04	U	U	0.045	0.18	0.045	U	U	0.042	0.17	0.042	U	U	0.041	0.17	0.041	U	U
Nitrotoluene, 3-	mg/kg	0.067	0.16	0.067	U	U	0.067	0.16	0.067	U	U	0.075	0.18	0.075	U	U	0.07	0.17	0.07	U	U	0.07	0.17	0.07	U	U
Nitrotoluene, 4-	mg/kg	0.05	0.16	0.05	U	U	0.05	0.16	0.05	U	U	0.055	0.18	0.055	U	U	0.052	0.17	0.052	U	U	0.051	0.17	0.051	U	U
RDX	mg/kg	0.068	0.16	0.068	U	U	0.068	0.16	0.068	U	U	0.076	0.18	0.076	U	U	0.071	0.17	0.071	U	U	0.071	0.17	0.071	U	U
Tetryl	mg/kg	0.041	0.16	0.041	U	U	0.041	0.16	0.041	U	U	0.046	0.18	0.046	U	U	0.042	0.17	0.042	U	U	0.042	0.17	0.042	U	U
Trinitrobenzene, 1,3,5-	mg/kg	0.04	0.16	0.04	U	U	0.04	0.16	0.04	U	U	0.045	0.18	0.045	U	U	0.042	0.17	0.042	U	U	0.101	0.17	0.041	J	J
Trinitrotoluene, 2,4,6-	mg/kg	0.04	0.16	0.04	U	U	0.04	0.16	0.04	U	U	0.045	0.18	0.045	U	U	0.179	0.17	0.042			1.02	0.17	0.041		
METALS (UNFILTERED)																										
Aluminum	mg/kg	4040	20	1.1		J	5440	11	0.62		J	6160	20	1.1		J	8190	12	0.67		J	6600	9.7	0.53		J
Antimony	mg/kg	0.44	5.9	0.44	U	UJ	0.25	3.4	0.25	U	UJ	0.45	6	0.45	U	UJ	0.28	3.7	0.28	U	UJ	1.9	5.8	0.44	B	J
Arsenic	mg/kg	3.5	0.78	0.35		J	3.1	0.45	0.2		J	2.4	0.8	0.36		J	7.9	0.49	0.22		J	15.3	0.77	0.35		J
Barium	mg/kg	46.8	20	0.49		J	14.8	11	0.28		J	19.2	20	0.5	B	J	32.8	12	0.31		J	24.2	9.7	0.24		J
Beryllium	mg/kg	0.42	0.49	0.098	B	J	0.46	0.28	0.056			0.71	0.5	0.1			0.37	0.31	0.061			0.35	0.24	0.048		
Cadmium	mg/kg	0.098	0.39	0.098	U	UJ	0.056	0.23	0.056	U	UJ	0.1	0.4	0.1	U	UJ	0.061	0.25	0.061	U	U	0.97	1.6	0.97	U	U
Calcium	mg/kg	3050	490	9.8		J	407	280	5.6		J	573	500	10		J	271	310	6.1	B	J	168	240	4.8	B	J
Chromium	mg/kg	6.1	0.98	0.16		J	8.7	0.56	0.09		J	8.3	1	0.16		J	11	0.61	0.098		J	11.9	0.48	0.077		J
Cobalt	mg/kg	4.6	4.9	0.081	B	J	6	2.8	0.047		J	3.8	5	0.083	B	J	4.2	3.1	0.051		J	2.9	2.4	0.04		J
Copper	mg/kg	8.7	2.5	0.21		J	11.6	1.4	0.12		J	7.3	2.5	0.21		J	30.5	1.5	0.13		J	46.4	1.2	0.1		J
Iron	mg/kg	16300	9.8	2.3		J	11400	5.6	1.3		J	8760	10	2.3		J	18500	6.1	1.4		J	45200	9.7	2.2		J
Lead	mg/kg	9.3	9.8	0.2	B	J	7.3	5.6	0.11		J	7.1	10	0.2	B	J	13.3	6.1	0.12		J	15.8	9.7	0.19		J
Magnesium	mg/kg	1230	490	9.8		J	533	280	5.6		J	548	500	10		J	544	310	6.1		J	306	240	4.8		J
Manganese	mg/kg	1040	7.4	0.25		J	114	0.85	0.028		J	48.7	1.5	0.05		J	24.1	0.92	0.031		J	10.1	1.5	0.048		J
Mercury	mg/kg	0.03	0.077	0.011	B	J	0.041	0.096	0.014	B	J	0.038	0.1	0.014	B	J	0.034	0.1	0.015	B	J	0.049	0.084	0.012	B	B
Nickel	mg/kg	19	3.9	0.23		J	14.8	2.3	0.13		J	17.8	4	0.23		J	14.5	2.5	0.14		J	12.7	1.9	0.11		J
Potassium	mg/kg	349	980	9.8	B	J	225	560	5.6	B	J	165	1000	10	B	J	462	610	6.1	B	J	720	480	4.8		J
Selenium	mg/kg	0.3	9.8	0.3	U	UJ	0.27	5.6	0.18	B	J	0.32	10	0.31	B	J	0.61	6.1	0.19	B	J	2.3	9.7	0.3	B	J
Silver	mg/kg	0.12	0.98	0.12	U	UJ	0.068	0.56	0.068	U	UJ	0.12	1	0.12	U	UJ	0.074	0.61	0.074	U	U	0.11	0.48	0.058	B	J
Sodium	mg/kg	49	980	49	U	U	28	560	28	U	U	50	1000	50	U	U	31	610	31	U	U	24	480	24	U	U
Thallium	mg/kg	0.33	0.98	0.33	U	UJ	3.8	5.6	3.8	U	UJ	3.4	5	3.4	U	UJ	0.21	0.61	0.21	U	U	1.7	3.9	1.7	U	U
Vanadium	mg/kg	11.4	4.9	0.065		J	17.4	2.8	0.037		J	15.6	5	0.066		J	24.2	3.1	0.04		J	25.5	4.8	0.064		J
Zinc	mg/kg	55.3	2	0.37		J	25.9	1.1	0.21		J	29.9	2	0.38		J	14.1	1.2	0.23		J	9.3	0.97	0.18		J
PESTICIDES/PCBS																										
Aroclor 1016	mg/kg	0.0088	0.018	0.0088	U	U	0.0097	0.019	0.0097	U	U	0.01	0.021	0.01	U	U	0.01	0.021	0.01	U	U	0.0095	0.019	0.0095	U	U
Aroclor 1221	mg/kg	0.014	0.018	0.014	U	U	0.015	0.019	0.015	U	U	0.017	0.021	0.017	U	U	0.017	0.021	0.017	U	U	0.015	0.019	0.015	U	U
Aroclor 1232	mg/kg	0.014	0.018	0.014	U	U	0.015	0.019	0.015	U	U	0.017	0.021	0.017	U	U	0.017	0.021	0.017	U	U	0.015	0.019	0.015	U	U
Aroclor 1242	mg/kg	0.0088	0.018	0.0088	U	U	0.0097	0.019	0.0097	U	U	0.01	0.021	0.01	U	U	0.01	0.021	0.01	U	U	0.0095	0.019	0.0095	U	U
Aroclor 1248	mg/kg	0.0088	0.018	0.0088	U	U	0.0097	0.019	0.0097	U	U	0.01	0.021	0.01	U	U	0.01	0.021	0.01	U	U	0.0095	0.019	0.0095	U	U
Aroclor 1254	mg/kg	0.0088	0.018	0.0088	U	U	0.0097	0.019	0.0097	U	U	0.01	0.021	0.01	U	U	0.01	0.021	0.01	U	U	0.0095	0.019	0.0095	U	U
Aroclor 1260	mg/kg	0.0088	0.018	0.0088	U	U	0.0097	0.019	0.0097	U	U	0.01	0.021	0.01	U	U	0.01	0.021	0.01	U	U	0.0095	0.019	0.0095	U	U
SEMIVOLATILES																										
3-Methylphenol and 4-Methylphenol	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Acenaphthene	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Acenaphthylene	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
ACETOPHENONE	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-DP07					TNTB-SL-DP08					TNTB-SL-DP08					TNTB-SL-DP09					TNTB-SL-DP09				
SAMPLE NO		DP0117					DP0118					DP0119					DP0120					DP0121				
SAMPLE DATE		24-Aug-09					25-Aug-09					25-Aug-09					25-Aug-09					25-Aug-09				
DEPTH		4 - 6 Ft					0 - 1 Ft					2 - 4 Ft					0 - 1 Ft					2 - 4 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Anthracene	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Atrazine	mg/kg																									
Benzaldehyde	mg/kg																									
Benzo(a)anthracene	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Benzo(a)pyrene	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Benzo(b)fluoranthene	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Benzo(ghi)perylene	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Benzo(k)fluoranthene	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Benzoic acid	mg/kg	0.36	0.89	0.36	U	U	0.38	0.96	0.38	U	U	0.42	1	0.42	U	U	0.42	1.1	0.42	U	U	0.38	0.95	0.38	U	U
Benzyl alcohol	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
BIBENZENE	mg/kg																									
Bis(2-chloroethoxy)methane	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Bis(2-chloroethyl)ether	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Bis(2-chloroisopropyl)ether	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Bis(2-ethylhexyl)phthalate	mg/kg	0.18	0.36	0.18	U	U	0.19	0.38	0.19	U	U	0.21	0.42	0.21	U	U	0.21	0.42	0.21	U	U	0.19	0.38	0.19	U	U
Bromophenyl phenyl ether, 4-	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Butyl benzyl phthalate	mg/kg	0.072	0.36	0.072	U	U	0.077	0.38	0.077	U	U	0.084	0.42	0.084	U	U	0.084	0.42	0.084	U	U	0.076	0.38	0.076	U	U
Caprolactam	mg/kg																									
Carbazole	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Chloro-3-methylphenol, 4-	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Chloroaniline, 4-	mg/kg	0.072	0.18	0.072	U	U	0.077	0.19	0.077	U	U	0.084	0.21	0.084	U	U	0.084	0.21	0.084	U	U	0.076	0.19	0.076	U	U
Chloronaphthalene, 2-	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Chlorophenol, 2-	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Chlorophenyl phenyl ether, 4-	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Chrysene	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Dibenz(a,h)anthracene	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Dibenzofuran	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Dichlorobenzene, 1,2-	mg/kg	0.047	0.18	0.047	U	U	0.05	0.19	0.05	U	U	0.054	0.21	0.054	U	U	0.055	0.21	0.055	U	U	0.049	0.19	0.049	U	U
Dichlorobenzene, 1,3-	mg/kg	0.047	0.18	0.047	U	U	0.05	0.19	0.05	U	U	0.054	0.21	0.054	U	U	0.055	0.21	0.055	U	U	0.049	0.19	0.049	U	U
Dichlorobenzene, 1,4-	mg/kg	0.043	0.18	0.043	U	U	0.046	0.19	0.046	U	U	0.05	0.21	0.05	U	U	0.05	0.21	0.05	U	U	0.046	0.19	0.046	U	U
Dichlorobenzidine, 3,3'-	mg/kg	0.072	0.36	0.072	U	U	0.077	0.38	0.077	U	U	0.084	0.42	0.084	U	U	0.084	0.42	0.084	U	U	0.076	0.38	0.076	U	U
Dichlorophenol, 2,4-	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Diethyl phthalate	mg/kg	0.18	0.36	0.18	U	U	0.19	0.38	0.19	U	U	0.21	0.42	0.21	U	U	0.21	0.42	0.21	U	U	0.19	0.38	0.19	U	U
Dimethyl phthalate	mg/kg	0.072	0.36	0.072	U	U	0.077	0.38	0.077	U	U	0.084	0.42	0.084	U	U	0.084	0.42	0.084	U	U	0.076	0.38	0.076	U	U
Dimethylphenol, 2,4-	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Di-n-butyl phthalate	mg/kg	0.072	0.36	0.072	U	U	0.077	0.38	0.077	U	U	0.084	0.42	0.084	U	U	0.084	0.42	0.084	U	U	0.076	0.38	0.076	U	U
Dinitro-2-methylphenol, 4,6-	mg/kg	0.11	0.36	0.11	U	U	0.12	0.38	0.12	U	U	0.13	0.42	0.13	U	U	0.13	0.42	0.13	U	U	0.12	0.38	0.12	U	U
Dinitrophenol, 2,4-	mg/kg	0.36	0.89	0.36	U	U	0.38	0.96	0.38	U	U	0.42	1	0.42	U	U	0.42	1.1	0.42	U	U	0.38	0.95	0.38	U	U
Dinitrotoluene, 2,4-	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Dinitrotoluene, 2,6-	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Di-n-octyl phthalate	mg/kg	0.072	0.36	0.072	U	U	0.077	0.38	0.077	U	U	0.084	0.42	0.084	U	U	0.084	0.42	0.084	U	U	0.076	0.38	0.076	U	U
DIPHENYLAMINE	mg/kg																									
Fluoranthene	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Fluorene	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Hexachlorobenzene	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Hexachlorobutadiene	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Hexachlorocyclopentadiene	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Hexachloroethane	mg/kg	0.043	0.18	0.043	U	U	0.046	0.19	0.046	U	U	0.05	0.21	0.05	U	U	0.05	0.21	0.05	U	U	0.046	0.19	0.046	U	U
Indeno(1,2,3-cd)pyrene	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Isophorone	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Methylnaphthalene, 2-	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.259	0.19	0.038		
Methylphenol, 2-	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-DP07					TNTB-SL-DP08					TNTB-SL-DP08					TNTB-SL-DP09					TNTB-SL-DP09				
SAMPLE NO		DP0117					DP0118					DP0119					DP0120					DP0121				
SAMPLE DATE		24-Aug-09					25-Aug-09					25-Aug-09					25-Aug-09					25-Aug-09				
DEPTH		4 - 6 Ft					0 - 1 Ft					2 - 4 Ft					0 - 1 Ft					2 - 4 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Methylphenol, 4-	mg/kg																									
Naphthalene	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.0765	0.19	0.038	J	J
Nitroaniline, 2-	mg/kg	0.072	0.36	0.072	U	U	0.077	0.38	0.077	U	U	0.084	0.42	0.084	U	U	0.084	0.42	0.084	U	U	0.076	0.38	0.076	U	U
Nitroaniline, 3-	mg/kg	0.072	0.36	0.072	U	U	0.077	0.38	0.077	U	U	0.084	0.42	0.084	U	U	0.084	0.42	0.084	U	U	0.076	0.38	0.076	U	U
Nitroaniline, 4-	mg/kg	0.072	0.36	0.072	U	U	0.077	0.38	0.077	U	U	0.084	0.42	0.084	U	U	0.084	0.42	0.084	U	U	0.076	0.38	0.076	U	U
Nitrobenzene	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Nitrophenol, 2-	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Nitrophenol, 4-	mg/kg	0.36	0.89	0.36	U	U	0.38	0.96	0.38	U	U	0.42	1	0.42	U	U	0.42	1.1	0.42	U	U	0.38	0.95	0.38	U	U
n-Nitrosodimethylamine	mg/kg																									
n-Nitroso-di-n-propylamine	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
n-Nitrosodiphenylamine	mg/kg	0.072	0.18	0.072	U	U	0.077	0.19	0.077	U	U	0.084	0.21	0.084	U	U	0.084	0.21	0.084	U	U	0.076	0.19	0.076	U	U
Pentachlorophenol	mg/kg	0.36	0.89	0.36	U	U	0.38	0.96	0.38	U	U	0.42	1	0.42	U	U	0.42	1.1	0.42	U	U	0.38	0.95	0.38	U	U
Phenanthrene	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.124	0.19	0.038	J	J
Phenol	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Pyrene	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Trichlorobenzene, 1,2,4-	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Trichlorophenol, 2,4,5-	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
Trichlorophenol, 2,4,6-	mg/kg	0.036	0.18	0.036	U	U	0.038	0.19	0.038	U	U	0.042	0.21	0.042	U	U	0.042	0.21	0.042	U	U	0.038	0.19	0.038	U	U
WATER QUALITY																										
% Solids	Percent	94.4	0				86.8	0				80.9	0				80.7	0				87.5	0			
Total organic carbon	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-DP10					TNTB-SL-DP10					TNTB-SL-DP11					TNTB-SL-DP12					TNTB-SL-DP13				
SAMPLE NO		DP0122					DP0123					DP0124					DP0125					DP0126				
SAMPLE DATE		25-Aug-09					25-Aug-09					20-Aug-09					20-Aug-09					25-Aug-09				
DEPTH		0 - 1 Ft					2 - 3_5 Ft					8 - 10 Ft					8 - 10 Ft					2 - 3_5 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
EXPLOSIVES																										
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.2	0.16	0.041			0.0637	0.17	0.042	J	J	0.038	0.15	0.038	U	U	0.037	0.15	0.037	U	U	0.04	0.16	0.04	U	U
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.329	0.16	0.09			0.092	0.17	0.092	U	U	0.082	0.15	0.082	U	U	0.081	0.15	0.081	U	U	0.088	0.16	0.088	U	U
Dinitrobenzene, 1,3-	mg/kg	0.044	0.16	0.044	U	U	0.045	0.17	0.045	U	U	0.04	0.15	0.04	U	U	0.039	0.15	0.039	U	U	0.043	0.16	0.043	U	U
Dinitrotoluene, 2,4-	mg/kg	0.049	0.16	0.049	U	U	0.051	0.17	0.051	U	U	0.045	0.15	0.045	U	U	0.0846	0.15	0.045	J	J	0.049	0.16	0.049	U	U
Dinitrotoluene, 2,6-	mg/kg	0.044	0.16	0.044	U	U	0.045	0.17	0.045	U	U	0.04	0.15	0.04	U	U	0.098	0.15	0.039	J	J	0.043	0.16	0.043	U	U
HMX	mg/kg	0.071	0.16	0.071	U	U	0.073	0.17	0.073	U	U	0.065	0.15	0.065	U	U	0.064	0.15	0.064	U	U	0.07	0.16	0.07	U	U
Nitrobenzene	mg/kg	0.054	0.16	0.054	U	U	0.056	0.17	0.056	U	U	0.05	0.15	0.05	U	U	0.049	0.15	0.049	U	U	0.053	0.16	0.053	U	U
Nitrotoluene, 2-	mg/kg	0.041	0.16	0.041	U	U	0.042	0.17	0.042	U	U	0.038	0.15	0.038	U	U	0.037	0.15	0.037	U	U	0.04	0.16	0.04	U	U
Nitrotoluene, 3-	mg/kg	0.069	0.16	0.069	U	U	0.071	0.17	0.071	U	U	0.063	0.15	0.063	U	U	0.062	0.15	0.062	U	U	0.068	0.16	0.068	U	U
Nitrotoluene, 4-	mg/kg	0.051	0.16	0.051	U	U	0.052	0.17	0.052	U	U	0.047	0.15	0.047	U	U	0.046	0.15	0.046	U	U	0.05	0.16	0.05	U	U
RDX	mg/kg	0.07	0.16	0.07	U	U	0.072	0.17	0.072	U	U	0.064	0.15	0.064	U	U	0.063	0.15	0.063	U	U	0.069	0.16	0.069	U	U
Tetryl	mg/kg	0.042	0.16	0.042	U	U	0.043	0.17	0.043	U	U	0.038	0.15	0.038	U	U	0.038	0.15	0.038	U	U	0.041	0.16	0.041	U	U
Trinitrobenzene, 1,3,5-	mg/kg	0.041	0.16	0.041	U	U	0.042	0.17	0.042	U	U	0.038	0.15	0.038	U	U	0.037	0.15	0.037	U	U	0.04	0.16	0.04	U	U
Trinitrotoluene, 2,4,6-	mg/kg	0.908	0.16	0.041			0.065	0.17	0.042	J	J	0.038	0.15	0.038	U	U	0.037	0.15	0.037	U	U	0.04	0.16	0.04	U	U
METALS (UNFILTERED)																										
Aluminum	mg/kg	6560	9.9	0.54		J	6710	11	0.6		J	2820	11	0.63		J	4460	11	0.63		J	6770	11	0.59		J
Antimony	mg/kg	0.38	3	0.22	B	J	0.43	3.3	0.25	B	J	0.26	3.4	0.26	U	UJ	0.57	6.9	0.51	B	J	0.49	3.2	0.24	B	J
Arsenic	mg/kg	6.4	0.4	0.18		J	12.8	0.44	0.2		J	1.5	0.46	0.21			10.3	0.92	0.41			11.7	0.43	0.19		J
Barium	mg/kg	19.9	9.9	0.25		J	19.4	11	0.27		J	8.1	11	0.29	B	J	21.1	11	0.29		J	14.2	11	0.27		J
Beryllium	mg/kg	0.4	0.25	0.049			0.71	0.27	0.055			0.23	0.29	0.057	B	J	0.3	0.29	0.057			0.81	0.27	0.054		
Cadmium	mg/kg	0.049	0.2	0.049	U	U	0.055	0.22	0.055	U	U	0.057	0.23	0.057	U	UJ	0.057	0.23	0.057	U	UJ	0.054	0.22	0.054	U	U
Calcium	mg/kg	258	250	4.9			126	270	5.5	B	J	17000	290	5.7		J	33800	570	11		J	449	270	5.4		
Chromium	mg/kg	9	0.49	0.079		J	9.7	0.55	0.087		J	6.2	1.1	0.182			6.2	1.1	0.184			10.1	0.54	0.086		J
Cobalt	mg/kg	5.8	2.5	0.041		J	9.9	2.7	0.045		J	2.5	2.9	0.047	B	J	5.3	2.9	0.047			13.8	2.7	0.045		J
Copper	mg/kg	20.8	1.2	0.1		J	42.8	1.4	0.11		J	3.7	1.4	0.12			12.4	1.4	0.12			33.4	1.3	0.11		J
Iron	mg/kg	15700	4.9	1.1		J	24700	5.5	1.3		J	5520	5.7	1.3		J	10300	5.7	1.3		J	27000	5.4	1.2		J
Lead	mg/kg	11.6	4.9	0.099		J	15.2	5.5	0.11		J	3.2	5.7	0.11	B	J	6.3	11	0.23	B	J	11.8	5.4	0.11		J
Magnesium	mg/kg	574	250	4.9		J	916	270	5.5		J	4990	290	5.7		J	8360	290	5.7		J	715	270	5.4		J
Manganese	mg/kg	79.8	0.74	0.025		J	58.7	0.82	0.027		J	138	0.86	0.029		J	184	0.86	0.029		J	94.8	0.81	0.027		J
Mercury	mg/kg	0.05	0.086	0.012	B	J	0.078	0.083	0.012	B	J	0.014	0.1	0.014	U	U	0.018	0.096	0.014	B	J	0.034	0.094	0.014	B	J
Nickel	mg/kg	17.4	2	0.11		J	22.8	2.2	0.13		J	5.5	2.3	0.13			14.4	2.3	0.13			23.8	2.2	0.12		J
Potassium	mg/kg	414	490	4.9	B	J	740	550	5.5		J	515	570	5.7	B	J	1380	570	5.7		J	601	540	5.4		J
Selenium	mg/kg	0.49	4.9	0.15	B	J	0.4	5.5	0.17	B	J	0.49	5.7	0.18	B	J	0.46	11	0.35	B	J	0.39	5.4	0.17	B	J
Silver	mg/kg	0.059	0.49	0.059	U	U	0.065	0.55	0.065	U	U	0.069	0.57	0.069	U	U	0.069	0.57	0.069	U	U	0.065	0.54	0.065	U	U
Sodium	mg/kg	25	490	25	U	U	27	550	27	U	U	234	570	29	B	J	225	570	29	B	J	27	540	27	U	U
Thallium	mg/kg	1.7	2	1.7	U	U	0.19	0.55	0.19	U	U	1.9	2.9	1.9	U	U	0.19	0.57	0.19	U	U	0.18	0.54	0.18	U	U
Vanadium	mg/kg	19.4	2.5	0.033		J	22.9	2.7	0.036		J	11.3	2.9	0.038		J	10	2.9	0.038		J	27.5	2.7	0.036		J
Zinc	mg/kg	22.9	0.99	0.19		J	54.8	1.1	0.21		J	15.8	1.1	0.22		J	67.6	1.1	0.22		J	31.9	1.1	0.2		J
PESTICIDES/PCBS																										
Aroclor 1016	mg/kg	0.0092	0.018	0.0092	U	U	0.0094	0.019	0.0094	U	U	0.01	0.02	0.01	U	U	0.0096	0.019	0.0096	U	U	0.0094	0.019	0.0094	U	U
Aroclor 1221	mg/kg	0.015	0.018	0.015	U	U	0.015	0.019	0.015	U	U	0.016	0.02	0.016	U	U	0.015	0.019	0.015	U	U	0.015	0.019	0.015	U	U
Aroclor 1232	mg/kg	0.015	0.018	0.015	U	U	0.015	0.019	0.015	U	U	0.016	0.02	0.016	U	U	0.015	0.019	0.015	U	U	0.015	0.019	0.015	U	U
Aroclor 1242	mg/kg	0.0092	0.018	0.0092	U	U	0.0094	0.019	0.0094	U	U	0.01	0.02	0.01	U	U	0.0096	0.019	0.0096	U	U	0.0094	0.019	0.0094	U	U
Aroclor 1248	mg/kg	0.0092	0.018	0.0092	U	U	0.0094	0.019	0.0094	U	U	0.01	0.02	0.01	U	U	0.0096	0.019	0.0096	U	U	0.0094	0.019	0.0094	U	U
Aroclor 1254	mg/kg	0.0092	0.018	0.0092	U	U	0.0094	0.019	0.0094	U	U	0.01	0.02	0.01	U	U	0.0096	0.019	0.0096	U	U	0.0094	0.019	0.0094	U	U
Aroclor 1260	mg/kg	0.0092	0.018	0.0092	U	U	0.0094	0.019	0.0094	U	U	0.01	0.02	0.01	U	U	0.0096	0.019	0.0096	U	U	0.0094	0.019	0.0094	U	U
SEMIVOLATILES																										
3-Methylphenol and 4-Methylphenol	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Acenaphthene	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Acenaphthylene	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
ACETOPHENONE	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-DP10					TNTB-SL-DP10					TNTB-SL-DP11					TNTB-SL-DP12					TNTB-SL-DP13				
SAMPLE NO		DP0122					DP0123					DP0124					DP0125					DP0126				
SAMPLE DATE		25-Aug-09					25-Aug-09					20-Aug-09					20-Aug-09					25-Aug-09				
DEPTH		0 - 1 Ft					2 - 3_5 Ft					8 - 10 Ft					8 - 10 Ft					2 - 3_5 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Anthracene	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Atrazine	mg/kg																									
Benzaldehyde	mg/kg																									
Benzo(a)anthracene	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.0413	0.19	0.039	J	J	0.037	0.19	0.037	U	U
Benzo(a)pyrene	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Benzo(b)fluoranthene	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.045	0.19	0.039	J	J	0.037	0.19	0.037	U	U
Benzo(ghi)perylene	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Benzo(k)fluoranthene	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Benzoic acid	mg/kg	0.36	0.9	0.36	U	U	0.37	0.94	0.37	U	U	0.39	0.97	0.39	U	U	0.39	0.97	0.39	U	U	0.37	0.93	0.37	U	U
Benzyl alcohol	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
BIBENZENE	mg/kg																									
Bis(2-chloroethoxy)methane	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Bis(2-chloroethyl)ether	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Bis(2-chloroisopropyl)ether	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Bis(2-ethylhexyl)phthalate	mg/kg	0.18	0.36	0.18	U	U	0.19	0.37	0.19	U	U	0.19	0.39	0.19	U	U	0.19	0.39	0.19	U	U	0.19	0.37	0.19	U	U
Bromophenyl phenyl ether, 4-	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Butyl benzyl phthalate	mg/kg	0.072	0.36	0.072	U	U	0.075	0.37	0.075	U	U	0.078	0.39	0.078	U	U	0.078	0.39	0.078	U	U	0.075	0.37	0.075	U	U
Caprolactam	mg/kg																									
Carbazole	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Chloro-3-methylphenol, 4-	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Chloroaniline, 4-	mg/kg	0.072	0.18	0.072	U	U	0.075	0.19	0.075	U	U	0.078	0.19	0.078	U	U	0.078	0.19	0.078	U	U	0.075	0.19	0.075	U	U
Chloronaphthalene, 2-	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Chlorophenol, 2-	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Chlorophenyl phenyl ether, 4-	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Chrysene	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Dibenz(a,h)anthracene	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Dibenzofuran	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Dichlorobenzene, 1,2-	mg/kg	0.047	0.18	0.047	U	U	0.049	0.19	0.049	U	U	0.05	0.19	0.05	U	U	0.05	0.19	0.05	U	U	0.048	0.19	0.048	U	U
Dichlorobenzene, 1,3-	mg/kg	0.047	0.18	0.047	U	U	0.049	0.19	0.049	U	U	0.05	0.19	0.05	U	U	0.05	0.19	0.05	U	U	0.048	0.19	0.048	U	U
Dichlorobenzene, 1,4-	mg/kg	0.043	0.18	0.043	U	U	0.045	0.19	0.045	U	U	0.047	0.19	0.047	U	U	0.047	0.19	0.047	U	U	0.045	0.19	0.045	U	U
Dichlorobenzidine, 3,3'-	mg/kg	0.072	0.36	0.072	U	U	0.075	0.37	0.075	U	U	0.078	0.39	0.078	U	U	0.078	0.39	0.078	U	U	0.075	0.37	0.075	U	U
Dichlorophenol, 2,4-	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Diethyl phthalate	mg/kg	0.18	0.36	0.18	U	U	0.19	0.37	0.19	U	U	0.19	0.39	0.19	U	U	0.19	0.39	0.19	U	U	0.19	0.37	0.19	U	U
Dimethyl phthalate	mg/kg	0.072	0.36	0.072	U	U	0.075	0.37	0.075	U	U	0.078	0.39	0.078	U	U	0.078	0.39	0.078	U	U	0.075	0.37	0.075	U	U
Dimethylphenol, 2,4-	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Di-n-butyl phthalate	mg/kg	0.072	0.36	0.072	U	U	0.075	0.37	0.075	U	U	0.078	0.39	0.078	U	U	0.078	0.39	0.078	U	U	0.075	0.37	0.075	U	U
Dinitro-2-methylphenol, 4,6-	mg/kg	0.12	0.36	0.12	U	U	0.12	0.37	0.12	U	U	0.12	0.39	0.12	U	U	0.12	0.39	0.12	U	U	0.12	0.37	0.12	U	U
Dinitrophenol, 2,4-	mg/kg	0.36	0.9	0.36	U	U	0.37	0.94	0.37	U	U	0.39	0.97	0.39	U	U	0.39	0.97	0.39	U	U	0.37	0.93	0.37	U	U
Dinitrotoluene, 2,4-	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Dinitrotoluene, 2,6-	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Di-n-octyl phthalate	mg/kg	0.072	0.36	0.072	U	U	0.075	0.37	0.075	U	U	0.078	0.39	0.078	U	U	0.078	0.39	0.078	U	U	0.075	0.37	0.075	U	U
DIPHENYLAMINE	mg/kg																									
Fluoranthene	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.117	0.19	0.039	J	J	0.037	0.19	0.037	U	U
Fluorene	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Hexachlorobenzene	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Hexachlorobutadiene	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Hexachlorocyclopentadiene	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Hexachloroethane	mg/kg	0.043	0.18	0.043	U	U	0.045	0.19	0.045	U	U	0.047	0.19	0.047	U	U	0.047	0.19	0.047	U	U	0.045	0.19	0.045	U	U
Indeno(1,2,3-cd)pyrene	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Isophorone	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Methylnaphthalene, 2-	mg/kg	0.0658	0.18	0.036	J	J	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Methylphenol, 2-	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-DP10					TNTB-SL-DP10					TNTB-SL-DP11					TNTB-SL-DP12					TNTB-SL-DP13				
SAMPLE NO		DP0122					DP0123					DP0124					DP0125					DP0126				
SAMPLE DATE		25-Aug-09					25-Aug-09					20-Aug-09					20-Aug-09					25-Aug-09				
DEPTH		0 - 1 Ft					2 - 3_5 Ft					8 - 10 Ft					8 - 10 Ft					2 - 3_5 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Methylphenol, 4-	mg/kg																									
Naphthalene	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Nitroaniline, 2-	mg/kg	0.072	0.36	0.072	U	U	0.075	0.37	0.075	U	U	0.078	0.39	0.078	U	U	0.078	0.39	0.078	U	U	0.075	0.37	0.075	U	U
Nitroaniline, 3-	mg/kg	0.072	0.36	0.072	U	U	0.075	0.37	0.075	U	U	0.078	0.39	0.078	U	U	0.078	0.39	0.078	U	U	0.075	0.37	0.075	U	U
Nitroaniline, 4-	mg/kg	0.072	0.36	0.072	U	U	0.075	0.37	0.075	U	U	0.078	0.39	0.078	U	U	0.078	0.39	0.078	U	U	0.075	0.37	0.075	U	U
Nitrobenzene	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Nitrophenol, 2-	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Nitrophenol, 4-	mg/kg	0.36	0.9	0.36	U	U	0.37	0.94	0.37	U	U	0.39	0.97	0.39	U	U	0.39	0.97	0.39	U	U	0.37	0.93	0.37	U	U
n-Nitrosodimethylamine	mg/kg																									
n-Nitroso-di-n-propylamine	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
n-Nitrosodiphenylamine	mg/kg	0.072	0.18	0.072	U	U	0.075	0.19	0.075	U	U	0.078	0.19	0.078	U	U	0.078	0.19	0.078	U	U	0.075	0.19	0.075	U	U
Pentachlorophenol	mg/kg	0.36	0.9	0.36	U	U	0.37	0.94	0.37	U	U	0.39	0.97	0.39	U	U	0.39	0.97	0.39	U	U	0.37	0.93	0.37	U	U
Phenanthrene	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.132	0.19	0.039	J	J	0.037	0.19	0.037	U	U
Phenol	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Pyrene	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.0757	0.19	0.039	J	J	0.037	0.19	0.037	U	U
Trichlorobenzene, 1,2,4-	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Trichlorophenol, 2,4,5-	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
Trichlorophenol, 2,4,6-	mg/kg	0.036	0.18	0.036	U	U	0.037	0.19	0.037	U	U	0.039	0.19	0.039	U	U	0.039	0.19	0.039	U	U	0.037	0.19	0.037	U	U
WATER QUALITY																										
% Solids	Percent	91.1	0				88.2	0				83.4	0				85.7	0				88.5	0			
Total organic carbon	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-DP14					TNTB-SL-DP14					TNTB-SL-TP01					TNTB-SL-TP02					TNTB-SL-TP03				
SAMPLE NO		DP0127					DP0130					SL0085					SL0086					SL0087				
SAMPLE DATE		25-Aug-09					25-Aug-09					28-Jul-09					28-Jul-09					28-Jul-09				
DEPTH		2 - 3_5 Ft					2 - 3_5 Ft					2 - 3 Ft					2 - 3 Ft					2 - 3 Ft				
SAMPLE PURPOSE		REG					FD					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
EXPLOSIVES																										
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.044	0.18	0.044	U	U	0.04	0.16	0.04	U	U	1.2	0.15	0.038			0.182	0.16	0.039			0.184	0.17	0.043		
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.096	0.18	0.096	U	U	0.087	0.16	0.087	U	U	1.05	0.15	0.083			0.21	0.16	0.085			0.17	0.17	0.095		
Dinitrobenzene, 1,3-	mg/kg	0.047	0.18	0.047	U	U	0.042	0.16	0.042	U	U	0.04	0.15	0.04	U	U	0.041	0.16	0.041	U	U	0.046	0.17	0.046	U	U
Dinitrotoluene, 2,4-	mg/kg	0.053	0.18	0.053	U	U	0.048	0.16	0.048	U	U	0.173	0.15	0.046			0.047	0.16	0.047	U	U	0.052	0.17	0.052	U	U
Dinitrotoluene, 2,6-	mg/kg	0.047	0.18	0.047	U	U	0.042	0.16	0.042	U	U	0.101	0.15	0.04	J	J	0.041	0.16	0.041	U	U	0.046	0.17	0.046	U	U
HMX	mg/kg	0.076	0.18	0.076	U	U	0.069	0.16	0.069	U	U	0.066	0.15	0.066	U	U	0.067	0.16	0.067	U	U	0.075	0.17	0.075	U	U
Nitrobenzene	mg/kg	0.058	0.18	0.058	U	U	0.053	0.16	0.053	U	U	0.05	0.15	0.05	U	U	0.052	0.16	0.052	U	U	0.057	0.17	0.057	U	U
Nitrotoluene, 2-	mg/kg	0.044	0.18	0.044	U	U	0.04	0.16	0.04	U	U	0.038	0.15	0.038	U	U	0.039	0.16	0.039	U	U	0.043	0.17	0.043	U	U
Nitrotoluene, 3-	mg/kg	0.074	0.18	0.074	U	U	0.067	0.16	0.067	U	U	0.064	0.15	0.064	U	U	0.066	0.16	0.066	U	U	0.073	0.17	0.073	U	U
Nitrotoluene, 4-	mg/kg	0.055	0.18	0.055	U	U	0.05	0.16	0.05	U	U	0.047	0.15	0.047	U	U	0.048	0.16	0.048	U	U	0.054	0.17	0.054	U	U
RDX	mg/kg	0.075	0.18	0.075	U	U	0.068	0.16	0.068	U	U	0.065	0.15	0.065	U	U	0.066	0.16	0.066	U	U	0.074	0.17	0.074	U	U
Tetryl	mg/kg	0.045	0.18	0.045	U	U	0.041	0.16	0.041	U	U	0.039	0.15	0.039	U	U	0.04	0.16	0.04	U	U	0.044	0.17	0.044	U	U
Trinitrobenzene, 1,3,5-	mg/kg	0.044	0.18	0.044	U	U	0.04	0.16	0.04	U	U	0.0739	0.15	0.038	J	J	0.039	0.16	0.039	U	U	0.043	0.17	0.043	U	U
Trinitrotoluene, 2,4,6-	mg/kg	0.044	0.18	0.044	U	U	0.04	0.16	0.04	U	U	3.65	0.15	0.038			0.039	0.16	0.039	U	U	0.064	0.17	0.043	J	J
METALS (UNFILTERED)																										
Aluminum	mg/kg	6300	11	0.58		J	5610	9.3	0.51		J															
Antimony	mg/kg	0.29	3.2	0.24	B	J	0.38	2.8	0.21	B	J															
Arsenic	mg/kg	6.2	0.42	0.19		J	6.7	0.37	0.17		J															
Barium	mg/kg	20.2	11	0.26		J	18.6	9.3	0.23		J															
Beryllium	mg/kg	0.62	0.26	0.053			0.62	0.23	0.046																	
Cadmium	mg/kg	0.053	0.21	0.053	U	U	0.046	0.19	0.046	U	U															
Calcium	mg/kg	590	260	5.3			539	230	4.6																	
Chromium	mg/kg	9.9	0.53	0.085		J	9.1	0.46	0.074		J															
Cobalt	mg/kg	11.2	2.6	0.044		J	8.8	2.3	0.038		J															
Copper	mg/kg	25.6	1.3	0.11		J	26.5	1.2	0.097		J															
Iron	mg/kg	20000	5.3	1.2		J	19200	4.6	1.1		J															
Lead	mg/kg	11.1	5.3	0.11		J	12	4.6	0.093		J															
Magnesium	mg/kg	786	260	5.3		J	769	230	4.6		J															
Manganese	mg/kg	98.1	0.79	0.026		J	89.1	0.7	0.023		J															
Mercury	mg/kg	0.045	0.091	0.013	B	J	0.04	0.081	0.012	B	J															
Nickel	mg/kg	17.2	2.1	0.12		J	16.9	1.9	0.11		J															
Potassium	mg/kg	558	530	5.3		J	575	460	4.6		J															
Selenium	mg/kg	0.16	5.3	0.16	U	UJ	0.34	4.6	0.14	B	J															
Silver	mg/kg	0.064	0.53	0.064	U	U	0.056	0.46	0.056	U	U															
Sodium	mg/kg	26	530	26	U	U	23	460	23	U	U															
Thallium	mg/kg	0.9	2.1	0.9	U	U	0.16	0.46	0.16	U	U															
Vanadium	mg/kg	21.1	2.6	0.035		J	20.4	2.3	0.031		J															
Zinc	mg/kg	26.2	1.1	0.2		J	26.4	0.93	0.18		J															
PESTICIDES/PCBS																										
Aroclor 1016	mg/kg	0.0093	0.019	0.0093	U	U	0.0092	0.018	0.0092	U	U															
Aroclor 1221	mg/kg	0.015	0.019	0.015	U	U	0.015	0.018	0.015	U	U															
Aroclor 1232	mg/kg	0.015	0.019	0.015	U	U	0.015	0.018	0.015	U	U															
Aroclor 1242	mg/kg	0.0093	0.019	0.0093	U	U	0.0092	0.018	0.0092	U	U															
Aroclor 1248	mg/kg	0.0093	0.019	0.0093	U	U	0.0092	0.018	0.0092	U	U															
Aroclor 1254	mg/kg	0.0093	0.019	0.0093	U	U	0.0092	0.018	0.0092	U	U															
Aroclor 1260	mg/kg	0.0093	0.019	0.0093	U	U	0.0092	0.018	0.0092	U	U															
SEMIVOLATILES																										
3-Methylphenol and 4-Methylphenol	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Acenaphthene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Acenaphthylene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
ACETOPHENONE	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-DP14					TNTB-SL-DP14					TNTB-SL-TP01					TNTB-SL-TP02					TNTB-SL-TP03				
SAMPLE NO		DP0127					DP0130					SL0085					SL0086					SL0087				
SAMPLE DATE		25-Aug-09					25-Aug-09					28-Jul-09					28-Jul-09					28-Jul-09				
DEPTH		2 - 3_5 Ft					2 - 3_5 Ft					2 - 3 Ft					2 - 3 Ft					2 - 3 Ft				
SAMPLE PURPOSE		REG					FD					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Anthracene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Atrazine	mg/kg																									
Benzaldehyde	mg/kg																									
Benzo(a)anthracene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Benzo(a)pyrene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Benzo(b)fluoranthene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Benzo(ghi)perylene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Benzo(k)fluoranthene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Benzoic acid	mg/kg	0.38	0.96	0.38	U	U	0.37	0.94	0.37	U	U															
Benzyl alcohol	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
BIBENZENE	mg/kg																									
Bis(2-chloroethoxy)methane	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Bis(2-chloroethyl)ether	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Bis(2-chloroisopropyl)ether	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Bis(2-ethylhexyl)phthalate	mg/kg	0.19	0.38	0.19	U	U	0.19	0.37	0.19	U	U															
Bromophenyl phenyl ether, 4-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Butyl benzyl phthalate	mg/kg	0.077	0.38	0.077	U	U	0.075	0.37	0.075	U	U															
Caprolactam	mg/kg																									
Carbazole	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Chloro-3-methylphenol, 4-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Chloroaniline, 4-	mg/kg	0.077	0.19	0.077	U	U	0.075	0.19	0.075	U	U															
Chloronaphthalene, 2-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Chlorophenol, 2-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Chlorophenyl phenyl ether, 4-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Chrysene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Dibenz(a,h)anthracene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Dibenzofuran	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Dichlorobenzene, 1,2-	mg/kg	0.05	0.19	0.05	U	U	0.049	0.19	0.049	U	U															
Dichlorobenzene, 1,3-	mg/kg	0.05	0.19	0.05	U	U	0.049	0.19	0.049	U	U															
Dichlorobenzene, 1,4-	mg/kg	0.046	0.19	0.046	U	U	0.045	0.19	0.045	U	U															
Dichlorobenzidine, 3,3'-	mg/kg	0.077	0.38	0.077	U	U	0.075	0.37	0.075	U	U															
Dichlorophenol, 2,4-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Diethyl phthalate	mg/kg	0.19	0.38	0.19	U	U	0.19	0.37	0.19	U	U															
Dimethyl phthalate	mg/kg	0.077	0.38	0.077	U	U	0.075	0.37	0.075	U	U															
Dimethylphenol, 2,4-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Di-n-butyl phthalate	mg/kg	0.077	0.38	0.077	U	U	0.075	0.37	0.075	U	U															
Dinitro-2-methylphenol, 4,6-	mg/kg	0.12	0.38	0.12	U	U	0.12	0.37	0.12	U	U															
Dinitrophenol, 2,4-	mg/kg	0.38	0.96	0.38	U	U	0.37	0.94	0.37	U	U															
Dinitrotoluene, 2,4-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Dinitrotoluene, 2,6-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Di-n-octyl phthalate	mg/kg	0.077	0.38	0.077	U	U	0.075	0.37	0.075	U	U															
DIPHENYLAMINE	mg/kg																									
Fluoranthene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Fluorene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Hexachlorobenzene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Hexachlorobutadiene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Hexachlorocyclopentadiene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Hexachloroethane	mg/kg	0.046	0.19	0.046	U	U	0.045	0.19	0.045	U	U															
Indeno(1,2,3-cd)pyrene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Isophorone	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Methylnaphthalene, 2-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Methylphenol, 2-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-DP14					TNTB-SL-DP14					TNTB-SL-TP01					TNTB-SL-TP02					TNTB-SL-TP03				
SAMPLE NO		DP0127					DP0130					SL0085					SL0086					SL0087				
SAMPLE DATE		25-Aug-09					25-Aug-09					28-Jul-09					28-Jul-09					28-Jul-09				
DEPTH		2 - 3_5 Ft					2 - 3_5 Ft					2 - 3 Ft					2 - 3 Ft					2 - 3 Ft				
SAMPLE PURPOSE		REG					FD					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Methylphenol, 4-	mg/kg																									
Naphthalene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Nitroaniline, 2-	mg/kg	0.077	0.38	0.077	U	U	0.075	0.37	0.075	U	U															
Nitroaniline, 3-	mg/kg	0.077	0.38	0.077	U	U	0.075	0.37	0.075	U	U															
Nitroaniline, 4-	mg/kg	0.077	0.38	0.077	U	U	0.075	0.37	0.075	U	U															
Nitrobenzene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Nitrophenol, 2-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Nitrophenol, 4-	mg/kg	0.38	0.96	0.38	U	U	0.37	0.94	0.37	U	U															
n-Nitrosodimethylamine	mg/kg																									
n-Nitroso-di-n-propylamine	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
n-Nitrosodiphenylamine	mg/kg	0.077	0.19	0.077	U	U	0.075	0.19	0.075	U	U															
Pentachlorophenol	mg/kg	0.38	0.96	0.38	U	U	0.37	0.94	0.37	U	U															
Phenanthrene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Phenol	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Pyrene	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Trichlorobenzene, 1,2,4-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Trichlorophenol, 2,4,5-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
Trichlorophenol, 2,4,6-	mg/kg	0.038	0.19	0.038	U	U	0.037	0.19	0.037	U	U															
WATER QUALITY																										
% Solids	Percent	88.3	0				90.6	0																		
Total organic carbon	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-TP04					TNTB-SL-TP05					TNTB-SL-TP06					TNTB-SL-TP07					TNTB-SL-TP07				
SAMPLE NO		SL0088					SL0089					SL0090					SL0091					SL0092				
SAMPLE DATE		29-Jul-09					29-Jul-09					29-Jul-09					29-Jul-09					29-Jul-09				
DEPTH		2 - 3 Ft					2 - 3 Ft					2 - 3 Ft					2 - 3 Ft					2 - 3 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					FD				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
EXPLOSIVES																										
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.039	0.15	0.039	U	U	0.038	0.15	0.038	U	U	0.035	0.14	0.035	U	U	0.04	0.16	0.04	U	UJ	0.041	0.16	0.041	U	U
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.084	0.15	0.084	U	U	0.083	0.15	0.083	U	U	0.076	0.14	0.076	U	U	0.088	0.16	0.088	U	UJ	0.089	0.16	0.089	U	U
Dinitrobenzene, 1,3-	mg/kg	0.041	0.15	0.041	U	U	0.04	0.15	0.04	U	U	0.037	0.14	0.037	U	U	0.043	0.16	0.043	U	U	0.043	0.16	0.043	U	U
Dinitrotoluene, 2,4-	mg/kg	0.046	0.15	0.046	U	U	0.046	0.15	0.046	U	U	0.042	0.14	0.042	U	U	0.049	0.16	0.049	U	U	0.049	0.16	0.049	U	U
Dinitrotoluene, 2,6-	mg/kg	0.041	0.15	0.041	U	U	0.04	0.15	0.04	U	U	0.037	0.14	0.037	U	U	0.043	0.16	0.043	U	U	0.043	0.16	0.043	U	U
HMX	mg/kg	0.066	0.15	0.066	U	U	0.065	0.15	0.065	U	U	0.06	0.14	0.06	U	U	0.07	0.16	0.07	U	U	0.07	0.16	0.07	U	U
Nitrobenzene	mg/kg	0.051	0.15	0.051	U	U	0.05	0.15	0.05	U	U	0.046	0.14	0.046	U	U	0.053	0.16	0.053	U	U	0.054	0.16	0.054	U	U
Nitrotoluene, 2-	mg/kg	0.039	0.15	0.039	U	U	0.038	0.15	0.038	U	U	0.035	0.14	0.035	U	U	0.04	0.16	0.04	U	U	0.041	0.16	0.041	U	U
Nitrotoluene, 3-	mg/kg	0.065	0.15	0.065	U	U	0.064	0.15	0.064	U	U	0.059	0.14	0.059	U	U	0.068	0.16	0.068	U	U	0.068	0.16	0.068	U	U
Nitrotoluene, 4-	mg/kg	0.048	0.15	0.048	U	U	0.047	0.15	0.047	U	U	0.043	0.14	0.043	U	U	0.05	0.16	0.05	U	U	0.05	0.16	0.05	U	U
RDX	mg/kg	0.066	0.15	0.066	U	U	0.065	0.15	0.065	U	U	0.059	0.14	0.059	U	U	0.069	0.16	0.069	U	U	0.069	0.16	0.069	U	U
Tetryl	mg/kg	0.039	0.15	0.039	U	U	0.039	0.15	0.039	U	U	0.036	0.14	0.036	U	U	0.041	0.16	0.041	U	U	0.041	0.16	0.041	U	U
Trinitrobenzene, 1,3,5-	mg/kg	0.039	0.15	0.039	U	U	0.038	0.15	0.038	U	U	0.035	0.14	0.035	U	U	0.04	0.16	0.04	U	U	0.041	0.16	0.041	U	U
Trinitrotoluene, 2,4,6-	mg/kg	0.039	0.15	0.039	U	U	0.038	0.15	0.038	U	U	0.035	0.14	0.035	U	U	0.04	0.16	0.04	U	U	0.041	0.16	0.041	U	U
METALS (UNFILTERED)																										
Aluminum	mg/kg																									
Antimony	mg/kg																									
Arsenic	mg/kg																									
Barium	mg/kg																									
Beryllium	mg/kg																									
Cadmium	mg/kg																									
Calcium	mg/kg																									
Chromium	mg/kg																									
Cobalt	mg/kg																									
Copper	mg/kg																									
Iron	mg/kg																									
Lead	mg/kg																									
Magnesium	mg/kg																									
Manganese	mg/kg																									
Mercury	mg/kg																									
Nickel	mg/kg																									
Potassium	mg/kg																									
Selenium	mg/kg																									
Silver	mg/kg																									
Sodium	mg/kg																									
Thallium	mg/kg																									
Vanadium	mg/kg																									
Zinc	mg/kg																									
PESTICIDES/PCBS																										
Aroclor 1016	mg/kg																									
Aroclor 1221	mg/kg																									
Aroclor 1232	mg/kg																									
Aroclor 1242	mg/kg																									
Aroclor 1248	mg/kg																									
Aroclor 1254	mg/kg																									
Aroclor 1260	mg/kg																									
SEMIVOLATILES																										
3-Methylphenol and 4-Methylphenol	mg/kg																									
Acenaphthene	mg/kg																									
Acenaphthylene	mg/kg																									
ACETOPHENONE	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-TP04					TNTB-SL-TP05					TNTB-SL-TP06					TNTB-SL-TP07					TNTB-SL-TP07				
SAMPLE NO		SL0088					SL0089					SL0090					SL0091					SL0092				
SAMPLE DATE		29-Jul-09					29-Jul-09					29-Jul-09					29-Jul-09					29-Jul-09				
DEPTH		2 - 3 Ft					2 - 3 Ft					2 - 3 Ft					2 - 3 Ft					2 - 3 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					FD				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Anthracene	mg/kg																									
Atrazine	mg/kg																									
Benzaldehyde	mg/kg																									
Benzo(a)anthracene	mg/kg																									
Benzo(a)pyrene	mg/kg																									
Benzo(b)fluoranthene	mg/kg																									
Benzo(ghi)perylene	mg/kg																									
Benzo(k)fluoranthene	mg/kg																									
Benzoic acid	mg/kg																									
Benzyl alcohol	mg/kg																									
BIBENZENE	mg/kg																									
Bis(2-chloroethoxy)methane	mg/kg																									
Bis(2-chloroethyl)ether	mg/kg																									
Bis(2-chloroisopropyl)ether	mg/kg																									
Bis(2-ethylhexyl)phthalate	mg/kg																									
Bromophenyl phenyl ether, 4-	mg/kg																									
Butyl benzyl phthalate	mg/kg																									
Caprolactam	mg/kg																									
Carbazole	mg/kg																									
Chloro-3-methylphenol, 4-	mg/kg																									
Chloroaniline, 4-	mg/kg																									
Chloronaphthalene, 2-	mg/kg																									
Chlorophenol, 2-	mg/kg																									
Chlorophenyl phenyl ether, 4-	mg/kg																									
Chrysene	mg/kg																									
Dibenz(a,h)anthracene	mg/kg																									
Dibenzofuran	mg/kg																									
Dichlorobenzene, 1,2-	mg/kg																									
Dichlorobenzene, 1,3-	mg/kg																									
Dichlorobenzene, 1,4-	mg/kg																									
Dichlorobenzidine, 3,3'-	mg/kg																									
Dichlorophenol, 2,4-	mg/kg																									
Diethyl phthalate	mg/kg																									
Dimethyl phthalate	mg/kg																									
Dimethylphenol, 2,4-	mg/kg																									
Di-n-butyl phthalate	mg/kg																									
Dinitro-2-methylphenol, 4,6-	mg/kg																									
Dinitrophenol, 2,4-	mg/kg																									
Dinitrotoluene, 2,4-	mg/kg																									
Dinitrotoluene, 2,6-	mg/kg																									
Di-n-octyl phthalate	mg/kg																									
DIPHENYLAMINE	mg/kg																									
Fluoranthene	mg/kg																									
Fluorene	mg/kg																									
Hexachlorobenzene	mg/kg																									
Hexachlorobutadiene	mg/kg																									
Hexachlorocyclopentadiene	mg/kg																									
Hexachloroethane	mg/kg																									
Indeno(1,2,3-cd)pyrene	mg/kg																									
Isophorone	mg/kg																									
Methylnaphthalene, 2-	mg/kg																									
Methylphenol, 2-	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-TP04					TNTB-SL-TP05					TNTB-SL-TP06					TNTB-SL-TP07					TNTB-SL-TP07				
SAMPLE NO		SL0088					SL0089					SL0090					SL0091					SL0092				
SAMPLE DATE		29-Jul-09					29-Jul-09					29-Jul-09					29-Jul-09					29-Jul-09				
DEPTH		2 - 3 Ft					2 - 3 Ft					2 - 3 Ft					2 - 3 Ft					2 - 3 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					FD				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Methylphenol, 4-	mg/kg																									
Naphthalene	mg/kg																									
Nitroaniline, 2-	mg/kg																									
Nitroaniline, 3-	mg/kg																									
Nitroaniline, 4-	mg/kg																									
Nitrobenzene	mg/kg																									
Nitrophenol, 2-	mg/kg																									
Nitrophenol, 4-	mg/kg																									
n-Nitrosodimethylamine	mg/kg																									
n-Nitroso-di-n-propylamine	mg/kg																									
n-Nitrosodiphenylamine	mg/kg																									
Pentachlorophenol	mg/kg																									
Phenanthrene	mg/kg																									
Phenol	mg/kg																									
Pyrene	mg/kg																									
Trichlorobenzene, 1,2,4-	mg/kg																									
Trichlorophenol, 2,4,5-	mg/kg																									
Trichlorophenol, 2,4,6-	mg/kg																									
WATER QUALITY																										
% Solids	Percent																									
Total organic carbon	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-TP08					TNTB-SL-TP09					TNTB-SL-TP10					TNTB-SL-TP10					TNTB-SL-TP11				
SAMPLE NO		SL0094					SL0095					SL0096					SL0097					SL0099				
SAMPLE DATE		29-Jul-09					29-Jul-09					29-Jul-09					29-Jul-09					29-Jul-09				
DEPTH		2 - 3 Ft					2 - 3 Ft					2 - 3 Ft					2 - 3 Ft					1_5 - 2 Ft				
SAMPLE PURPOSE		REG					REG					REG					FD					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
EXPLOSIVES																										
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.038	0.15	0.038	U	U	0.042	0.17	0.042	U	U	0.042	0.17	0.042	U	U	0.042	0.17	0.042	U	U	0.042	0.17	0.042	U	U
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.083	0.15	0.083	U	U	0.092	0.17	0.092	U	U	0.092	0.17	0.092	U	U	0.092	0.17	0.092	U	U	0.091	0.17	0.091	U	U
Dinitrobenzene, 1,3-	mg/kg	0.04	0.15	0.04	U	U	0.045	0.17	0.045	U	U	0.045	0.17	0.045	U	U	0.045	0.17	0.045	U	U	0.044	0.17	0.044	U	U
Dinitrotoluene, 2,4-	mg/kg	0.046	0.15	0.046	U	U	0.051	0.17	0.051	U	U	0.051	0.17	0.051	U	U	0.05	0.17	0.05	U	U	0.05	0.17	0.05	U	U
Dinitrotoluene, 2,6-	mg/kg	0.04	0.15	0.04	U	U	0.045	0.17	0.045	U	U	0.045	0.17	0.045	U	U	0.045	0.17	0.045	U	U	0.044	0.17	0.044	U	U
HMX	mg/kg	0.065	0.15	0.065	U	U	0.073	0.17	0.073	U	U	0.073	0.17	0.073	U	U	0.072	0.17	0.072	U	U	0.072	0.17	0.072	U	U
Nitrobenzene	mg/kg	0.05	0.15	0.05	U	U	0.056	0.17	0.056	U	U	0.056	0.17	0.056	U	U	0.055	0.17	0.055	U	U	0.055	0.17	0.055	U	U
Nitrotoluene, 2-	mg/kg	0.038	0.15	0.038	U	U	0.042	0.17	0.042	U	U	0.042	0.17	0.042	U	U	0.042	0.17	0.042	U	U	0.042	0.17	0.042	U	U
Nitrotoluene, 3-	mg/kg	0.064	0.15	0.064	U	U	0.071	0.17	0.071	U	U	0.071	0.17	0.071	U	U	0.071	0.17	0.071	U	U	0.07	0.17	0.07	U	U
Nitrotoluene, 4-	mg/kg	0.047	0.15	0.047	U	U	0.052	0.17	0.052	U	U	0.053	0.17	0.053	U	U	0.052	0.17	0.052	U	U	0.052	0.17	0.052	U	U
RDX	mg/kg	0.065	0.15	0.065	U	U	0.072	0.17	0.072	U	U	0.072	0.17	0.072	U	U	0.071	0.17	0.071	U	U	0.071	0.17	0.071	U	U
Tetryl	mg/kg	0.039	0.15	0.039	U	U	0.043	0.17	0.043	U	U	0.043	0.17	0.043	U	U	0.043	0.17	0.043	U	U	0.042	0.17	0.042	U	U
Trinitrobenzene, 1,3,5-	mg/kg	0.038	0.15	0.038	U	U	0.042	0.17	0.042	U	U	0.042	0.17	0.042	U	U	0.042	0.17	0.042	U	U	0.042	0.17	0.042	U	U
Trinitrotoluene, 2,4,6-	mg/kg	0.038	0.15	0.038	U	U	0.042	0.17	0.042	U	U	0.042	0.17	0.042	U	U	0.042	0.17	0.042	U	U	0.042	0.17	0.042	U	U
METALS (UNFILTERED)																										
Aluminum	mg/kg																									
Antimony	mg/kg																									
Arsenic	mg/kg																									
Barium	mg/kg																									
Beryllium	mg/kg																									
Cadmium	mg/kg																									
Calcium	mg/kg																									
Chromium	mg/kg																									
Cobalt	mg/kg																									
Copper	mg/kg																									
Iron	mg/kg																									
Lead	mg/kg																									
Magnesium	mg/kg																									
Manganese	mg/kg																									
Mercury	mg/kg																									
Nickel	mg/kg																									
Potassium	mg/kg																									
Selenium	mg/kg																									
Silver	mg/kg																									
Sodium	mg/kg																									
Thallium	mg/kg																									
Vanadium	mg/kg																									
Zinc	mg/kg																									
PESTICIDES/PCBS																										
Aroclor 1016	mg/kg																									
Aroclor 1221	mg/kg																									
Aroclor 1232	mg/kg																									
Aroclor 1242	mg/kg																									
Aroclor 1248	mg/kg																									
Aroclor 1254	mg/kg																									
Aroclor 1260	mg/kg																									
SEMIVOLATILES																										
3-Methylphenol and 4-Methylphenol	mg/kg																									
Acenaphthene	mg/kg																									
Acenaphthylene	mg/kg																									
ACETOPHENONE	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-TP08					TNTB-SL-TP09					TNTB-SL-TP10					TNTB-SL-TP10					TNTB-SL-TP11				
SAMPLE NO		SL0094					SL0095					SL0096					SL0097					SL0099				
SAMPLE DATE		29-Jul-09					29-Jul-09					29-Jul-09					29-Jul-09					29-Jul-09				
DEPTH		2 - 3 Ft					2 - 3 Ft					2 - 3 Ft					2 - 3 Ft					1_5 - 2 Ft				
SAMPLE PURPOSE		REG					REG					REG					FD					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Anthracene	mg/kg																									
Atrazine	mg/kg																									
Benzaldehyde	mg/kg																									
Benzo(a)anthracene	mg/kg																									
Benzo(a)pyrene	mg/kg																									
Benzo(b)fluoranthene	mg/kg																									
Benzo(ghi)perylene	mg/kg																									
Benzo(k)fluoranthene	mg/kg																									
Benzoic acid	mg/kg																									
Benzyl alcohol	mg/kg																									
BIBENZENE	mg/kg																									
Bis(2-chloroethoxy)methane	mg/kg																									
Bis(2-chloroethyl)ether	mg/kg																									
Bis(2-chloroisopropyl)ether	mg/kg																									
Bis(2-ethylhexyl)phthalate	mg/kg																									
Bromophenyl phenyl ether, 4-	mg/kg																									
Butyl benzyl phthalate	mg/kg																									
Caprolactam	mg/kg																									
Carbazole	mg/kg																									
Chloro-3-methylphenol, 4-	mg/kg																									
Chloroaniline, 4-	mg/kg																									
Chloronaphthalene, 2-	mg/kg																									
Chlorophenol, 2-	mg/kg																									
Chlorophenyl phenyl ether, 4-	mg/kg																									
Chrysene	mg/kg																									
Dibenz(a,h)anthracene	mg/kg																									
Dibenzofuran	mg/kg																									
Dichlorobenzene, 1,2-	mg/kg																									
Dichlorobenzene, 1,3-	mg/kg																									
Dichlorobenzene, 1,4-	mg/kg																									
Dichlorobenzidine, 3,3'-	mg/kg																									
Dichlorophenol, 2,4-	mg/kg																									
Diethyl phthalate	mg/kg																									
Dimethyl phthalate	mg/kg																									
Dimethylphenol, 2,4-	mg/kg																									
Di-n-butyl phthalate	mg/kg																									
Dinitro-2-methylphenol, 4,6-	mg/kg																									
Dinitrophenol, 2,4-	mg/kg																									
Dinitrotoluene, 2,4-	mg/kg																									
Dinitrotoluene, 2,6-	mg/kg																									
Di-n-octyl phthalate	mg/kg																									
DIPHENYLAMINE	mg/kg																									
Fluoranthene	mg/kg																									
Fluorene	mg/kg																									
Hexachlorobenzene	mg/kg																									
Hexachlorobutadiene	mg/kg																									
Hexachlorocyclopentadiene	mg/kg																									
Hexachloroethane	mg/kg																									
Indeno(1,2,3-cd)pyrene	mg/kg																									
Isophorone	mg/kg																									
Methylnaphthalene, 2-	mg/kg																									
Methylphenol, 2-	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-TP08					TNTB-SL-TP09					TNTB-SL-TP10					TNTB-SL-TP10					TNTB-SL-TP11				
SAMPLE NO		SL0094					SL0095					SL0096					SL0097					SL0099				
SAMPLE DATE		29-Jul-09					29-Jul-09					29-Jul-09					29-Jul-09					29-Jul-09				
DEPTH		2 - 3 Ft					2 - 3 Ft					2 - 3 Ft					2 - 3 Ft					1_5 - 2 Ft				
SAMPLE PURPOSE		REG					REG					REG					FD					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Methylphenol, 4-	mg/kg																									
Naphthalene	mg/kg																									
Nitroaniline, 2-	mg/kg																									
Nitroaniline, 3-	mg/kg																									
Nitroaniline, 4-	mg/kg																									
Nitrobenzene	mg/kg																									
Nitrophenol, 2-	mg/kg																									
Nitrophenol, 4-	mg/kg																									
n-Nitrosodimethylamine	mg/kg																									
n-Nitroso-di-n-propylamine	mg/kg																									
n-Nitrosodiphenylamine	mg/kg																									
Pentachlorophenol	mg/kg																									
Phenanthrene	mg/kg																									
Phenol	mg/kg																									
Pyrene	mg/kg																									
Trichlorobenzene, 1,2,4-	mg/kg																									
Trichlorophenol, 2,4,5-	mg/kg																									
Trichlorophenol, 2,4,6-	mg/kg																									
WATER QUALITY																										
% Solids	Percent																									
Total organic carbon	mg/kg																									

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-TP12					TNTB-SL-TP13					TNTB-SL-TP14					TNTB-SL-TP15					TNTB-SL-TP16					TNTB-SL-TP17				
SAMPLE NO		SL0100					SL0101					SL0102					SL0103					SL0104					SL0105				
SAMPLE DATE		29-Jul-09					29-Jul-09					29-Jul-09					30-Jul-09					30-Jul-09					30-Jul-09				
DEPTH		1_5 - 2 Ft					1_5 - 2 Ft					1_5 - 2 Ft					1_5 - 2 Ft					1_5 - 2 Ft					1_5 - 2 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
EXPLOSIVES																															
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.043	0.17	0.043	U	U	0.038	0.15	0.038	U	U	0.043	0.17	0.043	U	U	0.038	0.15	0.038	U	U	0.04	0.16	0.04	U	U	0.043	0.17	0.043	U	U
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.094	0.17	0.094	U	U	0.083	0.15	0.083	U	U	0.094	0.17	0.094	U	U	0.082	0.15	0.082	U	U	0.087	0.16	0.087	U	U	0.094	0.17	0.094	U	U
Dinitrobenzene, 1,3-	mg/kg	0.045	0.17	0.045	U	U	0.04	0.15	0.04	U	U	0.045	0.17	0.045	U	U	0.04	0.15	0.04	U	U	0.042	0.16	0.042	U	U	0.046	0.17	0.046	U	U
Dinitrotoluene, 2,4-	mg/kg	0.052	0.17	0.052	U	U	0.046	0.15	0.046	U	U	0.052	0.17	0.052	U	U	0.045	0.15	0.045	U	U	0.048	0.16	0.048	U	U	0.052	0.17	0.052	U	U
Dinitrotoluene, 2,6-	mg/kg	0.045	0.17	0.045	U	U	0.04	0.15	0.04	U	U	0.045	0.17	0.045	U	U	0.04	0.15	0.04	U	U	0.042	0.16	0.042	U	U	0.046	0.17	0.046	U	U
HMX	mg/kg	0.074	0.17	0.074	U	U	0.066	0.15	0.066	U	U	0.074	0.17	0.074	U	U	0.065	0.15	0.065	U	U	0.068	0.16	0.068	U	U	0.074	0.17	0.074	U	U
Nitrobenzene	mg/kg	0.057	0.17	0.057	U	U	0.05	0.15	0.05	U	U	0.057	0.17	0.057	U	U	0.05	0.15	0.05	U	U	0.052	0.16	0.052	U	U	0.057	0.17	0.057	U	U
Nitrotoluene, 2-	mg/kg	0.043	0.17	0.043	U	U	0.038	0.15	0.038	U	U	0.043	0.17	0.043	U	U	0.038	0.15	0.038	U	U	0.04	0.16	0.04	U	U	0.043	0.17	0.043	U	U
Nitrotoluene, 3-	mg/kg	0.072	0.17	0.072	U	U	0.064	0.15	0.064	U	U	0.072	0.17	0.072	U	U	0.063	0.15	0.063	U	U	0.067	0.16	0.067	U	U	0.073	0.17	0.073	U	U
Nitrotoluene, 4-	mg/kg	0.053	0.17	0.053	U	U	0.047	0.15	0.047	U	U	0.053	0.17	0.053	U	U	0.047	0.15	0.047	U	U	0.049	0.16	0.049	U	U	0.054	0.17	0.054	U	U
RDX	mg/kg	0.073	0.17	0.073	U	U	0.065	0.15	0.065	U	U	0.073	0.17	0.073	U	U	0.064	0.15	0.064	U	U	0.067	0.16	0.067	U	U	0.074	0.17	0.074	U	U
Tetryl	mg/kg	0.044	0.17	0.044	U	U	0.039	0.15	0.039	U	U	0.044	0.17	0.044	U	U	0.038	0.15	0.038	U	U	0.04	0.16	0.04	U	U	0.044	0.17	0.044	U	U
Trinitrobenzene, 1,3,5-	mg/kg	0.043	0.17	0.043	U	U	0.038	0.15	0.038	U	U	0.043	0.17	0.043	U	U	0.038	0.15	0.038	U	U	0.04	0.16	0.04	U	U	0.043	0.17	0.043	U	U
Trinitrotoluene, 2,4,6-	mg/kg	0.043	0.17	0.043	U	U	0.038	0.15	0.038	U	U	0.043	0.17	0.043	U	U	0.038	0.15	0.038	U	U	0.04	0.16	0.04	U	U	0.043	0.17	0.043	U	U
METALS (UNFILTERED)																															
Aluminum	mg/kg																														
Antimony	mg/kg																														
Arsenic	mg/kg																														
Barium	mg/kg																														
Beryllium	mg/kg																														
Cadmium	mg/kg																														
Calcium	mg/kg																														
Chromium	mg/kg																														
Cobalt	mg/kg																														
Copper	mg/kg																														
Iron	mg/kg																														
Lead	mg/kg																														
Magnesium	mg/kg																														
Manganese	mg/kg																														
Mercury	mg/kg																														
Nickel	mg/kg																														
Potassium	mg/kg																														
Selenium	mg/kg																														
Silver	mg/kg																														
Sodium	mg/kg																														
Thallium	mg/kg																														
Vanadium	mg/kg																														
Zinc	mg/kg																														
PESTICIDES/PCBS																															
Aroclor 1016	mg/kg																														
Aroclor 1221	mg/kg																														
Aroclor 1232	mg/kg																														
Aroclor 1242	mg/kg																														
Aroclor 1248	mg/kg																														
Aroclor 1254	mg/kg																														
Aroclor 1260	mg/kg																														
SEMIVOLATILES																															
3-Methylphenol and 4-Methylphenol	mg/kg																														
Acenaphthene	mg/kg																														
Acenaphthylene	mg/kg																														
ACETOPHENONE	mg/kg																														

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-TP12					TNTB-SL-TP13					TNTB-SL-TP14					TNTB-SL-TP15					TNTB-SL-TP16					TNTB-SL-TP17				
SAMPLE NO		SL0100					SL0101					SL0102					SL0103					SL0104					SL0105				
SAMPLE DATE		29-Jul-09					29-Jul-09					29-Jul-09					30-Jul-09					30-Jul-09					30-Jul-09				
DEPTH		1_5 - 2 Ft					1_5 - 2 Ft					1_5 - 2 Ft					1_5 - 2 Ft					1_5 - 2 Ft					1_5 - 2 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Anthracene	mg/kg																														
Atrazine	mg/kg																														
Benzaldehyde	mg/kg																														
Benzo(a)anthracene	mg/kg																														
Benzo(a)pyrene	mg/kg																														
Benzo(b)fluoranthene	mg/kg																														
Benzo(ghi)perylene	mg/kg																														
Benzo(k)fluoranthene	mg/kg																														
Benzoic acid	mg/kg																														
Benzyl alcohol	mg/kg																														
BIBENZENE	mg/kg																														
Bis(2-chloroethoxy)methane	mg/kg																														
Bis(2-chloroethyl)ether	mg/kg																														
Bis(2-chloroisopropyl)ether	mg/kg																														
Bis(2-ethylhexyl)phthalate	mg/kg																														
Bromophenyl phenyl ether, 4-	mg/kg																														
Butyl benzyl phthalate	mg/kg																														
Caprolactam	mg/kg																														
Carbazole	mg/kg																														
Chloro-3-methylphenol, 4-	mg/kg																														
Chloroaniline, 4-	mg/kg																														
Chloronaphthalene, 2-	mg/kg																														
Chlorophenol, 2-	mg/kg																														
Chlorophenyl phenyl ether, 4-	mg/kg																														
Chrysene	mg/kg																														
Dibenz(a,h)anthracene	mg/kg																														
Dibenzofuran	mg/kg																														
Dichlorobenzene, 1,2-	mg/kg																														
Dichlorobenzene, 1,3-	mg/kg																														
Dichlorobenzene, 1,4-	mg/kg																														
Dichlorobenzidine, 3,3'-	mg/kg																														
Dichlorophenol, 2,4-	mg/kg																														
Diethyl phthalate	mg/kg																														
Dimethyl phthalate	mg/kg																														
Dimethylphenol, 2,4-	mg/kg																														
Di-n-butyl phthalate	mg/kg																														
Dinitro-2-methylphenol, 4,6-	mg/kg																														
Dinitrophenol, 2,4-	mg/kg																														
Dinitrotoluene, 2,4-	mg/kg																														
Dinitrotoluene, 2,6-	mg/kg																														
Di-n-octyl phthalate	mg/kg																														
DIPHENYLAMINE	mg/kg																														
Fluoranthene	mg/kg																														
Fluorene	mg/kg																														
Hexachlorobenzene	mg/kg																														
Hexachlorobutadiene	mg/kg																														
Hexachlorocyclopentadiene	mg/kg																														
Hexachloroethane	mg/kg																														
Indeno(1,2,3-cd)pyrene	mg/kg																														
Isophorone	mg/kg																														
Methylnaphthalene, 2-	mg/kg																														
Methylphenol, 2-	mg/kg																														

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-TP12					TNTB-SL-TP13					TNTB-SL-TP14					TNTB-SL-TP15					TNTB-SL-TP16					TNTB-SL-TP17				
SAMPLE NO		SL0100					SL0101					SL0102					SL0103					SL0104					SL0105				
SAMPLE DATE		29-Jul-09					29-Jul-09					29-Jul-09					30-Jul-09					30-Jul-09					30-Jul-09				
DEPTH		1_5 - 2 Ft					1_5 - 2 Ft					1_5 - 2 Ft					1_5 - 2 Ft					1_5 - 2 Ft					1_5 - 2 Ft				
SAMPLE PURPOSE		REG					REG					REG					REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Methylphenol, 4-	mg/kg																														
Naphthalene	mg/kg																														
Nitroaniline, 2-	mg/kg																														
Nitroaniline, 3-	mg/kg																														
Nitroaniline, 4-	mg/kg																														
Nitrobenzene	mg/kg																														
Nitrophenol, 2-	mg/kg																														
Nitrophenol, 4-	mg/kg																														
n-Nitrosodimethylamine	mg/kg																														
n-Nitroso-di-n-propylamine	mg/kg																														
n-Nitrosodiphenylamine	mg/kg																														
Pentachlorophenol	mg/kg																														
Phenanthrene	mg/kg																														
Phenol	mg/kg																														
Pyrene	mg/kg																														
Trichlorobenzene, 1,2,4-	mg/kg																														
Trichlorophenol, 2,4,5-	mg/kg																														
Trichlorophenol, 2,4,6-	mg/kg																														
WATER QUALITY																															
% Solids	Percent																														
Total organic carbon	mg/kg																														

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-TP18					TNTB-SL-TP19					TNTB-SL-TP20				
SAMPLE NO		SL0106					SL0107					SL0108				
SAMPLE DATE		30-Jul-09					30-Jul-09					30-Jul-09				
DEPTH		1_5 - 2 Ft					1_5 - 2 Ft					1_5 - 2 Ft				
SAMPLE PURPOSE		REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
EXPLOSIVES																
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.046	0.18	0.046	U	U	0.037	0.15	0.037	U	U	0.036	0.14	0.036	U	U
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.1	0.18	0.1	U	U	0.081	0.15	0.081	U	U	0.078	0.14	0.078	U	U
Dinitrobenzene, 1,3-	mg/kg	0.049	0.18	0.049	U	U	0.04	0.15	0.04	U	U	0.038	0.14	0.038	U	U
Dinitrotoluene, 2,4-	mg/kg	0.055	0.18	0.055	U	U	0.045	0.15	0.045	U	U	0.043	0.14	0.043	U	U
Dinitrotoluene, 2,6-	mg/kg	0.049	0.18	0.049	U	U	0.04	0.15	0.04	U	U	0.038	0.14	0.038	U	U
HMX	mg/kg	0.079	0.18	0.079	U	U	0.064	0.15	0.064	U	U	0.062	0.14	0.062	U	U
Nitrobenzene	mg/kg	0.061	0.18	0.061	U	U	0.049	0.15	0.049	U	U	0.047	0.14	0.047	U	U
Nitrotoluene, 2-	mg/kg	0.046	0.18	0.046	U	U	0.037	0.15	0.037	U	U	0.036	0.14	0.036	U	U
Nitrotoluene, 3-	mg/kg	0.077	0.18	0.077	U	U	0.063	0.15	0.063	U	U	0.06	0.14	0.06	U	U
Nitrotoluene, 4-	mg/kg	0.057	0.18	0.057	U	U	0.046	0.15	0.046	U	U	0.045	0.14	0.045	U	U
RDX	mg/kg	0.078	0.18	0.078	U	U	0.063	0.15	0.063	U	U	0.061	0.14	0.061	U	U
Tetryl	mg/kg	0.047	0.18	0.047	U	U	0.038	0.15	0.038	U	U	0.037	0.14	0.037	U	U
Trinitrobenzene, 1,3,5-	mg/kg	0.046	0.18	0.046	U	U	0.037	0.15	0.037	U	U	0.036	0.14	0.036	U	U
Trinitrotoluene, 2,4,6-	mg/kg	0.046	0.18	0.046	U	U	0.15	0.15	0.15	U	U	0.0991	0.14	0.036	J	J
METALS (UNFILTERED)																
Aluminum	mg/kg															
Antimony	mg/kg															
Arsenic	mg/kg															
Barium	mg/kg															
Beryllium	mg/kg															
Cadmium	mg/kg															
Calcium	mg/kg															
Chromium	mg/kg															
Cobalt	mg/kg															
Copper	mg/kg															
Iron	mg/kg															
Lead	mg/kg															
Magnesium	mg/kg															
Manganese	mg/kg															
Mercury	mg/kg															
Nickel	mg/kg															
Potassium	mg/kg															
Selenium	mg/kg															
Silver	mg/kg															
Sodium	mg/kg															
Thallium	mg/kg															
Vanadium	mg/kg															
Zinc	mg/kg															
PESTICIDES/PCBS																
Aroclor 1016	mg/kg															
Aroclor 1221	mg/kg															
Aroclor 1232	mg/kg															
Aroclor 1242	mg/kg															
Aroclor 1248	mg/kg															
Aroclor 1254	mg/kg															
Aroclor 1260	mg/kg															
SEMIVOLATILES																
3-Methylphenol and 4-Methylphenol	mg/kg															
Acenaphthene	mg/kg															
Acenaphthylene	mg/kg															
ACETOPHENONE	mg/kg															

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-TP18					TNTB-SL-TP19					TNTB-SL-TP20				
SAMPLE NO		SL0106					SL0107					SL0108				
SAMPLE DATE		30-Jul-09					30-Jul-09					30-Jul-09				
DEPTH		1_5 - 2 Ft					1_5 - 2 Ft					1_5 - 2 Ft				
SAMPLE PURPOSE		REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Anthracene	mg/kg															
Atrazine	mg/kg															
Benzaldehyde	mg/kg															
Benzo(a)anthracene	mg/kg															
Benzo(a)pyrene	mg/kg															
Benzo(b)fluoranthene	mg/kg															
Benzo(ghi)perylene	mg/kg															
Benzo(k)fluoranthene	mg/kg															
Benzoic acid	mg/kg															
Benzyl alcohol	mg/kg															
BIBENZENE	mg/kg															
Bis(2-chloroethoxy)methane	mg/kg															
Bis(2-chloroethyl)ether	mg/kg															
Bis(2-chloroisopropyl)ether	mg/kg															
Bis(2-ethylhexyl)phthalate	mg/kg															
Bromophenyl phenyl ether, 4-	mg/kg															
Butyl benzyl phthalate	mg/kg															
Caprolactam	mg/kg															
Carbazole	mg/kg															
Chloro-3-methylphenol, 4-	mg/kg															
Chloroaniline, 4-	mg/kg															
Chloronaphthalene, 2-	mg/kg															
Chlorophenol, 2-	mg/kg															
Chlorophenyl phenyl ether, 4-	mg/kg															
Chrysene	mg/kg															
Dibenz(a,h)anthracene	mg/kg															
Dibenzofuran	mg/kg															
Dichlorobenzene, 1,2-	mg/kg															
Dichlorobenzene, 1,3-	mg/kg															
Dichlorobenzene, 1,4-	mg/kg															
Dichlorobenzidine, 3,3'-	mg/kg															
Dichlorophenol, 2,4-	mg/kg															
Diethyl phthalate	mg/kg															
Dimethyl phthalate	mg/kg															
Dimethylphenol, 2,4-	mg/kg															
Di-n-butyl phthalate	mg/kg															
Dinitro-2-methylphenol, 4,6-	mg/kg															
Dinitrophenol, 2,4-	mg/kg															
Dinitrotoluene, 2,4-	mg/kg															
Dinitrotoluene, 2,6-	mg/kg															
Di-n-octyl phthalate	mg/kg															
DIPHENYLAMINE	mg/kg															
Fluoranthene	mg/kg															
Fluorene	mg/kg															
Hexachlorobenzene	mg/kg															
Hexachlorobutadiene	mg/kg															
Hexachlorocyclopentadiene	mg/kg															
Hexachloroethane	mg/kg															
Indeno(1,2,3-cd)pyrene	mg/kg															
Isophorone	mg/kg															
Methylnaphthalene, 2-	mg/kg															
Methylphenol, 2-	mg/kg															

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		TNTB-SL-TP18					TNTB-SL-TP19					TNTB-SL-TP20				
SAMPLE NO		SL0106					SL0107					SL0108				
SAMPLE DATE		30-Jul-09					30-Jul-09					30-Jul-09				
DEPTH		1_5 - 2 Ft					1_5 - 2 Ft					1_5 - 2 Ft				
SAMPLE PURPOSE		REG					REG					REG				
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Methylphenol, 4-	mg/kg															
Naphthalene	mg/kg															
Nitroaniline, 2-	mg/kg															
Nitroaniline, 3-	mg/kg															
Nitroaniline, 4-	mg/kg															
Nitrobenzene	mg/kg															
Nitrophenol, 2-	mg/kg															
Nitrophenol, 4-	mg/kg															
n-Nitrosodimethylamine	mg/kg															
n-Nitroso-di-n-propylamine	mg/kg															
n-Nitrosodiphenylamine	mg/kg															
Pentachlorophenol	mg/kg															
Phenanthrene	mg/kg															
Phenol	mg/kg															
Pyrene	mg/kg															
Trichlorobenzene, 1,2,4-	mg/kg															
Trichlorophenol, 2,4,5-	mg/kg															
Trichlorophenol, 2,4,6-	mg/kg															
WATER QUALITY																
% Solids	Percent															
Total organic carbon	mg/kg															

Table E-1

Soil Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

FD - Field duplicate.
LQ - Laboratory qualifier.
MDL - Method detection limit.
mg/kg - Milligram(s) per kologram.
REG - Regular sample.
RL - Reporting limit.
VQ - Validation qualifier.

Validation Qualifiers:
U - Nondetect.
J - Estimated Concentration.
UJ - Nondetected; detection limit is estimated.
B - Analyte also found in blank.
R - Rejected.

Table E-2

Bedrock Groundwater Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

		LOCATION CODE	1SLA-BEDGW-002					1SLA-BEDGW-002					1SLA-BEDGW-003					1SLA-BEDGW-003					1SLA-BEDGW-003				
		SAMPLE NO	SL3084					SL3094					SL3085					SL3095					SL3096				
		SAMPLE DATE	7-May-09					11-Nov-09					6-May-09					10-Nov-09					10-Nov-09				
		DEPTH	0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft				
		SAMPLE PURPOSE	REG					REG					REG					REG					FD				
Parameter	Filtered	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
EXPLOSIVES																											
Amino-2,6-dinitrotoluene, 4-	N	µg/L	0.048	0.19	0.048	U	UJ	0.048	0.19	0.048	U	U	0.049	0.2	0.049	U	UJ	0.048	0.19	0.048	U	R	0.049	0.2	0.049	U	UJ
Amino-4,6-dinitrotoluene, 2-	N	µg/L	0.073	0.19	0.073	U	UJ	0.073	0.19	0.073	U	U	0.4	0.4	0.4	U	UJ	0.074	0.19	0.074	U	R	0.075	0.2	0.075	U	UJ
Dinitrobenzene, 1,3-	N	µg/L	0.049	0.19	0.049	U	UJ	0.049	0.19	0.049	U	U	0.05	0.2	0.05	U	UJ	0.049	0.19	0.049	U	R	0.05	0.2	0.05	U	UJ
Dinitrotoluene, 2,4-	N	µg/L	0.062	0.19	0.062	U	UJ	0.062	0.19	0.062	U	U	0.064	0.2	0.064	U	UJ	0.062	0.19	0.062	U	UJ	0.064	0.2	0.064	U	UJ
Dinitrotoluene, 2,6-	N	µg/L	0.089	0.19	0.089	U	UJ	0.19	0.19	0.19	U	U	0.091	0.2	0.091	U	UJ	0.089	0.19	0.089	U	R	0.091	0.2	0.091	U	UJ
HMX	N	µg/L	0.1	0.19	0.1	U	UJ	0.1	0.19	0.1	U	U	0.11	0.2	0.11	U	UJ	0.1	0.19	0.1	U	R	0.11	0.2	0.11	U	UJ
Nitrobenzene	N	µg/L	0.048	0.19	0.048	U	UJ	0.048	0.19	0.048	U	U	0.049	0.2	0.049	U	UJ	0.048	0.19	0.048	U	R	0.049	0.2	0.049	U	UJ
Nitrotoluene, 2-	N	µg/L	1.1	1.1	1.1	U	UJ	0.061	0.19	0.061	U	U	0.063	0.2	0.063	U	UJ	0.062	0.19	0.062	U	R	0.063	0.2	0.063	U	UJ
Nitrotoluene, 3-	N	µg/L	0.092	0.19	0.092	U	UJ	0.092	0.19	0.092	U	U	0.095	0.2	0.095	U	UJ	0.093	0.19	0.093	U	R	0.095	0.2	0.095	U	UJ
Nitrotoluene, 4-	N	µg/L	0.072	0.19	0.072	U	U	0.072	0.19	0.072	U	U	0.075	0.2	0.075	U	UJ	0.073	0.19	0.073	U	R	0.075	0.2	0.075	U	UJ
RDX	N	µg/L	0.071	0.19	0.071	U	UJ	0.071	0.19	0.071	U	U	0.074	0.2	0.074	U	UJ	0.072	0.19	0.072	U	R	0.074	0.2	0.074	U	UJ
Tetryl	N	µg/L	0.074	0.19	0.074	U	UJ	0.074	0.19	0.074	U	U	0.076	0.2	0.076	U	UJ	0.075	0.19	0.075	U	R	0.076	0.2	0.076	U	UJ
Trinitrobenzene, 1,3,5-	N	µg/L	0.048	0.19	0.048	U	UJ	0.048	0.19	0.048	U	U	0.049	0.2	0.049	U	UJ	0.048	0.19	0.048	U	UJ	0.049	0.2	0.049	U	UJ
Trinitrotoluene, 2,4,6-	N	µg/L	0.066	0.19	0.066	U	UJ	0.066	0.19	0.066	U	U	0.068	0.2	0.068	U	UJ	0.066	0.19	0.066	U	R	0.068	0.2	0.068	U	UJ
FIELD TESTS																											
Dissolved Oxygen	N	mg/L	0.75	0.3				8.11	0.3				2.57	0.3				2.24	0.3								
FERROUS IRON	N	mg/L	0	0.042				0	0.042				0	0.042				0	0.042								
Oxidation Reduction Potential	N	mV	-314.2	0.02				-3.7	0.02				-306.9	0.02				7.5	0.02								
pH	N	pH_units	6.69	0				6.68	0				6.66	0				6.48	0								
Specific Conductivity	N	mS/cm	3.724	0				4.365	0				13.47	0				13.8	0								
Temperature	N	C	11.5	0				10.32	0				14.01	0				10.21	0								
Turbidity	N	NTU	13.6	10				40.5	10				34.8	10				39	10								
METALS (UNFILTERED)																											
Aluminum	N	µg/L	64	200	11	B	B	70.4	200	11	B	J	441	200	11			1590	400	22			1900	200	11		
Antimony	N	µg/L	4.5	6	4.5	U	U	4.5	6	4.5	U	U	9	12	9	U	U	9	12	9	U	U	9	12	9	U	U
Arsenic	N	µg/L	34.9	10	3.6			3.6	10	3.6	U	U	50.3	20	7.2			57.9	20	7.2		J	83.5	20	7.2		J
Barium	N	µg/L	317	200	5			228	200	5			1310	200	5			1570	200	5			1520	200	5		
Beryllium	N	µg/L	1	4	1	U	U	1	4	1	U	U	1	4	1	U	U	1	4	1	U	U	1	4	1	U	U
Cadmium	N	µg/L	1	5	1	U	U	1	5	1	U	U	1	5	1	U	U	2	10	2	U	U	1	5	1	U	U
Calcium	N	µg/L	231000	1000	100			238000	1000	100		J	598000	2000	200			684000	2000	200			693000	2000	200		
Chromium	N	µg/L	1.6	10	1.6	U	U	1.6	10	1.6	U	U	1.6	10	1.6	U	U	3.4	10	1.6	B	J	4.6	10	1.6	B	J
Cobalt	N	µg/L	0.83	50	0.83	U	U	0.83	50	0.83	U	U	0.83	50	0.83	U	U	0.83	50	0.83	U	U	0.83	50	0.83	U	U
Copper	N	µg/L	2.1	25	2.1	U	U	2.1	25	2.1	U	U	2.1	25	2.1	U	U	2.1	25	2.1	U	U	7.8	25	2.1	B	J
Iron	N	µg/L	23	300	23	U	U	23	300	23	U	U	677	300	23			2610	600	46		J	3870	300	23		J
Lead	N	µg/L	2	5	2	U	U	2	10	2	U	U	5.7	10	4	B	B	4	10	4	U	U	4	10	4	U	U
Magnesium	N	µg/L	133000	5000	100			134000	5000	100			442000	5000	100			504000	10000	200			494000	5000	100		
Manganese	N	µg/L	256	15	0.5			15.2	15	0.5			506	15	0.5			288	30	1			376	15	0.5		
Mercury	N	µg/L	0.14	1	0.14	U	UJ	0.23	1	0.14	B	J	0.14	1	0.14	U	U	0.14	1	0.14	U	U	0.14	1	0.14	U	U
Nickel	N	µg/L	2.3	40	2.3	U	U	2.3	40	2.3	U	U	7.9	40	2.3	B	J	6.9	40	2.3	B	J	8.3	40	2.3	B	J
Potassium	N	µg/L	48200	10000	100			58300	10000	100			117000	20000	200			134000	50000	500		J	139000	50000	500		J
Selenium	N	µg/L	4.1	10	3.1	B	J	8.1	10	3.1	B	J	10.7	20	6.2	B	J	28.2	20	6.2		J	30.3	20	6.2		J
Silver	N	µg/L	1.2	10	1.2	U	U	1.2	10	1.2	U	U	1.2	10	1.2	U	U	1.2	10	1.2	U	U	1.2	10	1.2	U	U
Sodium	N	µg/L	340000	100000	5000			334000	100000	5000			1350000	200000	10000			1510000	400000	20000			1530000	400000	20000		
Thallium	N	µg/L	3.4	20	3.4	U	U	3.4	10	3.4	U	U	3.4	20	3.4	U	U	6.8	20	6.8	U	U	3.4	10	3.4	U	U
Vanadium	N	µg/L	1.4	50	0.66	B	J	2.1	50	0.66	B	J	2.2	50	0.66	B	J	4.6	100	1.3	B	J	3.4	50	0.66	B	J
Zinc	N	µg/L	10.8	20	3.8	B	J	9.1	20	3.8	B	J	16.7	20	3.8	B	B	13.2	20	3.8	B	J	16.9	20	3.8	B	J
METALS (FILTERED)																											
Aluminum	Y	µg/L	19.6	200	11	B	J	23	200	11	B	J	28.7	200	11	B	J	21	200	11	B	J	60.4	400	22	B	J
Antimony	Y	µg/L	4.5	6	4.5	U	U	4.5	6	4.5	U	U	9	12	9	U	U	9	12	9	U	U	9	12	9	U	U
Arsenic	Y	µg/L	33.7	10	3.6			3.6	10	3.6	U	U	52.8	20	7.2			93.1	20	7.2		J	32.5	20	7.2		J
Barium	Y	µg/L	312	200	5			229	200	5			1430	200	5			1540	200	5			1690	200	5		

Table E-2

Bedrock Groundwater Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

		LOCATION CODE	1SLA-BEDGW-002					1SLA-BEDGW-002					1SLA-BEDGW-003					1SLA-BEDGW-003					1SLA-BEDGW-003				
		SAMPLE NO	SL3084					SL3094					SL3085					SL3095					SL3096				
		SAMPLE DATE	7-May-09					11-Nov-09					6-May-09					10-Nov-09					10-Nov-09				
		DEPTH	0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft				
		SAMPLE PURPOSE	REG					REG					REG					REG					FD				
Parameter	Filtered	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Beryllium	Y	µg/L	1	4	1	U	U	1	4	1	U	U	1	4	1	U	U	1	4	1	U	U	1	4	1	U	U
Cadmium	Y	µg/L	1	5	1	U	U	1	5	1	U	U	1	5	1	U	U	1	5	1	U	U	2	10	2	U	U
Calcium	Y	µg/L	222000	1000	100			240000	1000	100		J	633000	2000	200			664000	2000	200			669000	2000	200		
Chromium	Y	µg/L	1.6	10	1.6	U	U	1.6	10	1.6	U	U	1.6	10	1.6	U	U	1.6	10	1.6	U	U	1.6	10	1.6	U	U
Cobalt	Y	µg/L	0.83	50	0.83	U	U	0.83	50	0.83	U	U	0.83	50	0.83	U	U	0.83	50	0.83	U	U	0.83	50	0.83	U	U
Copper	Y	µg/L	2.1	25	2.1	U	U	2.1	25	2.1	U	U	2.1	25	2.1	U	U	2.1	25	2.1	U	U	2.1	25	2.1	U	U
Iron	Y	µg/L	460	600	460	U	U	23	300	23	U	U	23	300	23	U	U	71.1	300	23	B	J	46	600	46	U	U
Lead	Y	µg/L	2	5	2	U	U	2	10	2	U	U	5.3	10	4	B	J	4	10	4	U	U	4	10	4	U	U
Magnesium	Y	µg/L	134000	5000	100			137000	5000	100			489000	5000	100			496000	5000	100			518000	10000	200		
Manganese	Y	µg/L	232	15	0.5			6.1	15	0.5	B	J	510	15	0.5			235	15	0.5		J	149	30	1		J
Mercury	Y	µg/L	0.14	1	0.14	U	UJ	0.14	1	0.14	U	U	0.14	1	0.14	U	U	0.14	1	0.14	U	U	0.14	1	0.14	U	U
Nickel	Y	µg/L	2.3	40	2.3	U	U	2.3	40	2.3	U	U	2.3	40	2.3	U	U	2.3	40	2.3	U	U	2.3	40	2.3	U	U
Potassium	Y	µg/L	47700	10000	100			59200	10000	100			124000	20000	200			130000	50000	500		J	140000	50000	500		J
Selenium	Y	µg/L	5.1	10	3.1	B	J	8.3	10	3.1	B	J	6.9	20	6.2	B	J	23.6	20	6.2		J	25.7	20	6.2		J
Silver	Y	µg/L	1.2	10	1.2	U	U	1.2	10	1.2	U	U	1.2	10	1.2	U	U	1.2	10	1.2	U	U	1.2	10	1.2	U	U
Sodium	Y	µg/L	337000	100000	5000			344000	100000	5000			1380000	200000	10000			1490000	400000	20000			1580000	400000	20000		
Thallium	Y	µg/L	3.4	20	3.4	U	U	3.4	10	3.4	U	U	3.4	20	3.4	U	U	3.4	10	3.4	U	U	6.8	20	6.8	U	U
Vanadium	Y	µg/L	1.2	50	0.66	B	J	1.9	50	0.66	B	J	1.4	50	0.66	B	J	0.92	50	0.66	B	J	1.3	100	1.3	U	U
Zinc	Y	µg/L	7.6	20	3.8	B	J	3.8	20	3.8	U	U	3.8	20	3.8	U	U	3.8	20	3.8	U	U	3.8	20	3.8	U	U
SEMIVOLATILES																											
3-Methylphenol and 4-Methylphenol	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	2.8	4.8	0.96	J	J	4	4.8	0.96	J	J	4.1	4.8	0.95	J	J
Acenaphthene	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Acenaphthylene	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
ACETOPHENONE	N	µg/L																									
Anthracene	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Atrazine	N	µg/L																									
Benzaldehyde	N	µg/L																									
Benzo(a)anthracene	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Benzo(a)pyrene	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Benzo(b)fluoranthene	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Benzo(ghi)perylene	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Benzo(k)fluoranthene	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Benzoic acid	N	µg/L	9.6	24	9.6	U	U	39	97	39	U	U	9.6	24	9.6	U	U	9.6	24	9.6	U	U	9.5	24	9.5	U	U
Benzyl alcohol	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
BIBENZENE	N	µg/L																									
Bis(2-chloroethoxy)methane	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Bis(2-chloroethyl)ether	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Bis(2-chloroisopropyl)ether	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Bis(2-ethylhexyl)phthalate	N	µg/L	1.9	4.8	1.9	U	U	7.8	19	7.8	U	U	1.9	4.8	1.9	U	U	1.9	4.8	1.9	U	U	1.9	4.8	1.9	U	U
Bromophenyl phenyl ether, 4-	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Butyl benzyl phthalate	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Caprolactam	N	µg/L																									
Carbazole	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Chloro-3-methylphenol, 4-	N	µg/L	0.96	4.8	0.96	U	U	9.8	19	3.9	J	J	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Chloroaniline, 4-	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Chloronaphthalene, 2-	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Chlorophenol, 2-	N	µg/L	1.2	4.8	1.2	U	U	4.7	19	4.7	U	U	1.2	4.8	1.2	U	U	1.2	4.8	1.2	U	U	1.1	4.8	1.1	U	U
Chlorophenyl phenyl ether, 4-	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Chrysene	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Dibenz(a,h)anthracene	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Dibenzofuran	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Dichlorobenzene, 1,2-	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U

Table E-2

Bedrock Groundwater Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

		LOCATION CODE	1SLA-BEDGW-002					1SLA-BEDGW-002					1SLA-BEDGW-003					1SLA-BEDGW-003					1SLA-BEDGW-003				
		SAMPLE NO	SL3084					SL3094					SL3085					SL3095					SL3096				
		SAMPLE DATE	7-May-09					11-Nov-09					6-May-09					10-Nov-09					10-Nov-09				
		DEPTH	0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft				
		SAMPLE PURPOSE	REG					REG					REG					REG					FD				
Parameter	Filtered	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Dichlorobenzene, 1,3-	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Dichlorobenzene, 1,4-	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Dichlorobenzidine, 3,3'-	N	µg/L	1.9	9.6	1.9	U	U	7.8	39	7.8	U	U	1.9	9.6	1.9	U	U	1.9	9.6	1.9	U	U	1.9	9.5	1.9	U	U
Dichlorophenol, 2,4-	N	µg/L	1.2	4.8	1.2	U	U	5	19	5	U	U	1.2	4.8	1.2	U	U	1.2	4.8	1.2	U	U	1.2	4.8	1.2	U	U
Diethyl phthalate	N	µg/L	1.9	4.8	1.9	U	U	7.8	19	7.8	U	U	1.9	4.8	1.9	U	U	1.9	4.8	1.9	U	U	1.9	4.8	1.9	U	U
Dimethyl phthalate	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Dimethylphenol, 2,4-	N	µg/L	3.2	4.8	1.2	J	J	4.8	19	4.7	J	J	6.8	4.8	1.2			9.2	4.8	1.2			10.1	4.8	1.1		
Di-n-butyl phthalate	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Dinitro-2-methylphenol, 4,6-	N	µg/L	3.8	9.6	3.8	U	U	16	39	16	U	U	3.8	9.6	3.8	U	U	3.8	9.6	3.8	U	U	3.8	9.5	3.8	U	U
Dinitrophenol, 2,4-	N	µg/L	9.6	24	9.6	U	U	39	97	39	U	U	9.6	24	9.6	U	U	9.6	24	9.6	U	U	9.5	24	9.5	U	U
Dinitrotoluene, 2,4-	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Dinitrotoluene, 2,6-	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Di-n-octyl phthalate	N	µg/L	1.4	4.8	1.4	U	U	5.8	19	5.8	U	U	1.4	4.8	1.4	U	U	1.4	4.8	1.4	U	U	1.4	4.8	1.4	U	U
Fluoranthene	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Fluorene	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Hexachlorobenzene	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Hexachlorobutadiene	N	µg/L	2.4	4.8	2.4	U	U	9.7	19	9.7	U	U	2.4	4.8	2.4	U	U	2.4	4.8	2.4	U	U	2.4	4.8	2.4	U	U
Hexachlorocyclopentadiene	N	µg/L	1.2	4.8	1.2	U	U	5	19	5	U	U	1.2	4.8	1.2	U	U	1.2	4.8	1.2	U	UJ	1.2	4.8	1.2	U	U
Hexachloroethane	N	µg/L	2.4	4.8	2.4	U	U	9.7	19	9.7	U	U	2.4	4.8	2.4	U	U	2.4	4.8	2.4	U	U	2.4	4.8	2.4	U	U
Indeno(1,2,3-cd)pyrene	N	µg/L	1.1	4.8	1.1	U	U	4.3	19	4.3	U	U	1.1	4.8	1.1	U	U	1.1	4.8	1.1	U	U	1	4.8	1	U	U
Isophorone	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Methylnaphthalene, 2-	N	µg/L	18.1	4.8	0.96			33.8	19	3.9			9.7	4.8	0.96			10.8	4.8	0.96		J	22.1	4.8	0.95		J
Methylphenol, 2-	N	µg/L	1.2	4.8	0.96	J	J	3.9	19	3.9	U	U	4.8	4.8	0.96			6.1	4.8	0.96			6.6	4.8	0.95		
Methylphenol, 4-	N	µg/L																									
Naphthalene	N	µg/L	18.3	4.8	0.96			32	19	3.9			13	4.8	0.96			16.4	4.8	0.96		J	24.5	4.8	0.95		J
Nitroaniline, 2-	N	µg/L	1.9	9.6	1.9	U	U	7.8	39	7.8	U	U	1.9	9.6	1.9	U	U	1.9	9.6	1.9	U	U	1.9	9.5	1.9	U	U
Nitroaniline, 3-	N	µg/L	1.9	9.6	1.9	U	U	7.8	39	7.8	U	U	1.9	9.6	1.9	U	U	1.9	9.6	1.9	U	U	1.9	9.5	1.9	U	U
Nitroaniline, 4-	N	µg/L	1.9	9.6	1.9	U	U	7.8	39	7.8	U	U	1.9	9.6	1.9	U	U	1.9	9.6	1.9	U	U	1.9	9.5	1.9	U	U
Nitrobenzene	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Nitrophenol, 2-	N	µg/L	1.2	4.8	1.2	U	U	5	19	5	U	U	1.2	4.8	1.2	U	U	1.2	4.8	1.2	U	U	1.2	4.8	1.2	U	U
Nitrophenol, 4-	N	µg/L	9.6	24	9.6	U	U	39	97	39	U	U	9.6	24	9.6	U	U	9.6	24	9.6	U	UJ	9.5	24	9.5	U	U
n-Nitroso-di-n-propylamine	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
n-Nitrosodiphenylamine	N	µg/L	1.9	4.8	1.9	U	U	7.8	19	7.8	U	U	1.9	4.8	1.9	U	U	1.9	4.8	1.9	U	U	1.9	4.8	1.9	U	U
Pentachlorophenol	N	µg/L	9.6	24	9.6	U	U	39	97	39	U	U	9.6	24	9.6	U	U	9.6	24	9.6	U	U	9.5	24	9.5	U	U
Phenanthrene	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Phenol	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	1.1	4.8	0.96	J	J	0.95	4.8	0.95	U	U
Pyrene	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Trichlorobenzene, 1,2,4-	N	µg/L	0.96	4.8	0.96	U	U	3.9	19	3.9	U	U	0.96	4.8	0.96	U	U	0.96	4.8	0.96	U	U	0.95	4.8	0.95	U	U
Trichlorophenol, 2,4,5-	N	µg/L	1.3	4.8	1.3	U	U	5.4	19	5.4	U	U	1.3	4.8	1.3	U	U	1.3	4.8	1.3	U	U	1.3	4.8	1.3	U	U
Trichlorophenol, 2,4,6-	N	µg/L	1.3	4.8	1.3	U	U	5.4	19	5.4	U	U	1.3	4.8	1.3	U	U	1.3	4.8	1.3	U	U	1.3	4.8	1.3	U	U
VOLATILES																											
Acetone	N	µg/L	50	130	50	U	R	106	25	10		J	100	250	100	U	U	130	250	100	J	J	139	250	100	J	J
Benzene	N	µg/L	16.7	5	2			12.3	1	0.4			114	10	4			175	10	4			119	10	4		
Bromodichloromethane	N	µg/L	1	5	1	U	U	0.2	1	0.2	U	U	2	10	2	U	U	2	10	2	U	U	2	10	2	U	U
Bromoform	N	µg/L	1.7	5	1.7	U	U	0.33	1	0.33	U	U	3.3	10	3.3	U	U	3.3	10	3.3	U	U	3.3	10	3.3	U	U
Bromomethane	N	µg/L	3.9	10	3.9	U	U	0.78	2	0.78	U	U	7.8	20	7.8	U	U	7.8	20	7.8	U	U	7.8	20	7.8	U	U
Butanone, 2-	N	µg/L	10	25	10	U	U	33.5	5	2			20	50	20	U	U	20	50	20	U	U	20	50	20	U	U
Carbon disulfide	N	µg/L	2	10	2	U	U	0.4	2	0.4	U	U	6.5	20	4	J	J	4	20	4	U	U	4.1	20	4	J	J
Carbon tetrachloride	N	µg/L	1.1	5	1.1	U	U	0.22	1	0.22	U	U	2.2	10	2.2	U	U	2.2	10	2.2	U	U	2.2	10	2.2	U	U
Chlorobenzene	N	µg/L	1.1	5	1.1	U	U	0.22	1	0.22	U	U	2.2	10	2.2	U	U	2.2	10	2.2	U	U	2.2	10	2.2	U	U
Chloroethane	N	µg/L	2.4	10	2.4	U	U	0.48	2	0.48	U	U	4.8	20	4.8	U	U	4.8	20	4.8	U	U	4.8	20	4.8	U	U
Chloroform	N	µg/L	1.4	5	1.4	U	U	0.28	1	0.28	U	U	15.3	10	2.8			2.8	10	2.8	U	U	16.6	10	2.8		B

Table E-2

Bedrock Groundwater Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

		LOCATION CODE	1SLA-BEDGW-002					1SLA-BEDGW-002					1SLA-BEDGW-003					1SLA-BEDGW-003					1SLA-BEDGW-003				
		SAMPLE NO	SL3084					SL3094					SL3085					SL3095					SL3096				
		SAMPLE DATE	7-May-09					11-Nov-09					6-May-09					10-Nov-09					10-Nov-09				
		DEPTH	0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft				
		SAMPLE PURPOSE	REG					REG					REG					REG					FD				
Parameter	Filtered	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Chloromethane	N	µg/L	3.1	10	3.1	U	U	3.1	10	3.1	U	U	6.1	20	6.1	U	U	394	20	6.1			467	20	6.1		
Cyclohexane	N	µg/L																									
Dibromo-3-chloropropane, 1,2-	N	µg/L																									
Dibromochloromethane	N	µg/L	1	5	1	U	U	0.2	1	0.2	U	U	2	10	2	U	U	2	10	2	U	U	2	10	2	U	U
Dibromoethane, 1,2-	N	µg/L																									
Dichlorobenzene, 1,2-	N	µg/L																									
Dichlorobenzene, 1,3-	N	µg/L																									
Dichlorobenzene, 1,4-	N	µg/L																									
Dichlorodifluoromethane	N	µg/L																									
Dichloroethane, 1,1-	N	µg/L	1.2	5	1.2	U	U	0.24	1	0.24	U	U	2.4	10	2.4	U	U	2.4	10	2.4	U	U	2.4	10	2.4	U	U
Dichloroethane, 1,2-	N	µg/L	1.7	5	1.7	U	U	0.34	1	0.34	U	U	3.4	10	3.4	U	U	3.4	10	3.4	U	U	3.4	10	3.4	U	U
Dichloroethene, 1,1-	N	µg/L	2.7	5	2.7	U	U	0.54	1	0.54	U	U	5.4	10	5.4	U	U	5.4	10	5.4	U	U	5.4	10	5.4	U	U
Dichloroethene, cis-1,2-	N	µg/L	1	5	1	U	U	0.2	1	0.2	U	U	2	10	2	U	U	2	10	2	U	U	2	10	2	U	U
Dichloroethene, trans-1,2-	N	µg/L	2.3	5	2.3	U	U	0.45	1	0.45	U	U	4.5	10	4.5	U	U	4.5	10	4.5	U	U	4.5	10	4.5	U	U
Dichloropropane, 1,2-	N	µg/L	1.1	5	1.1	U	U	0.21	1	0.21	U	U	2.1	10	2.1	U	U	2.1	10	2.1	U	U	2.1	10	2.1	U	U
Dichloropropene, cis-1,3-	N	µg/L	1.1	5	1.1	U	U	0.21	1	0.21	U	U	2.1	10	2.1	U	U	2.1	10	2.1	U	U	2.1	10	2.1	U	U
Dichloropropene, trans-1,3-	N	µg/L	1.1	5	1.1	U	U	2.9	1	0.21			2.1	10	2.1	U	U	2.1	10	2.1	U	U	2.1	10	2.1	U	U
Ethylbenzene	N	µg/L	151	5	2.2			148	5	2.2			128	10	4.3			144	10	4.3			160	10	4.3		
Hexanone, 2-	N	µg/L	25	50	25	U	U	5	10	5	U	U	50	100	50	U	U	50	100	50	U	U	50	100	50	U	U
Isopropylbenzene	N	µg/L																									
METHYL ACETATE	N	µg/L																									
Methyl Tertiary Butyl Ether	N	µg/L																									
Methyl-2-pentanone, 4-	N	µg/L	10	25	10	U	U	2	5	2	U	U	20	50	20	U	U	20	50	20	U	U	20	50	20	U	U
Methylcyclohexane	N	µg/L																									
Methylene chloride	N	µg/L	6.7	25	5	JB	B	1	5	1	U	U	10	50	10	U	U	10	50	10	U	U	10	50	10	U	U
Styrene	N	µg/L	1.8	5	1.8	U	U	0.36	1	0.36	U	U	3.6	10	3.6	U	U	3.6	10	3.6	U	U	3.6	10	3.6	U	U
Tetrachloroethane, 1,1,2,2-	N	µg/L	1.1	5	1.1	U	U	0.21	1	0.21	U	U	2.1	10	2.1	U	U	2.1	10	2.1	U	U	2.1	10	2.1	U	U
Tetrachloroethene	N	µg/L	1.1	5	1.1	U	U	0.22	1	0.22	U	U	2.2	10	2.2	U	U	2.2	10	2.2	U	U	2.2	10	2.2	U	U
Toluene	N	µg/L	399	5	1.8			352	5	1.8			516	10	3.5			586	10	3.5		J	625	10	3.5		
Trichlorobenzene, 1,2,4-	N	µg/L																									
Trichloroethane, 1,1,1-	N	µg/L	1.7	5	1.7	U	U	0.33	1	0.33	U	U	3.3	10	3.3	U	U	3.3	10	3.3	U	U	3.3	10	3.3	U	U
Trichloroethane, 1,1,2-	N	µg/L	1.3	5	1.3	U	U	0.26	1	0.26	U	U	2.6	10	2.6	U	U	2.6	10	2.6	U	U	2.6	10	2.6	U	U
Trichloroethene	N	µg/L	1.6	5	1.6	U	U	0.32	1	0.32	U	U	3.2	10	3.2	U	U	3.2	10	3.2	U	U	3.2	10	3.2	U	U
Trichlorofluoromethane	N	µg/L																									
Trichlorotrifluoroethane	N	µg/L																									
Vinyl chloride	N	µg/L	1.5	5	1.5	U	U	0.3	1	0.3	U	U	3	10	3	U	U	3	10	3	U	U	3	10	3	U	U
Xylenes, total	N	µg/L	740	15	5.8			710	15	5.8			680	30	12			775	30	12			849	30	12		
WATER QUALITY																											
Alkalinity	N	ppm																									
Alkalinity, Carbonate	N	µg/L	805000	5000	2500			1040000	25000	13000			606000	5000	2500			670000	25000	13000			600000	25000	13000		
Chloride	N	ppm	753	40	20			18.6	2	1			4410	100	50			6070	200	100		J	4410	200	100		J
Cyanide, total	N	ppm	0.041	0.01	0.005		J	0.025	0.05	0.025	U	U						0.005	0.01	0.005	U	U	0.005	0.01	0.005	U	U
Hardness	N	ppm																									
HARDNESS (as CaCO3)	N	ppm	1120	4	4			1150	4	4			3350	4	4												
Nitrate	N	ppm																									
Nitrate-Nitrite	N	ppm	0.093	0.1	0.037	B	J	1.5	0.1	0.03			0.37	1	0.37	U	U	0.15	0.1	0.03		J	0.2	0.1	0.03		J
Sulfate	N	ppm	42.3	2	1			2.1	2	1		J	17.6	2	1			100	200	100	U	U	100	200	100	U	U
Total dissolved solids	N	ppm	2250	1000	100			2600	1000	100			8270	1000	100			12200	1000	100			9520	1000	100		
Total suspended solids	N	ppm	6	10	4	B	J	30	10	4			190	100	40			145	10	4			113	10	4		
Turbidity	N	NTU	98.4	4	4		J	44	4	4		J	29.4	1	1			51.8	2	2		J	32.8	2	2		J

Table E-2

Bedrock Groundwater Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

C - Degrees Celcius.
FD - Field duplicate.
LQ - Laboratory qualifier.
MDL - Method detection limit.
µg/L - Microgram(s) per liter.
mS/cm - Millisiemen(s)/centimeter.
mV - Millivolts.
NTU - Nephalometric turbidity units.
REG - Regular sample.
RL - Reporting limit.
VQ - Validation qualifier.

Validation Qualifiers:
U - Nondetect.
J - Estimated Concentration.
UJ - Nondetected; detection limit is estimated.
B - Analyte also found in blank.
R - Rejected.

Table E-3

Overburden Groundwater Monitoring Well Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

		LOCATION CODE	1SLA-MW01					1SLA-MW02					1SLA-MW02					1SLA-MW03					1SLA-MW03				
		SAMPLE NO	SL3090					SL3081					SL3091					SL3082					SL3092				
		SAMPLE DATE	9-Nov-09					8-May-09					10-Nov-09					6-May-09					10-Nov-09				
		DEPTH	0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft				
		SAMPLE PURPOSE	REG					REG					REG					REG					REG				
Parameter	Filtered	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
EXPLOSIVES																											
Amino-2,6-dinitrotoluene, 4-	N	µg/L	0.048	0.19	0.048	U	U	0.048	0.19	0.048	U	U	0.05	0.2	0.05	U	U	0.049	0.19	0.049	U	U	0.048	0.19	0.048	U	U
Amino-4,6-dinitrotoluene, 2-	N	µg/L	0.073	0.19	0.073	U	U	0.074	0.19	0.074	U	U	0.076	0.2	0.076	U	U	0.075	0.19	0.075	U	U	0.074	0.19	0.074	U	U
Dinitrobenzene, 1,3-	N	µg/L	0.049	0.19	0.049	U	U	0.049	0.19	0.049	U	U	0.05	0.2	0.05	U	U	0.05	0.19	0.05	U	U	0.049	0.19	0.049	U	U
Dinitrotoluene, 2,4-	N	µg/L	0.062	0.19	0.062	U	U	0.062	0.19	0.062	U	U	0.064	0.2	0.064	U	U	0.063	0.19	0.063	U	U	0.062	0.19	0.062	U	U
Dinitrotoluene, 2,6-	N	µg/L	0.089	0.19	0.089	U	U	0.089	0.19	0.089	U	U	0.092	0.2	0.092	U	U	0.09	0.19	0.09	U	U	0.089	0.19	0.089	U	U
HMX	N	µg/L	0.1	0.19	0.1	U	U	0.1	0.19	0.1	U	U	0.11	0.2	0.11	U	U	0.11	0.19	0.11	U	U	0.1	0.19	0.1	U	U
Nitrobenzene	N	µg/L	0.048	0.19	0.048	U	U	0.048	0.19	0.048	U	U	0.05	0.2	0.05	U	U	0.049	0.19	0.049	U	U	0.048	0.19	0.048	U	U
Nitrotoluene, 2-	N	µg/L	0.061	0.19	0.061	U	U	0.062	0.19	0.062	U	U	0.063	0.2	0.063	U	U	0.062	0.19	0.062	U	U	0.062	0.19	0.062	U	U
Nitrotoluene, 3-	N	µg/L	0.092	0.19	0.092	U	U	0.093	0.19	0.093	U	U	0.096	0.2	0.096	U	U	0.094	0.19	0.094	U	U	0.093	0.19	0.093	U	U
Nitrotoluene, 4-	N	µg/L	0.072	0.19	0.072	U	U	0.073	0.19	0.073	U	U	0.075	0.2	0.075	U	U	0.074	0.19	0.074	U	U	0.073	0.19	0.073	U	U
RDX	N	µg/L	0.071	0.19	0.071	U	U	0.072	0.19	0.072	U	U	0.074	0.2	0.074	U	U	0.073	0.19	0.073	U	U	0.072	0.19	0.072	U	U
Tetryl	N	µg/L	0.074	0.19	0.074	U	U	0.075	0.19	0.075	U	U	0.077	0.2	0.077	U	U	0.076	0.19	0.076	U	U	0.075	0.19	0.075	U	U
Trinitrobenzene, 1,3,5-	N	µg/L	0.048	0.19	0.048	U	U	0.048	0.19	0.048	U	U	0.05	0.2	0.05	U	U	0.049	0.19	0.049	U	U	0.048	0.19	0.048	U	U
Trinitrotoluene, 2,4,6-	N	µg/L	0.066	0.19	0.066	U	U	0.066	0.19	0.066	U	U	0.068	0.2	0.068	U	U	0.067	0.19	0.067	U	U	0.066	0.19	0.066	U	U
FIELD TESTS																											
Dissolved Oxygen	N	mg/L	1.68	0.3				6.28	0.3				9.09	0.3				6.64	0.3				4.11	0.3			
FERROUS IRON	N	mg/L	0	0.042				0	0.042				0	0.042				0	0.042				0	0.042			
Oxidation Reduction Potential	N	mV	1	0.02				38.1	0.02				-23.1	0.02				-49.6	0.02				-35.1	0.02			
pH	N	pH_units	6.96	0				7.09	0				7.34	0				7.64	0				7.59	0			
Specific Conductivity	N	mS/cm	4.57	0				6.231	0				3.04	0				0.763	0				0.668	0			
Temperature	N	C	15.24	0				14.16	0				10.97	0				10.35	0				10.72	0			
Turbidity	N	NTU	4.2	10				40.1	10				14.4	10				96.6	10				-3	10			
METALS (UNFILTERED)																											
Aluminum	N	µg/L	112	200	11	B	J	117	200	11	B	J	497	200	11			353	200	11			317	200	11		
Antimony	N	µg/L	4.5	6	4.5	U	U	4.5	6	4.5	U	U	4.5	6	4.5	U	U	4.5	6	4.5	U	U	4.5	6	4.5	U	U
Arsenic	N	µg/L	3.6	10	3.6	U	U	3.6	10	3.6	U	U	3.6	10	3.6	U	U	3.6	10	3.6	U	U	3.6	10	3.6	U	U
Barium	N	µg/L	49.5	200	5	B	J	120	200	5	B	J	126	200	5	B	J	15.4	200	5	B	J	89.9	200	5	B	J
Beryllium	N	µg/L	1	4	1	U	U	1	4	1	U	U	1	4	1	U	U	1	4	1	U	U	1	4	1	U	U
Cadmium	N	µg/L	1	5	1	U	U	1	5	1	U	U	1	5	1	U	U	1	5	1	U	U	1	5	1	U	U
Calcium	N	µg/L	278000	1000	100			174000	1000	100			171000	1000	100			57100	1000	100			52500	1000	100		
Chromium	N	µg/L	1.6	10	1.6	U	U	1.6	10	1.6	U	U	1.6	10	1.6	U	U	1.6	10	1.6	U	U	1.6	10	1.6	U	U
Cobalt	N	µg/L	21.8	50	0.83	B	J	4.6	50	0.83	B	J	8.4	50	0.83	B	J	0.83	50	0.83	U	U	0.83	50	0.83	U	U
Copper	N	µg/L	2.1	25	2.1	U	U	2.1	25	2.1	U	U	2.1	25	2.1	U	U	2.1	25	2.1	U	U	2.1	25	2.1	U	U
Iron	N	µg/L	23	300	23	U	U	23	300	23	U	U	737	300	23		J	520	300	23			568	300	23		J
Lead	N	µg/L	2	5	2	U	U	2.7	5	2	B	J	2	5	2	U	U	2	5	2	U	U	2	5	2	U	U
Magnesium	N	µg/L	137000	5000	100			132000	5000	100			126000	5000	100			13500	5000	100			17100	5000	100		
Manganese	N	µg/L	401	15	0.5			112	15	0.5			186	15	0.5			111	15	0.5			350	15	0.5		
Mercury	N	µg/L	0.14	1	0.14	U	U	0.14	1	0.14	U	UJ	0.14	1	0.14	U	U	0.14	1	0.14	U	U	0.14	1	0.14	U	U
Nickel	N	µg/L	73.8	40	2.3			23.1	40	2.3	B	J	34.6	40	2.3	B	J	2.3	40	2.3	U	U	2.4	40	2.3	B	J
Potassium	N	µg/L	44800	10000	100		J	89900	20000	200			101000	20000	200		J	3890	10000	100	B	J	11800	10000	100		J
Selenium	N	µg/L	6.7	10	3.1	B	J	4.7	10	3.1	B	J	3.1	10	3.1	U	UJ	3.1	10	3.1	U	U	3.1	10	3.1	U	UJ
Silver	N	µg/L	1.2	10	1.2	U	U	1.2	10	1.2	U	U	1.2	10	1.2	U	U	1.2	10	1.2	U	U	1.2	10	1.2	U	U
Sodium	N	µg/L	188000	40000	2000			650000	100000	5000			677000	200000	10000			8980	10000	500	B	J	41700	10000	500		
Thallium	N	µg/L	4.4	10	3.4	B	J	3.4	20	3.4	U	U	3.4	10	3.4	U	U	3.4	20	3.4	U	U	3.4	10	3.4	U	U
Vanadium	N	µg/L	0.66	50	0.66	U	U	0.99	50	0.66	B	J	1.7	50	0.66	B	J	1	50	0.66	B	J	1.2	50	0.66	B	J
Zinc	N	µg/L	3.8	20	3.8	U	U	13.4	20	3.8	B	J	3.8	20	3.8	U	U	10.9	20	3.8	B	B	8.1	20	3.8	B	J
METALS (FILTERED)																											
Aluminum	Y	µg/L	11.6	200	11	B	J	17.9	200	11	B	J	46	200	11	B	J	11	200	11	U	U	11	200	11	U	U
Antimony	Y	µg/L	4.5	6	4.5	U	U	4.5	6	4.5	U	U	4.5	6	4.5	U	U	4.5	6	4.5	U	U	4.5	6	4.5	U	U
Arsenic	Y	µg/L	3.6	10	3.6	U	U	3.6	10	3.6	U	U	3.6	10	3.6	U	U	3.6	10	3.6	U	U	3.6	10	3.6	U	U
Barium	Y	µg/L	51.8	200	5	B	J	116	200	5	B	J	122	200	5	B	J	13	200	5	B	J	76.2	200	5	B	J

Table E-3

Overburden Groundwater Monitoring Well Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

		LOCATION CODE	1SLA-MW01					1SLA-MW02					1SLA-MW02					1SLA-MW03					1SLA-MW03				
		SAMPLE NO	SL3090					SL3081					SL3091					SL3082					SL3092				
		SAMPLE DATE	9-Nov-09					8-May-09					10-Nov-09					6-May-09					10-Nov-09				
		DEPTH	0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft				
		SAMPLE PURPOSE	REG					REG					REG					REG					REG				
Parameter	Filtered	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Beryllium	Y	µg/L	1	4	1	U	U	1	4	1	U	U	1	4	1	U	U	1	4	1	U	U	1	4	1	U	U
Cadmium	Y	µg/L	1	5	1	U	U	1	5	1	U	U	1	5	1	U	U	1	5	1	U	U	1	5	1	U	U
Calcium	Y	µg/L	283000	1000	100			175000	1000	100			163000	1000	100			56800	1000	100			53100	1000	100		
Chromium	Y	µg/L	1.6	10	1.6	U	U	1.6	10	1.6	U	U	1.6	10	1.6	U	U	1.6	10	1.6	U	U	1.6	10	1.6	U	U
Cobalt	Y	µg/L	22.3	50	0.83	B	J	7.3	50	0.83	B	J	6.5	50	0.83	B	J	0.83	50	0.83	U	U	0.83	50	0.83	U	U
Copper	Y	µg/L	2.1	25	2.1	U	U	2.1	25	2.1	U	U	2.1	25	2.1	U	U	2.1	25	2.1	U	U	2.1	25	2.1	U	U
Iron	Y	µg/L	23	300	23	U	U	460	600	460	U	U	23	300	23	U	U	23	300	23	U	U	23	300	23	U	U
Lead	Y	µg/L	2	5	2	U	U	2	5	2	U	U	2	5	2	U	U	2	5	2	U	U	2	5	2	U	U
Magnesium	Y	µg/L	141000	5000	100			134000	5000	100			122000	5000	100			13300	5000	100			16700	5000	100		
Manganese	Y	µg/L	409	15	0.5			131	15	0.5			145	15	0.5			108	15	0.5			364	15	0.5		
Mercury	Y	µg/L	0.14	1	0.14	U	U	0.14	1	0.14	U	UJ	0.14	1	0.14	U	U	0.14	1	0.14	U	U	0.14	1	0.14	U	U
Nickel	Y	µg/L	75	40	2.3			33.7	40	2.3	B	J	31.5	40	2.3	B	J	2.3	40	2.3	U	U	2.3	40	2.3	U	U
Potassium	Y	µg/L	48400	10000	100		J	99700	20000	200			92200	20000	200		J	3550	10000	100	B	J	11300	10000	100		J
Selenium	Y	µg/L	6.4	10	3.1	B	J	4.7	10	3.1	B	J	3.1	10	3.1	U	UJ	3.1	10	3.1	U	U	3.1	10	3.1	U	UJ
Silver	Y	µg/L	1.2	10	1.2	U	U	1.2	10	1.2	U	U	1.2	10	1.2	U	U	1.2	10	1.2	U	U	1.2	10	1.2	U	U
Sodium	Y	µg/L	188000	40000	2000			644000	100000	5000			641000	200000	10000			8370	10000	500	B	J	38200	10000	500		
Thallium	Y	µg/L	3.4	10	3.4	U	U	3.4	20	3.4	U	U	3.4	10	3.4	U	U	3.4	20	3.4	U	U	3.4	10	3.4	U	U
Vanadium	Y	µg/L	0.66	50	0.66	U	U	1.2	50	0.66	B	J	0.66	50	0.66	U	U	0.66	50	0.66	U	U	0.66	50	0.66	U	U
Zinc	Y	µg/L	9	20	3.8	B	J	14.2	20	3.8	B	J	7.6	20	3.8	B	J	7.5	20	3.8	B	J	3.8	20	3.8	U	U
SEMIVOLATILES																											
3-Methylphenol and 4-Methylphenol	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Acenaphthene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Acenaphthylene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Anthracene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Benzo(a)anthracene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Benzo(a)pyrene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Benzo(b)fluoranthene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Benzo(ghi)perylene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Benzo(k)fluoranthene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Benzoic acid	N	µg/L	9.5	24	9.5	U	U	9.8	25	9.8	U	UJ	9.8	25	9.8	U	U	9.6	24	9.6	U	U	9.7	24	9.7	U	U
Benzyl alcohol	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Bis(2-chloroethoxy)methane	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Bis(2-chloroethyl)ether	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Bis(2-chloroisopropyl)ether	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Bis(2-ethylhexyl)phthalate	N	µg/L	1.9	4.8	1.9	U	U	2	4.9	2	U	UJ	2	4.9	2	U	U	1.9	4.8	1.9	U	U	1.9	4.9	1.9	U	U
Bromophenyl phenyl ether, 4-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Butyl benzyl phthalate	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Carbazole	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Chloro-3-methylphenol, 4-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Chloroaniline, 4-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Chloronaphthalene, 2-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Chlorophenol, 2-	N	µg/L	1.1	4.8	1.1	U	U	1.2	4.9	1.2	U	UJ	1.2	4.9	1.2	U	U	1.2	4.8	1.2	U	U	1.2	4.9	1.2	U	U
Chlorophenyl phenyl ether, 4-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Chrysene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Dibenz(a,h)anthracene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Dibenzofuran	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Dichlorobenzene, 1,2-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Dichlorobenzene, 1,3-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Dichlorobenzene, 1,4-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Dichlorobenzidine, 3,3'-	N	µg/L	1.9	9.5	1.9	U	U	2	9.8	2	U	UJ	2	9.8	2	U	U	1.9	9.6	1.9	U	U	1.9	9.7	1.9	U	U
Dichlorophenol, 2,4-	N	µg/L	1.2	4.8	1.2	U	U	1.3	4.9	1.3	U	UJ	1.3	4.9	1.3	U	U	1.2	4.8	1.2	U	U	1.3	4.9	1.3	U	U
Diethyl phthalate	N	µg/L	1.9	4.8	1.9	U	U	2	4.9	2	U	UJ	2	4.9	2	U	U	1.9	4.8	1.9	U	U	1.9	4.9	1.9	U	U

Table E-3

Overburden Groundwater Monitoring Well Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

		LOCATION CODE	1SLA-MW01					1SLA-MW02					1SLA-MW02					1SLA-MW03					1SLA-MW03				
		SAMPLE NO	SL3090					SL3081					SL3091					SL3082					SL3092				
		SAMPLE DATE	9-Nov-09					8-May-09					10-Nov-09					6-May-09					10-Nov-09				
		DEPTH	0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft				
		SAMPLE PURPOSE	REG					REG					REG					REG					REG				
Parameter	Filtered	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Dimethyl phthalate	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Dimethylphenol, 2,4-	N	µg/L	1.1	4.8	1.1	U	U	1.2	4.9	1.2	U	UJ	1.2	4.9	1.2	U	U	1.2	4.8	1.2	U	U	1.2	4.9	1.2	U	U
Di-n-butyl phthalate	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Dinitro-2-methylphenol, 4,6-	N	µg/L	3.8	9.5	3.8	U	U	3.9	9.8	3.9	U	UJ	3.9	9.8	3.9	U	U	3.8	9.6	3.8	U	U	3.9	9.7	3.9	U	U
Dinitrophenol, 2,4-	N	µg/L	9.5	24	9.5	U	U	9.8	25	9.8	U	UJ	9.8	25	9.8	U	U	9.6	24	9.6	U	U	9.7	24	9.7	U	U
Dinitrotoluene, 2,4-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Dinitrotoluene, 2,6-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Di-n-octyl phthalate	N	µg/L	1.4	4.8	1.4	U	U	1.5	4.9	1.5	U	UJ	1.5	4.9	1.5	U	U	1.4	4.8	1.4	U	U	1.5	4.9	1.5	U	U
Fluoranthene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Fluorene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Hexachlorobenzene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Hexachlorobutadiene	N	µg/L	2.4	4.8	2.4	U	U	2.5	4.9	2.5	U	UJ	2.5	4.9	2.5	U	U	2.4	4.8	2.4	U	U	2.4	4.9	2.4	U	U
Hexachlorocyclopentadiene	N	µg/L	1.2	4.8	1.2	U	U	1.3	4.9	1.3	U	UJ	1.3	4.9	1.3	U	U	1.2	4.8	1.2	U	U	1.3	4.9	1.3	U	U
Hexachloroethane	N	µg/L	2.4	4.8	2.4	U	U	2.5	4.9	2.5	U	UJ	2.5	4.9	2.5	U	U	2.4	4.8	2.4	U	U	2.4	4.9	2.4	U	U
Indeno(1,2,3-cd)pyrene	N	µg/L	1	4.8	1	U	U	1.1	4.9	1.1	U	UJ	1.1	4.9	1.1	U	U	1.1	4.8	1.1	U	U	1.1	4.9	1.1	U	U
Isophorone	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Methylnaphthalene, 2-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Methylphenol, 2-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Naphthalene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Nitroaniline, 2-	N	µg/L	1.9	9.5	1.9	U	U	2	9.8	2	U	UJ	2	9.8	2	U	U	1.9	9.6	1.9	U	U	1.9	9.7	1.9	U	U
Nitroaniline, 3-	N	µg/L	1.9	9.5	1.9	U	U	2	9.8	2	U	UJ	2	9.8	2	U	U	1.9	9.6	1.9	U	U	1.9	9.7	1.9	U	U
Nitroaniline, 4-	N	µg/L	1.9	9.5	1.9	U	U	2	9.8	2	U	UJ	2	9.8	2	U	U	1.9	9.6	1.9	U	U	1.9	9.7	1.9	U	U
Nitrobenzene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Nitrophenol, 2-	N	µg/L	1.2	4.8	1.2	U	U	1.3	4.9	1.3	U	UJ	1.3	4.9	1.3	U	U	1.2	4.8	1.2	U	U	1.3	4.9	1.3	U	U
Nitrophenol, 4-	N	µg/L	9.5	24	9.5	U	U	9.8	25	9.8	U	UJ	9.8	25	9.8	U	U	9.6	24	9.6	U	U	9.7	24	9.7	U	U
n-Nitroso-di-n-propylamine	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
n-Nitrosodiphenylamine	N	µg/L	1.9	4.8	1.9	U	U	2	4.9	2	U	UJ	2	4.9	2	U	U	1.9	4.8	1.9	U	U	1.9	4.9	1.9	U	U
Pentachlorophenol	N	µg/L	9.5	24	9.5	U	U	9.8	25	9.8	U	UJ	9.8	25	9.8	U	U	9.6	24	9.6	U	U	9.7	24	9.7	U	U
Phenanthrene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Phenol	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Pyrene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Trichlorobenzene, 1,2,4-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	UJ	0.98	4.9	0.98	U	U	0.96	4.8	0.96	U	U	0.97	4.9	0.97	U	U
Trichlorophenol, 2,4,5-	N	µg/L	1.3	4.8	1.3	U	U	1.4	4.9	1.4	U	UJ	1.4	4.9	1.4	U	U	1.3	4.8	1.3	U	U	1.4	4.9	1.4	U	U
Trichlorophenol, 2,4,6-	N	µg/L	1.3	4.8	1.3	U	U	1.4	4.9	1.4	U	UJ	1.4	4.9	1.4	U	U	1.3	4.8	1.3	U	U	1.4	4.9	1.4	U	U
VOLATILES																											
Acetone	N	µg/L	10	25	10	U	R	10	25	10	U	R	10	25	10	U	R	10	25	10	U	U	10	25	10	U	R
Benzene	N	µg/L	0.4	1	0.4	U	U	0.4	1	0.4	U	U	0.4	1	0.4	U	U	0.4	1	0.4	U	U	0.4	1	0.4	U	U
Bromodichloromethane	N	µg/L	0.2	1	0.2	U	U	0.2	1	0.2	U	U	0.2	1	0.2	U	U	0.2	1	0.2	U	U	0.2	1	0.2	U	U
Bromoform	N	µg/L	0.33	1	0.33	U	U	0.33	1	0.33	U	U	0.33	1	0.33	U	U	0.33	1	0.33	U	U	0.33	1	0.33	U	U
Bromomethane	N	µg/L	0.78	2	0.78	U	U	0.78	2	0.78	U	U	0.78	2	0.78	U	U	0.78	2	0.78	U	U	0.78	2	0.78	U	U
Butanone, 2-	N	µg/L	2	5	2	U	U	2	5	2	U	U	2	5	2	U	U	2	5	2	U	U	2	5	2	U	U
Carbon disulfide	N	µg/L	0.4	2	0.4	U	U	0.4	2	0.4	U	U	0.4	2	0.4	U	U	1	2	0.4	J	J	0.4	2	0.4	U	U
Carbon tetrachloride	N	µg/L	0.22	1	0.22	U	U	0.22	1	0.22	U	U	0.22	1	0.22	U	U	0.22	1	0.22	U	U	0.22	1	0.22	U	U
Chlorobenzene	N	µg/L	0.22	1	0.22	U	U	0.22	1	0.22	U	U	0.22	1	0.22	U	U	0.22	1	0.22	U	U	0.22	1	0.22	U	U
Chloroethane	N	µg/L	0.48	2	0.48	U	U	0.48	2	0.48	U	U	0.48	2	0.48	U	U	0.48	2	0.48	U	U	0.48	2	0.48	U	U
Chloroform	N	µg/L	0.28	1	0.28	U	U	0.28	1	0.28	U	U	0.28	1	0.28	U	U	0.28	1	0.28	U	U	0.28	1	0.28	U	U
Chloromethane	N	µg/L	0.61	2	0.61	U	U	0.61	2	0.61	U	U	0.61	2	0.61	U	U	0.61	2	0.61	U	U	0.61	2	0.61	U	U
Dibromochloromethane	N	µg/L	0.2	1	0.2	U	U	0.2	1	0.2	U	U	0.2	1	0.2	U	U	0.2	1	0.2	U	U	0.2	1	0.2	U	U
Dichloroethane, 1,1-	N	µg/L	0.24	1	0.24	U	U	0.24	1	0.24	U	U	0.24	1	0.24	U	U	0.24	1	0.24	U	U	0.24	1	0.24	U	U
Dichloroethane, 1,2-	N	µg/L	0.34	1	0.34	U	U	0.34	1	0.34	U	U	0.34	1	0.34	U	U	0.34	1	0.34	U	U	0.34	1	0.34	U	U
Dichloroethene, 1,1-	N	µg/L	0.54	1	0.54	U	U	0.54	1	0.54	U	U	0.54	1	0.54	U	U	0.54	1	0.54	U	U	0.54	1	0.54	U	U
Dichloroethene, cis-1,2-	N	µg/L	0.2	1	0.2	U	U	0.2	1	0.2	U	U	0.2	1	0.2	U	U	0.2	1	0.2	U	U	0.2	1	0.2	U	U

Table E-3

Overburden Groundwater Monitoring Well Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

		LOCATION CODE	1SLA-MW01					1SLA-MW02					1SLA-MW02					1SLA-MW03					1SLA-MW03				
		SAMPLE NO	SL3090					SL3081					SL3091					SL3082					SL3092				
		SAMPLE DATE	9-Nov-09					8-May-09					10-Nov-09					6-May-09					10-Nov-09				
		DEPTH	0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft				
		SAMPLE PURPOSE	REG					REG					REG					REG					REG				
Parameter	Filtered	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Dichloroethene, trans-1,2-	N	µg/L	0.45	1	0.45	U	U	0.45	1	0.45	U	U	0.45	1	0.45	U	U	0.45	1	0.45	U	U	0.45	1	0.45	U	U
Dichloropropane, 1,2-	N	µg/L	0.21	1	0.21	U	U	0.21	1	0.21	U	U	0.21	1	0.21	U	U	0.21	1	0.21	U	U	0.21	1	0.21	U	U
Dichloropropene, cis-1,3-	N	µg/L	0.21	1	0.21	U	U	0.21	1	0.21	U	U	0.21	1	0.21	U	U	0.21	1	0.21	U	U	0.21	1	0.21	U	U
Dichloropropene, trans-1,3-	N	µg/L	0.21	1	0.21	U	U	0.21	1	0.21	U	U	0.21	1	0.21	U	U	0.21	1	0.21	U	U	0.21	1	0.21	U	U
Ethylbenzene	N	µg/L	0.43	1	0.43	U	U	0.43	1	0.43	U	U	0.43	1	0.43	U	U	0.57	1	0.43	J	J	0.43	1	0.43	U	U
Hexanone, 2-	N	µg/L	5	10	5	U	U	5	10	5	U	UJ	5	10	5	U	U	5	10	5	U	U	5	10	5	U	U
Methyl-2-pentanone, 4-	N	µg/L	2	5	2	U	U	2	5	2	U	U	2	5	2	U	U	2	5	2	U	U	2	5	2	U	U
Methylene chloride	N	µg/L	1	5	1	U	U	1	5	1	U	U	1	5	1	U	U	1	5	1	U	U	1	5	1	U	U
Styrene	N	µg/L	0.36	1	0.36	U	U	0.36	1	0.36	U	U	0.36	1	0.36	U	U	0.36	1	0.36	U	U	0.36	1	0.36	U	U
Tetrachloroethane, 1,1,2,2-	N	µg/L	0.21	1	0.21	U	U	0.21	1	0.21	U	U	0.21	1	0.21	U	U	0.21	1	0.21	U	U	0.21	1	0.21	U	U
Tetrachloroethene	N	µg/L	0.22	1	0.22	U	U	0.22	1	0.22	U	U	0.22	1	0.22	U	U	0.22	1	0.22	U	U	0.22	1	0.22	U	U
Toluene	N	µg/L	0.35	1	0.35	U	U	0.35	1	0.35	U	U	0.35	1	0.35	U	U	1	1	0.35			0.35	1	0.35	U	U
Trichloroethane, 1,1,1-	N	µg/L	0.33	1	0.33	U	U	0.33	1	0.33	U	U	0.33	1	0.33	U	U	0.33	1	0.33	U	U	0.33	1	0.33	U	U
Trichloroethane, 1,1,2-	N	µg/L	0.26	1	0.26	U	U	0.26	1	0.26	U	U	0.26	1	0.26	U	U	0.26	1	0.26	U	U	0.26	1	0.26	U	U
Trichloroethene	N	µg/L	0.32	1	0.32	U	U	0.32	1	0.32	U	U	0.32	1	0.32	U	U	0.32	1	0.32	U	U	0.32	1	0.32	U	U
Vinyl chloride	N	µg/L	0.3	1	0.3	U	U	0.3	1	0.3	U	U	0.3	1	0.3	U	U	0.3	1	0.3	U	U	0.3	1	0.3	U	U
Xylenes, total	N	µg/L	1.2	3	1.2	U	U	1.2	3	1.2	U	U	1.2	3	1.2	U	U	2.1	3	1.2	J	J	1.2	3	1.2	U	U
WATER QUALITY																											
Alkalinity, Carbonate	N	µg/L	470000	25000	13000			341000	5000	2500			518000	25000	13000			188000	5000	2500			245000	25000	13000		
Chloride	N	ppm	367	20	10		J	1340	100	50			1720	50	25		J	11.3	2	1			86.7	2	1		J
Cyanide, total	N	ppm	0.005	0.01	0.005	U	U	0.016	0.01	0.005			0.005	0.01	0.005	U	U	0.046	0.01	0.005		B	0.005	0.01	0.005	U	U
HARDNESS (as CaCO3)	N	ppm						975	4	4								198	4	4							
Nitrate-Nitrite	N	ppm	0.045	0.1	0.03	B	J	0.039	0.1	0.037	B	J	0.036	0.1	0.03	B	J	0.37	1	0.37	U	U	0.03	0.1	0.03	U	UJ
Sulfate	N	ppm	1270	20	10			38.2	2	1			26	50	25	B	J	8.5	2	1			16	2	1		
Total dissolved solids	N	ppm	3900	1000	100			2790	1000	100			2630	1000	100			213	100	10			362	100	10		
Total suspended solids	N	ppm	5	10	4	B	J	13	10	4			22	10	4			11	10	4			12	10	4		
Turbidity	N	NTU	2.3	1	1		J	3.5	1	1			7.1	1	1		J	7.2	1	1			5.4	1	1		J

Table E-3

Overburden Groundwater Monitoring Well Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

		LOCATION CODE	1SLB-MW01					1SLB-MW01					1SLB-MW02					1SLB-MW02				
		SAMPLE NO	SL3100					SL3102					SL3101					SL3103				
		SAMPLE DATE	18-Nov-09					4-May-10					17-Nov-09					4-May-10				
		DEPTH	0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft				
		SAMPLE PURPOSE	REG					REG					REG					REG				
Parameter	Filtered	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
EXPLOSIVES																						
Amino-2,6-dinitrotoluene, 4-	N	µg/L	0.049	0.2	0.049	U	U	0.082	0.2	0.082	U	U	0.049	0.19	0.049	U	U	0.08	0.19	0.08	U	U
Amino-4,6-dinitrotoluene, 2-	N	µg/L	0.075	0.2	0.075	U	U	0.091	0.2	0.091	U	U	0.075	0.19	0.075	U	U	0.088	0.19	0.088	U	U
Dinitrobenzene, 1,3-	N	µg/L	0.05	0.2	0.05	U	U	0.05	0.2	0.05	U	U	0.05	0.19	0.05	U	U	0.049	0.19	0.049	U	U
Dinitrotoluene, 2,4-	N	µg/L	0.064	0.2	0.064	U	U	0.05	0.2	0.05	U	U	0.063	0.19	0.063	U	U	0.049	0.19	0.049	U	U
Dinitrotoluene, 2,6-	N	µg/L	0.091	0.2	0.091	U	U	0.055	0.2	0.055	U	U	0.09	0.19	0.09	U	U	0.053	0.19	0.053	U	U
HMX	N	µg/L	0.11	0.2	0.11	U	U	0.059	0.2	0.059	U	U	0.11	0.19	0.11	U	U	0.057	0.19	0.057	U	U
Nitrobenzene	N	µg/L	0.049	0.2	0.049	U	U	0.056	0.2	0.056	U	U	0.049	0.19	0.049	U	U	0.054	0.19	0.054	U	U
Nitrotoluene, 2-	N	µg/L	0.063	0.2	0.063	U	U	0.086	0.2	0.086	U	U	0.062	0.19	0.062	U	U	0.18	0.19	0.083	J	J
Nitrotoluene, 3-	N	µg/L	0.095	0.2	0.095	U	U	0.074	0.2	0.074	U	U	0.094	0.19	0.094	U	U	0.072	0.19	0.072	U	U
Nitrotoluene, 4-	N	µg/L	0.075	0.2	0.075	U	U	0.067	0.2	0.067	U	U	0.074	0.19	0.074	U	U	0.19	0.19	0.19	U	U
RDX	N	µg/L	0.074	0.2	0.074	U	U	0.069	0.2	0.069	U	U	0.073	0.19	0.073	U	U	0.067	0.19	0.067	U	U
Tetryl	N	µg/L	0.076	0.2	0.076	U	U	0.051	0.2	0.051	U	U	0.076	0.19	0.076	U	U	0.05	0.19	0.05	U	U
Trinitrobenzene, 1,3,5-	N	µg/L	0.049	0.2	0.049	U	U	0.05	0.2	0.05	U	U	0.049	0.19	0.049	U	U	0.049	0.19	0.049	U	U
Trinitrotoluene, 2,4,6-	N	µg/L	0.068	0.2	0.068	U	U	0.052	0.2	0.052	U	U	0.067	0.19	0.067	U	U	0.05	0.19	0.05	U	U
FIELD TESTS																						
Dissolved Oxygen	N	mg/L	6.97	0.3									3.92	0.3								
FERROUS IRON	N	mg/L	0	0.042									0	0.042								
Oxidation Reduction Potential	N	mV	-40	0.02									-47.3	0.02								
pH	N	pH_units	7.57	0									7.51	0								
Specific Conductivity	N	mS/cm	0.697	0									0.494	0								
Temperature	N	C	10.58	0									12.34	0								
Turbidity	N	NTU	1.1	10									9	10								
METALS (UNFILTERED)																						
Aluminum	N	µg/L	24.6	200	11	B	J	20	200	20	U	U	69.8	200	11	B	J	20	200	20	U	U
Antimony	N	µg/L	4.5	6	4.5	U	U	2	6	2	U	U	4.5	6	4.5	U	U	2	6	2	U	U
Arsenic	N	µg/L	3.6	10	3.6	U	U	2	10	2	U	U	3.6	10	3.6	U	U	2	10	2	U	U
Barium	N	µg/L	98.2	200	5	B	J	23.6	200	5	B	J	22.7	200	5	B	J	22.3	200	5	B	J
Beryllium	N	µg/L	1	4	1	U	U	1	4	1	U	U	1	4	1	U	U	1	4	1	U	U
Cadmium	N	µg/L	1	5	1	U	U	1	5	1	U	U	1	5	1	U	U	1	5	1	U	U
Calcium	N	µg/L	88600	1000	100		J	94100	1000	100			63400	1000	100		J	58200	1000	100		
Chromium	N	µg/L	1.6	10	1.6	U	U	1	10	1	U	U	1.6	10	1.6	U	U	1	10	1	U	U
Cobalt	N	µg/L	0.83	50	0.83	U	U	1	50	1	U	U	0.83	50	0.83	U	U	1	50	1	U	U
Copper	N	µg/L	2.1	25	2.1	U	U	2	25	2	U	U	2.1	25	2.1	U	U	2	25	2	U	U
Iron	N	µg/L	23	300	23	U	U	30	300	30	U	U	23	300	23	U	U	41.4	300	30	B	J
Lead	N	µg/L	2	10	2	U	U	1	5	1	U	U	2.4	10	2	B	B	1	5	1	U	U
Magnesium	N	µg/L	18000	5000	100			13700	5000	100			11200	5000	100			10700	5000	100		
Manganese	N	µg/L	163	15	0.5			1	15	1	U	U	21.4	15	0.5			6.2	15	1	B	J
Mercury	N	µg/L	0.14	1	0.14	U	U	0.071	1	0.071	U	U	0.14	1	0.14	U	U	0.071	1	0.071	U	U
Nickel	N	µg/L	2.4	40	2.3	B	J	1	40	1	U	U	2.3	40	2.3	U	U	1	40	1	U	U
Potassium	N	µg/L	11100	10000	100			1520	10000	500	B	J	1260	10000	100	B	J	855	10000	500	B	J
Selenium	N	µg/L	3.6	10	3.1	B	J	2.9	10	2	B	J	4.9	10	3.1	B	J	2	10	2	U	U
Silver	N	µg/L	1.2	10	1.2	U	U	1	10	1	U	U	1.2	10	1.2	U	U	1	10	1	U	U
Sodium	N	µg/L	18300	10000	500		J	5180	10000	750	B	U	3160	10000	500	B	J	5100	10000	750	B	J
Thallium	N	µg/L	3.4	10	3.4	U	U	1.5	10	1.5	U	U	3.4	10	3.4	U	U	1.5	10	1.5	U	U
Vanadium	N	µg/L	0.66	50	0.66	U	UJ	1	50	1	U	U	0.66	50	0.66	U	UJ	1	50	1	U	U
Zinc	N	µg/L	3.8	20	3.8	U	U	5	20	5	U	U	3.8	20	3.8	U	U	5	20	5	U	U
METALS (FILTERED)																						
Aluminum	Y	µg/L	22.4	200	11	B	B	20	200	20	U	U	23.2	200	11	B	J	20	200	20	U	U
Antimony	Y	µg/L	4.5	6	4.5	U	U	2	6	2	U	U	4.5	6	4.5	U	U	2	6	2	U	U
Arsenic	Y	µg/L	3.6	10	3.6	U	U	2	10	2	U	U	3.6	10	3.6	U	U	2	10	2	U	U
Barium	Y	µg/L	101	200	5	B	J	25.6	200	5	B	J	23	200	5	B	J	22.5	200	5	B	J

Table E-3

Overburden Groundwater Monitoring Well Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

		LOCATION CODE	1SLB-MW01					1SLB-MW01					1SLB-MW02					1SLB-MW02				
		SAMPLE NO	SL3100					SL3102					SL3101					SL3103				
		SAMPLE DATE	18-Nov-09					4-May-10					17-Nov-09					4-May-10				
		DEPTH	0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft				
		SAMPLE PURPOSE	REG					REG					REG					REG				
Parameter	Filtered	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Beryllium	Y	µg/L	1	4	1	U	U	1	4	1	U	U	1	4	1	U	U	1	4	1	U	U
Cadmium	Y	µg/L	1	5	1	U	U	1	5	1	U	U	1	5	1	U	U	1	5	1	U	U
Calcium	Y	µg/L	84300	1000	100		J	97800	1000	100			60000	1000	100		J	56200	1000	100		
Chromium	Y	µg/L	1.6	10	1.6	U	U	1	10	1	U	U	1.6	10	1.6	U	U	1	10	1	U	U
Cobalt	Y	µg/L	0.83	50	0.83	U	U	1	50	1	U	U	0.83	50	0.83	U	U	1	50	1	U	U
Copper	Y	µg/L	2.1	25	2.1	U	U	2	25	2	U	U	2.1	25	2.1	U	U	2	25	2	U	U
Iron	Y	µg/L	101	300	23	B	J	30	300	30	U	U	28.2	300	23	B	J	30	300	30	U	U
Lead	Y	µg/L	2	10	2	U	U	1	5	1	U	U	2	10	2	U	U	1	5	1	U	U
Magnesium	Y	µg/L	17700	5000	100		J	14600	5000	100			10800	5000	100		J	10200	5000	100		
Manganese	Y	µg/L	162	15	0.5			1	15	1	U	U	20.3	15	0.5			6.2	15	1	B	J
Mercury	Y	µg/L	0.14	1	0.14	U	U	0.071	1	0.071	U	U	0.14	1	0.14	U	U	0.071	1	0.071	U	U
Nickel	Y	µg/L	4.2	40	2.3	B	J	1	40	1	U	U	2.3	40	2.3	U	U	1	40	1	U	U
Potassium	Y	µg/L	12100	10000	100		J	1600	10000	500	B	J	1670	10000	100	B	B	834	10000	500	B	J
Selenium	Y	µg/L	3.1	10	3.1	U	UJ	2	10	2	U	U	3.5	10	3.1	B	J	2.1	10	2	B	J
Silver	Y	µg/L	1.2	10	1.2	U	U	1	10	1	U	U	1.2	10	1.2	U	U	1	10	1	U	U
Sodium	Y	µg/L	20500	10000	500			5330	10000	750	B	U	4030	10000	500	B	J	4850	10000	750	B	J
Thallium	Y	µg/L	3.4	10	3.4	U	U	1.5	10	1.5	U	U	3.4	10	3.4	U	U	1.5	10	1.5	U	U
Vanadium	Y	µg/L	1.1	50	0.66	B	J	1	50	1	U	U	0.66	50	0.66	U	U	1	50	1	U	U
Zinc	Y	µg/L	3.8	20	3.8	U	U	5	20	5	U	U	3.8	20	3.8	U	U	5	20	5	U	U
SEMIVOLATILES																						
3-Methylphenol and 4-Methylphenol	N	µg/L	0.95	4.8	0.95	U	U	1.6	4.9	1.6	U	U	0.95	4.8	0.95	U	U	1.5	4.8	1.5	U	U
Acenaphthene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Acenaphthylene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Anthracene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Benzo(a)anthracene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Benzo(a)pyrene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Benzo(b)fluoranthene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Benzo(ghi)perylene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Benzo(k)fluoranthene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Benzoic acid	N	µg/L	9.5	24	9.5	U	U	9.8	25	9.8	U	U	9.5	24	9.5	U	U	9.5	24	9.5	U	U
Benzyl alcohol	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Bis(2-chloroethoxy)methane	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Bis(2-chloroethyl)ether	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Bis(2-chloroisopropyl)ether	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Bis(2-ethylhexyl)phthalate	N	µg/L	1.9	4.8	1.9	U	U	2	4.9	2	U	U	1.9	4.8	1.9	U	U	1.9	4.8	1.9	U	U
Bromophenyl phenyl ether, 4-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Butyl benzyl phthalate	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Carbazole	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Chloro-3-methylphenol, 4-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Chloroaniline, 4-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Chloronaphthalene, 2-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Chlorophenol, 2-	N	µg/L	1.1	4.8	1.1	U	U	0.98	4.9	0.98	U	U	1.1	4.8	1.1	U	U	0.95	4.8	0.95	U	U
Chlorophenyl phenyl ether, 4-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Chrysene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Dibenz(a,h)anthracene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Dibenzofuran	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Dichlorobenzene, 1,2-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Dichlorobenzene, 1,3-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Dichlorobenzene, 1,4-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Dichlorobenzidine, 3,3'-	N	µg/L	1.9	9.5	1.9	U	U	2	9.8	2	U	U	1.9	9.5	1.9	U	U	1.9	9.5	1.9	U	U
Dichlorophenol, 2,4-	N	µg/L	1.2	4.8	1.2	U	U	0.98	4.9	0.98	U	U	1.2	4.8	1.2	U	U	0.95	4.8	0.95	U	U
Diethyl phthalate	N	µg/L	5.3	4.8	1.9			2	4.9	2	U	U	1.9	4.8	1.9	U	U	1.9	4.8	1.9	U	U

Table E-3

Overburden Groundwater Monitoring Well Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

		LOCATION CODE	1SLB-MW01					1SLB-MW01					1SLB-MW02					1SLB-MW02				
		SAMPLE NO	SL3100					SL3102					SL3101					SL3103				
		SAMPLE DATE	18-Nov-09					4-May-10					17-Nov-09					4-May-10				
		DEPTH	0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft				
		SAMPLE PURPOSE	REG					REG					REG					REG				
Parameter	Filtered	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Dimethyl phthalate	N	µg/L	0.95	4.8	0.95	U	U	1.1	4.9	1.1	U	U	0.95	4.8	0.95	U	U	1	4.8	1	U	U
Dimethylphenol, 2,4-	N	µg/L	1.1	4.8	1.1	U	U	0.98	4.9	0.98	U	U	1.1	4.8	1.1	U	U	0.95	4.8	0.95	U	U
Di-n-butyl phthalate	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Dinitro-2-methylphenol, 4,6-	N	µg/L	3.8	9.5	3.8	U	U	0.98	9.8	0.98	U	U	3.8	9.5	3.8	U	U	0.95	9.5	0.95	U	U
Dinitrophenol, 2,4-	N	µg/L	9.5	24	9.5	U	U	9.8	25	9.8	U	U	9.5	24	9.5	U	U	9.5	24	9.5	U	U
Dinitrotoluene, 2,4-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Dinitrotoluene, 2,6-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Di-n-octyl phthalate	N	µg/L	1.4	4.8	1.4	U	U	0.98	4.9	0.98	U	U	1.4	4.8	1.4	U	U	0.95	4.8	0.95	U	U
Fluoranthene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Fluorene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Hexachlorobenzene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Hexachlorobutadiene	N	µg/L	2.4	4.8	2.4	U	U	2.5	4.9	2.5	U	U	2.4	4.8	2.4	U	U	2.5	4.8	2.5	U	U
Hexachlorocyclopentadiene	N	µg/L	1.2	4.8	1.2	U	U	4.8	9.8	4.8	U	U	1.2	4.8	1.2	U	U	4.7	9.5	4.7	U	U
Hexachloroethane	N	µg/L	2.4	4.8	2.4	U	U	2.2	4.9	2.2	U	U	2.4	4.8	2.4	U	U	2.1	4.8	2.1	U	U
Indeno(1,2,3-cd)pyrene	N	µg/L	1	4.8	1	U	U	0.98	4.9	0.98	U	U	1	4.8	1	U	U	0.95	4.8	0.95	U	U
Isophorone	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Methylnaphthalene, 2-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Methylphenol, 2-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Naphthalene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Nitroaniline, 2-	N	µg/L	1.9	9.5	1.9	U	U	0.98	4.9	0.98	U	U	1.9	9.5	1.9	U	U	0.95	4.8	0.95	U	U
Nitroaniline, 3-	N	µg/L	1.9	9.5	1.9	U	U	0.98	4.9	0.98	U	U	1.9	9.5	1.9	U	U	0.95	4.8	0.95	U	U
Nitroaniline, 4-	N	µg/L	1.9	9.5	1.9	U	U	0.98	4.9	0.98	U	U	1.9	9.5	1.9	U	U	0.95	4.8	0.95	U	U
Nitrobenzene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Nitrophenol, 2-	N	µg/L	1.2	4.8	1.2	U	U	0.98	4.9	0.98	U	U	1.2	4.8	1.2	U	U	0.95	4.8	0.95	U	U
Nitrophenol, 4-	N	µg/L	9.5	24	9.5	U	U	9.8	25	9.8	U	U	9.5	24	9.5	U	U	9.5	24	9.5	U	U
n-Nitroso-di-n-propylamine	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
n-Nitrosodiphenylamine	N	µg/L	1.9	4.8	1.9	U	U	0.98	4.9	0.98	U	U	1.9	4.8	1.9	U	U	0.95	4.8	0.95	U	U
Pentachlorophenol	N	µg/L	9.5	24	9.5	U	U	9.8	25	9.8	U	U	9.5	24	9.5	U	U	9.5	24	9.5	U	U
Phenanthrene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Phenol	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Pyrene	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Trichlorobenzene, 1,2,4-	N	µg/L	0.95	4.8	0.95	U	U	0.98	4.9	0.98	U	U	0.95	4.8	0.95	U	U	0.95	4.8	0.95	U	U
Trichlorophenol, 2,4,5-	N	µg/L	1.3	4.8	1.3	U	U	0.98	4.9	0.98	U	U	1.3	4.8	1.3	U	U	0.95	4.8	0.95	U	U
Trichlorophenol, 2,4,6-	N	µg/L	1.3	4.8	1.3	U	U	0.98	4.9	0.98	U	U	1.3	4.8	1.3	U	U	0.95	4.8	0.95	U	U
VOLATILES																						
Acetone	N	µg/L	10	25	10	U	U	10	25	10	U	R	10	25	10	U	U	10	25	10	U	R
Benzene	N	µg/L	0.4	1	0.4	U	U	0.21	1	0.21	U	U	0.4	1	0.4	U	U	0.21	1	0.21	U	U
Bromodichloromethane	N	µg/L	0.2	1	0.2	U	U	0.28	1	0.28	U	U	0.2	1	0.2	U	U	0.28	1	0.28	U	U
Bromoform	N	µg/L	0.33	1	0.33	U	U	0.24	1	0.24	U	U	0.33	1	0.33	U	U	0.24	1	0.24	U	U
Bromomethane	N	µg/L	0.78	2	0.78	U	U	0.78	2	0.78	U	U	0.78	2	0.78	U	U	0.78	2	0.78	U	U
Butanone, 2-	N	µg/L	2	5	2	U	U	2	5	2	U	U	2	5	2	U	U	2	5	2	U	U
Carbon disulfide	N	µg/L	0.4	2	0.4	U	U	0.4	2	0.4	U	U	0.4	2	0.4	U	U	0.4	2	0.4	U	U
Carbon tetrachloride	N	µg/L	0.22	1	0.22	U	U	0.34	1	0.34	U	U	0.22	1	0.22	U	U	0.34	1	0.34	U	U
Chlorobenzene	N	µg/L	0.22	1	0.22	U	U	0.2	1	0.2	U	U	0.22	1	0.22	U	U	0.2	1	0.2	U	U
Chloroethane	N	µg/L	0.48	2	0.48	U	U	0.51	2	0.51	U	U	0.48	2	0.48	U	U	0.51	2	0.51	U	U
Chloroform	N	µg/L	0.28	1	0.28	U	U	0.25	1	0.25	U	U	0.28	1	0.28	U	U	0.25	1	0.25	U	U
Chloromethane	N	µg/L	0.61	2	0.61	U	U	0.5	2	0.5	U	U	0.61	2	0.61	U	U	0.5	2	0.5	U	U
Dibromochloromethane	N	µg/L	0.2	1	0.2	U	U	0.33	1	0.33	U	U	0.2	1	0.2	U	U	0.33	1	0.33	U	U
Dichloroethane, 1,1-	N	µg/L	0.24	1	0.24	U	U	0.22	1	0.22	U	U	0.24	1	0.24	U	U	0.22	1	0.22	U	U
Dichloroethane, 1,2-	N	µg/L	0.34	1	0.34	U	U	0.33	1	0.33	U	U	0.34	1	0.34	U	U	0.33	1	0.33	U	U
Dichloroethene, 1,1-	N	µg/L	0.54	1	0.54	U	U	0.29	1	0.29	U	U	0.54	1	0.54	U	U	0.29	1	0.29	U	U
Dichloroethene, cis-1,2-	N	µg/L	0.2	1	0.2	U	U	0.32	1	0.32	U	U	0.2	1	0.2	U	U	0.32	1	0.32	U	U

Table E-3

Overburden Groundwater Monitoring Well Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

		LOCATION CODE	1SLB-MW01					1SLB-MW01					1SLB-MW02					1SLB-MW02				
		SAMPLE NO	SL3100					SL3102					SL3101					SL3103				
		SAMPLE DATE	18-Nov-09					4-May-10					17-Nov-09					4-May-10				
		DEPTH	0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft				
		SAMPLE PURPOSE	REG					REG					REG					REG				
Parameter	Filtered	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ
Dichloroethene, trans-1,2-	N	µg/L	0.45	1	0.45	U	U	0.34	1	0.34	U	U	0.45	1	0.45	U	U	0.34	1	0.34	U	U
Dichloropropane, 1,2-	N	µg/L	0.21	1	0.21	U	U	0.27	1	0.27	U	U	0.21	1	0.21	U	U	0.27	1	0.27	U	U
Dichloropropene, cis-1,3-	N	µg/L	0.21	1	0.21	U	U	0.2	1	0.2	U	U	0.21	1	0.21	U	U	0.2	1	0.2	U	U
Dichloropropene, trans-1,3-	N	µg/L	0.21	1	0.21	U	U	0.22	1	0.22	U	U	0.21	1	0.21	U	U	0.22	1	0.22	U	U
Ethylbenzene	N	µg/L	0.43	1	0.43	U	U	0.2	1	0.2	U	U	0.43	1	0.43	U	U	0.2	1	0.2	U	U
Hexanone, 2-	N	µg/L	5	10	5	U	U	5	10	5	U	U	5	10	5	U	U	5	10	5	U	U
Methyl-2-pentanone, 4-	N	µg/L	2	5	2	U	U	2	5	2	U	U	2	5	2	U	U	2	5	2	U	U
Methylene chloride	N	µg/L	1	5	1	U	U	2	5	2	U	U	1	5	1	U	U	2	5	2	U	U
Styrene	N	µg/L	0.36	1	0.36	U	U	0.2	1	0.2	U	U	0.36	1	0.36	U	U	0.2	1	0.2	U	U
Tetrachloroethane, 1,1,2,2-	N	µg/L	0.21	1	0.21	U	U	0.29	1	0.29	U	U	0.21	1	0.21	U	U	0.29	1	0.29	U	U
Tetrachloroethene	N	µg/L	0.22	1	0.22	U	U	0.44	1	0.44	U	U	0.22	1	0.22	U	U	0.44	1	0.44	U	U
Toluene	N	µg/L	0.35	1	0.35	U	U	0.2	1	0.2	U	U	0.35	1	0.35	U	U	0.2	1	0.2	U	U
Trichloroethane, 1,1,1-	N	µg/L	0.33	1	0.33	U	U	0.22	1	0.22	U	U	0.33	1	0.33	U	U	0.22	1	0.22	U	U
Trichloroethane, 1,1,2-	N	µg/L	0.26	1	0.26	U	U	0.29	1	0.29	U	U	0.26	1	0.26	U	U	0.29	1	0.29	U	U
Trichloroethene	N	µg/L	0.32	1	0.32	U	U	0.24	1	0.24	U	U	0.32	1	0.32	U	U	0.24	1	0.24	U	U
Vinyl chloride	N	µg/L	0.3	1	0.3	U	U	0.28	1	0.28	U	U	0.3	1	0.3	U	U	0.28	1	0.28	U	U
Xylenes, total	N	µg/L	1.2	3	1.2	U	U	0.54	3	0.54	U	U	1.2	3	1.2	U	U	0.54	3	0.54	U	U
WATER QUALITY																						
Alkalinity, Carbonate	N	µg/L	275000	5000	2500			252000	5000	2500			190000	5000	2500			176000	5000	2500		
Chloride	N	ppm	18.1	2	1			6.7	2	1			5.4	2	1			4.4	2	1		J
Cyanide, total	N	ppm	0.005	0.01	0.005	U	UJ	0.005	0.01	0.005	U	U	0.005	0.01	0.005	U	UJ	0.005	0.01	0.005	U	U
HARDNESS (as CaCO3)	N	ppm	295	4	4			291	23	0.66			204	4	4			189	23	0.66		
Nitrate-Nitrite	N	ppm	0.23	0.1	0.03			0.014	0.1	0.1	B	J	0.044	0.1	0.03	B	J	0.1	0.1	0.1	UB	U
Sulfate	N	ppm	60.4	2	1			61.4	2	1			21.9	2	1			18.9	2	1		J
Total dissolved solids	N	ppm	369	100	10		J	342	100	10			234	100	10		J	204	100	10		
Total suspended solids	N	ppm	4	10	4	U	UJ	4	10	4	U	U	4	10	4	U	UJ	4	10	4	U	U
Turbidity	N	NTU	1.8	1	1			1	1	1	U	U	2.5	1	1			1.9	1	1		

Table E-3

Overburden Groundwater Monitoring Well Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

C - Degrees Celcius.
FD - Field duplicate.
LQ - Laboratory qualifier.
MDL - Method detection limit.
µg/L - Microgram(s) per liter.
mS/cm - Millisiemen(s)/centimeter.
mV - Millivolts.
NTU - Nephalometric turbidity units.
REG - Regular sample.
RL - Reporting limit.
VQ - Validation qualifier.

Validation Qualifiers:
U - Nondetect.
J - Estimated Concentration.
UJ - Nondetected; detection limit is estimated.
B - Analyte also found in blank.
R - Rejected.

Table E-4

Sediment Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE		1SLA-SD01					1SLA-SD02					1SLA-SD03					1SLA-SD04					1SLA-SD05					1SLA-SD06					1SLA-SD06			
SAMPLE NO		SL1000					SL1001					SL1002					SL1003					SL1004					SL1005					SL1006			
SAMPLE DATE		30-Oct-09					30-Oct-09					30-Oct-09					30-Oct-09					30-Oct-09					30-Oct-09					30-Oct-09			
DEPTH		0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft					0 - 0 Ft			
SAMPLE PURPOSE		REG					REG					REG					REG					REG					REG					FD			
Parameter	Units	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ	VQ	Result	RL	MDL	LQ
EXPLOSIVES																																			
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.039	0.16	0.039	U	U	0.044	0.18	0.044	U	U	0.041	0.17	0.041	U	U	0.039	0.15	0.039	U	U	0.039	0.16	0.039	U	U	0.043	0.17	0.043	U	U	0.044	0.18	0.044	U
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.085	0.16	0.085	U	U	0.096	0.18	0.096	U	U	0.09	0.17	0.09	U	U	0.084	0.15	0.084	U	U	0.086	0.16	0.086	U	U	0.093	0.17	0.093	U	U	0.097	0.18	0.097	U
Dinitrobenzene, 1,3-	mg/kg	0.041	0.16	0.041	U	U	0.047	0.18	0.047	U	U	0.044	0.17	0.044	U	U	0.041	0.15	0.041	U	U	0.042	0.16	0.042	U	U	0.045	0.17	0.045	U	U	0.047	0.18	0.047	U
Dinitrotoluene, 2,4-	mg/kg	0.047	0.16	0.047	U	U	0.053	0.18	0.053	U	U	0.05	0.17	0.05	U	U	0.046	0.15	0.046	U	U	0.047	0.16	0.047	U	U	0.051	0.17	0.051	U	U	0.053	0.18	0.053	U
Dinitrotoluene, 2,6-	mg/kg	0.041	0.16	0.041	U	U	0.047	0.18	0.047	U	U	0.044	0.17	0.044	U	U	0.041	0.15	0.041	U	U	0.042	0.16	0.042	U	U	0.045	0.17	0.045	U	U	0.047	0.18	0.047	U
HMX	mg/kg	0.067	0.16	0.067	U	U	0.076	0.18	0.076	U	U	0.071	0.17	0.071	U	U	0.066	0.15	0.066	U	U	0.068	0.16	0.068	U	U	0.074	0.17	0.074	U	U	0.076	0.18	0.076	U
Nitrobenzene	mg/kg	0.051	0.16	0.051	U	U	0.058	0.18	0.058	U	U	0.055	0.17	0.055	U	U	0.051	0.15	0.051	U	U	0.052	0.16	0.052	U	U	0.056	0.17	0.056	U	U	0.059	0.18	0.059	U
Nitrotoluene, 2-	mg/kg	0.039	0.16	0.039	U	U	0.044	0.18	0.044	U	U	0.041	0.17	0.041	U	U	0.039	0.15	0.039	U	U	0.039	0.16	0.039	U	U	0.043	0.17	0.043	U	U	0.044	0.18	0.044	U
Nitrotoluene, 3-	mg/kg	0.065	0.16	0.065	U	U	0.074	0.18	0.074	U	U	0.07	0.17	0.07	U	U	0.065	0.15	0.065	U	U	0.066	0.16	0.066	U	U	0.072	0.17	0.072	U	U	0.075	0.18	0.075	U
Nitrotoluene, 4-	mg/kg	0.048	0.16	0.048	U	U	0.055	0.18	0.055	U	U	0.051	0.17	0.051	U	U	0.048	0.15	0.048	U	U	0.049	0.16	0.049	U	U	0.053	0.17	0.053	U	U	0.055	0.18	0.055	U
RDX	mg/kg	0.066	0.16	0.066	U	U	0.075	0.18	0.075	U	U	0.071	0.17	0.071	U	U	0.066	0.15	0.066	U	U	0.067	0.16	0.067	U	U	0.073	0.17	0.073	U	U	0.076	0.18	0.076	U
Tetryl	mg/kg	0.04	0.16	0.04	U	U	0.045	0.18	0.045	U	U	0.042	0.17	0.042	U	U	0.039	0.15	0.039	U	U	0.04	0.16	0.04	U	U	0.044	0.17	0.044	U	U	0.045	0.18	0.045	U
Trinitrobenzene, 1,3,5-	mg/kg	0.039	0.16	0.039	U	U	0.044	0.18	0.044	U	U	0.041	0.17	0.041	U	U	0.039	0.15	0.039	U	U	0.039	0.16	0.039	U	U	0.043	0.17	0.043	U	U	0.044	0.18	0.044	U
Trinitrotoluene, 2,4,6-	mg/kg	0.039	0.16	0.039	U	U	0.044	0.18	0.044	U	U	0.041	0.17	0.041	U	U	0.039	0.15	0.039	U	U	0.039	0.16	0.039	U	U	0.043	0.17	0.043	U	U	0.044	0.18	0.044	U
PESTICIDES/PCBS																																			
Aroclor 1016	mg/kg	0.011	0.022	0.011	U	U	0.012	0.024	0.012	U	U	0.01	0.021	0.01	U	U	0.013	0.026	0.013	U	U	0.014	0.027	0.014	U	U	0.014	0.027	0.014	U	U	0.014	0.029	0.014	U
Aroclor 1221	mg/kg	0.018	0.022	0.018	U	U	0.02	0.024	0.02	U	U	0.017	0.021	0.017	U	U	0.021	0.026	0.021	U	U	0.022	0.027	0.022	U	U	0.022	0.027	0.022	U	U	0.023	0.029	0.023	U
Aroclor 1232	mg/kg	0.018	0.022	0.018	U	U	0.02	0.024	0.02	U	U	0.017	0.021	0.017	U	U	0.021	0.026	0.021	U	U	0.022	0.027	0.022	U	U	0.022	0.027	0.022	U	U	0.023	0.029	0.023	U
Aroclor 1242	mg/kg	0.011	0.022	0.011	U	U	0.012	0.024	0.012	U	U	0.01	0.021	0.01	U	U	0.013	0.026	0.013	U	U	0.014	0.027	0.014	U	U	0.014	0.027	0.014	U	U	0.014	0.029	0.014	U
Aroclor 1248	mg/kg	0.011	0.022	0.011	U	U	0.012	0.024	0.012	U	U	0.01	0.021	0.01	U	U	0.013	0.026	0.013	U	U	0.014	0.027	0.014	U	U	0.014	0.027	0.014	U	U	0.014	0.029	0.014	U
Aroclor 1254	mg/kg	0.011	0.022	0.011	U	U	0.0513	0.024	0.012			0.184	0.021	0.01			0.093	0.026	0.013			0.215	0.027	0.014			0.0398	0.027	0.014			0.0419	0.029	0.014	
Aroclor 1260	mg/kg	0.011	0.022	0.011	U	U	0.012	0.024	0.012	U	U	0.01	0.021	0.01	U	U	0.013	0.026	0.013	U	U	0.014	0.027	0.014	U	U	0.014	0.027	0.014	U	U	0.014	0.029	0.014	U
WATER QUALITY																																			
% Solids	Percent	75.2	0				68.3	0				80.6	0				63.6	0				60.7	0				61.1	0				58.9	0		

FD - Field duplicate.
LQ - Laboratory qualifier.
MDL - Method detection limit.
mg/kg - Milligram(s) per kologram.
REG - Regular sample.
RL - Reporting limit.
VQ - Validation qualifier.

Validation Qualifiers:
U - Nondetect.
J - Estimated Concentration.
UJ - Nondetected; detection limit is estimated.
B - Analyte also found in blank.
R - Rejected.

Table E-4

Sediment Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION CODE SAMPLE NO SAMPLE DATE DEPTH SAMPLE PURPOSE		
Parameter	Units	VQ
EXPLOSIVES		
Amino-2,6-dinitrotoluene, 4-	mg/kg	U
Amino-4,6-dinitrotoluene, 2-	mg/kg	U
Dinitrobenzene, 1,3-	mg/kg	U
Dinitrotoluene, 2,4-	mg/kg	U
Dinitrotoluene, 2,6-	mg/kg	U
HMX	mg/kg	U
Nitrobenzene	mg/kg	U
Nitrotoluene, 2-	mg/kg	U
Nitrotoluene, 3-	mg/kg	U
Nitrotoluene, 4-	mg/kg	U
RDX	mg/kg	U
Tetryl	mg/kg	U
Trinitrobenzene, 1,3,5-	mg/kg	U
Trinitrotoluene, 2,4,6-	mg/kg	U
PESTICIDES/PCBS		
Aroclor 1016	mg/kg	U
Aroclor 1221	mg/kg	U
Aroclor 1232	mg/kg	U
Aroclor 1242	mg/kg	U
Aroclor 1248	mg/kg	U
Aroclor 1254	mg/kg	
Aroclor 1260	mg/kg	U
WATER QUALITY		
% Solids	Percent	

FD - Field duplicate.
LQ - Laboratory qualifier.
MDL - Method detection limit.
mg/kg - Milligram(s) per kolograı
REG - Regular sample.
RL - Reporting limit.
VQ - Validation qualifier.

Validation Qualifiers:
U - Nondetect.
J - Estimated Concentration.
UJ - Nondetected; detection limi
B - Analyte also found in blank.
R - Rejected.

Table E-5

Surface Water Analytical Data Used in the TNTA/WWTP1 Sewer Line Baseline Human Health Risk Assessment
Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION_CODE			1SLA-SW01			1SLA-SW02			1SLA-SW03			1SLA-SW04			1SLA-SW05			1SLA-SW06			1SLA-SW06		
SAMPLE_NO			SL2000			SL2001			SL2002			SL2003			SL2004			SL2005			SL2006		
SAMPLE_DATE			30-Oct-09			30-Oct-09			30-Oct-09			30-Oct-09			30-Oct-09			30-Oct-09			30-Oct-09		
FK_DEPTH			0 - 0 Ft			0 - 0 Ft			0 - 0 Ft			0 - 0 Ft			0 - 0 Ft			0 - 0 Ft			0 - 0 Ft		
SAMPLE_PURPOSE			REG			REG			REG			REG			REG			REG			FD		
Parameter	Filtered	Units	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual
EXPLOSIVES																							
Amino-2,6-dinitrotoluene, 4-	N	µg/L	0.048	U	U	0.048	U	U	0.05	U	U	0.048	U	U	0.048	U	U	0.048	U	U	0.049	U	U
Amino-4,6-dinitrotoluene, 2-	N	µg/L	0.073	U	U	0.073	U	U	0.077	U	U	0.073	U	U	0.074	U	U	0.074	U	U	0.075	U	U
Dinitrobenzene, 1,3-	N	µg/L	0.049	U	U	0.049	U	U	0.051	U	U	0.049	U	U	0.049	U	U	0.049	U	U	0.05	U	U
Dinitrotoluene, 2,4-	N	µg/L	0.062	U	U	0.062	U	U	0.065	U	U	0.062	U	U	0.062	U	U	0.062	U	U	0.064	U	U
Dinitrotoluene, 2,6-	N	µg/L	0.089	U	U	0.089	U	U	0.093	U	U	0.089	U	U	0.089	U	U	0.089	U	U	0.091	U	U
HMX	N	µg/L	0.1	U	U	0.1	U	U	0.11	U	U	0.1	U	U	0.1	U	U	0.1	U	U	0.11	U	U
Nitrobenzene	N	µg/L	0.048	U	U	0.048	U	U	0.05	U	U	0.048	U	U	0.048	U	U	0.048	U	U	0.049	U	U
Nitrotoluene, 2-	N	µg/L	0.061	U	U	0.061	U	U	0.064	U	U	0.061	U	U	0.062	U	U	0.062	U	U	0.063	U	U
Nitrotoluene, 3-	N	µg/L	0.092	U	U	0.092	U	U	0.097	U	U	0.092	U	U	0.093	U	U	0.093	U	U	0.095	U	U
Nitrotoluene, 4-	N	µg/L	0.072	U	U	0.072	U	U	0.076	U	U	0.072	U	U	0.073	U	U	0.073	U	U	0.075	U	U
RDX	N	µg/L	0.071	U	U	0.071	U	U	0.075	U	U	0.071	U	U	0.072	U	U	0.072	U	U	0.074	U	U
Tetryl	N	µg/L	0.074	U	U	0.074	U	U	0.078	U	U	0.074	U	U	0.075	U	U	0.075	U	U	0.076	U	U
Trinitrobenzene, 1,3,5-	N	µg/L	0.048	U	U	0.048	U	U	0.05	U	U	0.048	U	U	0.048	U	U	0.048	U	U	0.049	U	U
Trinitrotoluene, 2,4,6-	N	µg/L	0.066	U	U	0.066	U	U	0.069	U	U	0.066	U	U	0.066	U	U	0.066	U	U	0.068	U	U

C - Degrees Celcius.
FD - Field duplicate.
LQ - Laboratory qualifier.
MDL - Method detection limit.
µg/L - Microgram(s) per liter.
REG - Regular sample.
RL - Reporting limit.
VQ - Validation qualifier.

Validation Qualifiers:
U - Nondetect.
J - Estimated Concentration.
UJ - Nondetected; detection limit is estimated.
B - Analyte also found in blank.
R - Rejected.

APPENDIX F

RISK EVALUATION AND CALCULATIONS FOR THE TP-27 HOT SPOT AND THE TNTA/WWTP1 SEWER LINES MINUS THE POTENTIAL HOT SPOTS

Table F-1

Summary of Soil Samples Evaluated in the Baseline Human Health Risk Assessment
TNTA/WWTP1 Sewer Lines - Minus Potential Hot Spots
Plum Brook Ordnance Works, Sandusky, Ohio

Sample Location	Sample Number	Sample Purpose	Sample Date	Depth of Sample (ft bgs)			Analysis
Surface Soil							
SL-SB01	SL0061	REG	1/13/2009	0	-	1	Exp, Metals, PCB, SVOC, TOC
SL-SB03	SL0067	REG	1/13/2009	0	-	1	Exp, Metals, PCB, SVOC
SL-SB04	SL0069	REG	1/13/2009	0	-	1	Exp, Metals, PCB, SVOC
SL-SB06	SL0073	REG	1/13/2009	0	-	1	Exp, Metals, PCB, SVOC
SL-SB07	SL0075	REG	1/14/2009	0	-	1	Exp, Metals, PCB, SVOC
SL-SB07	SL0076	FD	1/14/2009	0	-	1	Exp, Metals, PCB, SVOC
SL-SB08	SL0079	REG	1/14/2009	0	-	1	Exp, Metals, PCB, SVOC
Subsurface Soil							
45A CL-1	45A CL-1	REG	11/4/2010	8	-	10	Exp
45A CL-2	45A CL-2	REG	11/4/2010	8	-	10	Exp
45A CL-3	45A CL-3	REG	11/4/2010	8	-	10	Exp
53B CL-1	53B CL-1	REG	11/5/2010	8	-	10	Exp
53B CL-2	53B CL-2	REG	11/5/2010	8	-	10	Exp
53B CL-3	53B CL-3	REG	11/5/2010	8	-	10	Exp
SL-SB01	SL0062	REG	1/13/2009	4	-	6	Exp, Metals, PCB, SVOC
SL-SB03	SL0068	REG	1/13/2009	5	-	6	Exp, Metals, PCB, SVOC
SL-SB04	SL0070	REG	1/13/2009	3.4	-	5.4	Exp, Metals, PCB, SVOC
SL-SB06	SL0074	REG	1/13/2009	5	-	6	Exp, Metals, PCB, SVOC
SL-SB07	SL0078	REG	1/14/2009	5	-	6	Exp, Metals, PCB, SVOC
SL-SB08	SL0080	REG	1/14/2009	7.1	-	9.1	Exp, Metals, PCB, SVOC
SL-SB09	SL0081	REG	1/12/2009	5	-	6	Exp, Metals, PCB, SVOC
SL-SB09	SL0082	REG	1/12/2009	8	-	10	Exp, Metals, PCB, SVOC
SL-SB10	SL0083	REG	1/12/2009	5	-	6	Exp, Metals, PCB, SVOC
SL-SB10	SL0084	REG	1/12/2009	8	-	10	Exp, Metals, PCB, SVOC
TNTA-SL-TP03	SL0003	REG	12/4/2008	5	-	5.5	Exp
TNTA-SL-TP04	SL0004	REG	12/4/2008	4	-	4.5	Exp
TNTA-SL-TP21	SL0025	REG	12/5/2008	4	-	4.5	Exp
TNTA-SL-TP22	SL0026	REG	12/5/2008	4	-	4.5	Exp
TNTA-SL-TP22	SL0027	FD	12/5/2008	4	-	4.5	Exp
TNTA-SL-TP23	SL0029	REG	12/5/2008	4	-	4.5	Exp
TNTA-SL-TP24	SL0030	REG	12/5/2008	4	-	4.25	Exp
TNTA-SL-TP25	SL0031	REG	12/5/2008	4	-	4.25	Exp
TNTA-SL-TP26	SL0032	REG	12/4/2008	4	-	4.3	Exp
TNTA-SL-TP27	SL0033	REG	12/4/2008	3	-	3.5	Exp
TNTA-SL-TP28	SL0034	REG	12/4/2008	3	-	3.25	Exp
TNTA-SL-TP28	SL0035	FD	12/4/2008	3	-	3.25	Exp
TNTA-SL-TP29	SL0037	REG	12/4/2008	5	-	5.5	Exp
TNTA-SL-TP30	SL0038	REG	12/4/2008	5	-	5.25	Exp

Table F-1

Summary of Soil Samples Evaluated in the Baseline Human Health Risk Assessment
TNTA/WWTP1 Sewer Lines - Minus Potential Hot Spots
Plum Brook Ordnance Works, Sandusky, Ohio

Sample Location	Sample Number	Sample Purpose	Sample Date	Depth of Sample (ft bgs)			Analysis
TNTA-SL-TP32	SL0040	REG	12/4/2008	5	-	5.5	Exp
TNTA-SL-TP34	SL0042	REG	12/4/2008	5	-	5.5	Exp
TNTA-SL-TP35	SL0043	REG	12/4/2008	5	-	5.25	Exp
TNTA-SL-TP36	SL0044	REG	12/4/2008	5	-	5.5	Exp
TNTA-SL-TP37	SL0045	REG	12/4/2008	4	-	4.25	Exp

ft bgs - Feet below ground surface.
FD - Field duplicate; averaged with regular sample.
Exp - Explosives.
PCB - Polychlorinated biphenyls.
REG - Regular sample.
SVOC - Semivolatile organic compounds.
TOC - Total organic carbon.

Table F-2

Statistical Summary and COPC Selection of Chemicals Detected in Surface Soil
TNTA/WWTP1 Sewer Lines - Minus Potential Hot Spots [a]
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Detection Frequency	Percent Detection	Range of Values, mg/kg: Detected Concentrations Minimum	VQ	Maximum	VQ	Method Detection Limits Minimum	Maximum	Mean mg/kg	BSC [b] mg/kg	RBSC [c] mg/kg	COPC? [d,e]	95% UCL [f] mg/kg	EPC [g] mg/kg
Inorganics														
Aluminum	6 / 6	100	7.50E+03	J/J	9.09E+03		1.01E+00	2.15E+00	8.58E+03	1.55E+04	7.70E+03	N (b)		---
Antimony	3 / 6	50	3.30E-01	J	5.29E-01	J/J	2.31E-01	2.69E-01	3.30E-01	9.30E+00	3.10E+00	N (a)		---
Arsenic	6 / 6	100	4.80E+00	J	1.22E+01	J	4.62E-01	5.38E-01	7.15E+00	3.65E+01	3.90E-01	N (b)		---
Barium	6 / 6	100	4.60E+01		5.23E+01		9.23E-02	1.08E-01	5.05E+01	8.26E+02	1.50E+03	N (a)		---
Beryllium	6 / 6	100	5.22E+00	J	7.87E+00	J	9.23E-02	1.08E-01	6.16E+00	1.00E+00	1.60E+01	N (a)		---
Cadmium	2 / 6	33	2.85E-01	J/J	3.87E-01	J	2.31E-01	2.69E-01	2.83E-01	NA	7.00E+00	N (a)		---
Calcium	6 / 6	100	3.99E+03		7.33E+03		2.52E+00	5.38E+00	4.96E+03	5.23E+04	Nutrient	N (c)		---
Chromium	6 / 6	100	1.12E+01		1.41E+01		2.31E-01	2.69E-01	1.27E+01	2.90E+01	2.90E-01	N (b)		---
Cobalt	6 / 6	100	4.19E+00		8.65E+00		9.20E-02	2.03E-01	5.98E+00	1.16E+02	2.30E+00	N (b)		---
Copper	6 / 6	100	1.54E+01		2.78E+01		2.31E-01	2.69E-01	1.95E+01	5.62E+01	3.10E+02	N (a)		---
Iron	6 / 6	100	1.46E+04		2.52E+04		9.23E-01	2.03E+00	1.80E+04	2.34E+05	5.50E+03	N (b)		---
Lead	6 / 6	100	1.03E+01		2.83E+01		2.31E-01	2.69E-01	1.65E+01	4.86E+01	4.00E+02	N (a)		---
Magnesium	6 / 6	100	1.61E+03	J	3.50E+03	J	9.23E-01	1.08E+00	2.29E+03	1.04E+04	Nutrient	N (c)		---
Manganese	6 / 6	100	1.53E+02		3.06E+02		9.23E-02	1.08E-01	2.16E+02	3.51E+03	1.80E+02	N (b)		---
Mercury	6 / 6	100	3.14E-02		4.43E-01		1.16E-02	1.27E-02	1.06E-01	8.50E-02	2.30E+00	N (a)		---
Nickel	6 / 6	100	2.68E+00	J	1.96E+01		1.39E-01	1.61E-01	1.12E+01	5.51E+01	1.50E+02	N (a)		---
Potassium	6 / 6	100	4.61E+02		9.00E+02		1.15E+01	1.35E+01	6.07E+02	3.39E+03	Nutrient	N (c)		---
Selenium	2 / 6	33	5.10E-01	J	5.17E-01	J	4.62E-01	5.38E-01	5.20E-01	2.00E+00	3.90E+01	N (a)		---
Sodium	6 / 6	100	3.11E+01		7.67E+01		5.05E+00	1.08E+01	5.01E+01	NA	Nutrient	N (c)		---
Thallium	1 / 6	17	3.66E-01	J	3.66E-01	J	2.31E-01	2.69E-01	2.73E-01	1.30E+00	7.80E-02	N (b)		---
Vanadium	6 / 6	100	1.98E+01		2.25E+01		9.23E-02	1.08E-01	2.09E+01	4.09E+01	3.90E+01	N (a)		---
Zinc	6 / 6	100	3.40E+01	J	7.23E+01		1.15E+00	1.35E+00	5.31E+01	3.22E+02	2.30E+03	N (a)		---
Polychlorinated biphenyls (PCB)														
Aroclor 1016	4 / 6	67	1.91E-02	J	8.28E-02	J	8.21E-03	9.24E-03	4.16E-02		3.90E-01	N (a)		---
Aroclor 1260	1 / 6	17	1.47E-01	J/J	1.47E-01	J/J	8.21E-03	9.24E-03	3.17E-02		2.20E-01	N (a)		---
Explosives														
Amino-2,6-dinitrotoluene, 4-	2 / 6	33	1.63E-01	J/U	4.71E-01		1.47E-01	1.50E-01	2.05E-01		1.50E+01	N (a)		---
Amino-4,6-dinitrotoluene, 2-	1 / 6	17	6.05E-01		6.05E-01		1.47E-01	1.50E-01	2.25E-01		1.50E+01	N (a)		---
Trinitrotoluene, 2,4,6-	2 / 6	33	2.71E-01	J	5.32E-01	J	1.47E-01	1.50E-01	2.33E-01		3.60E+00	N (a)		---
Semivolatile Organic Compounds														
Benzo(a)anthracene	2 / 6	33	4.70E-02	J	5.81E-02	J	2.72E-02	3.05E-02	3.62E-02		1.50E-01	N (a)		---
Benzo(a)pyrene	1 / 6	17	5.30E-02	J	5.30E-02	J	2.72E-02	3.05E-02	3.22E-02		1.50E-02	Y	4.13E-02	4.13E-02
Benzo(b)fluoranthene	2 / 6	33	7.13E-02	J	9.62E-02	J	6.90E-02	7.74E-02	7.53E-02		1.50E-01	N (a)		---
Benzoic acid	1 / 6	17	6.39E-01	QJ	6.39E-01	QJ	1.01E-01	1.13E-01	1.95E-01		2.40E+04	N (a)		---
Chrysene	2 / 6	33	6.32E-02	J	7.94E-02	J	1.64E-02	1.84E-02	3.50E-02		1.50E+01	N (a)		---
Dinitrotoluene, 2,4-	1 / 6	17	5.63E-02	J	5.63E-02	J	1.45E-02	1.63E-02	2.22E-02		7.20E-01	N (a)		---
Fluoranthene	3 / 6	50	2.61E-02	J/U	1.63E-01	J	8.95E-03	1.00E-02	5.46E-02		2.30E+02	N (a)		---
Phenanthrene	2 / 6	33	4.27E-02	J	1.02E-01	J	1.01E-02	1.13E-02	3.10E-02		1.70E+02 h	N (a)		---
Pyrene	2 / 6	33	7.26E-02	J	1.20E-01	J	1.65E-02	1.85E-02	4.35E-02		1.70E+02	N (a)		---

Table F-2

Statistical Summary and COPC Selection of Chemicals Detected in Surface Soil
TNTA/WWTP1 Sewer Lines - Minus Potential Hot Spots [a]
Plum Brook Ordnance Works, Sandusky, Ohio

COPC - Chemical of potential concern.
BSC - Background screening criterion.
RBSC - Risk-based screening concentration.
VQ - Validation qualifier.
J - The compound/analyte was positively identified; the reported result is the estimated concentration of the compound/analyte detected in the sample analyzed
Q - Estimated due to instrument response below method criteria.
/U - The compound/analyte was positively identified in one sample averaged with a field duplicate that was nondetect (U qualified)
mg/kg - Milligrams per kilogram.

[a] See text for details.
[b] IT Corporation (IT), 1998, ***Site Investigation of Acid Areas*** , Plum Brook Ordnance Works, Sandusky, Ohio, August.
[c] Risk-Based Screening Concentrations based on USEPA Regional Screening Level Table (November 2011) residential soil values and are based on a risk level of 1.0E-06 and a hazard index of 0.1.
[d] N - Chemical is not chosen as a COPC:
(a) - Maximum detected concentration is less than the RBSC.
(b) - Maximum detected concentration is less than the BSC.
(c) - Essential nutrient.
[e] Y - Chemical is chosen as COPC.
[f] 95% UCL (Upper confidence limit) determined using ProUCL Version 4.1 (U.S. Environmental Protection Agency (EPA), 2011, ProUCL Version 4.1, Office of Research and Development, Las Vegas, Nevada, and Technology Support Center, Atlanta, GA, May, on line at http://www.epa.gov/esd/tsc/TSC_form.htm.
[g] Concentration used in risk assessment equal to 95% UCL or maximum detected concentration, whichever is lower.
[h] RBSC based on pyrene.

Table F-3

Statistical Summary and COPC Selection of Chemicals Detected in Subsurface Soil
TNTA/WWTP1 Sewer Lines - Minus Potential Hot Spots [a]
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Detection Frequency	Percent Detection	Range of Values, mg/kg: Detected Concentrations Minimum	VQ	Maximum	VQ	Method Detection Limits Minimum	Maximum	Mean mg/kg	BSC [b] mg/kg	RBSC [c] mg/kg	COPC? [d,e]	95% UCL [f] mg/kg	EPC [g] mg/kg
Inorganics														
Aluminum	10 / 10	100	7.04E+03		1.03E+04		8.77E-01	1.99E+00	8.72E+03	1.55E+04	7.70E+03	N (b)		---
Antimony	10 / 10	100	2.94E-01	J	5.72E-01		2.05E-01	2.49E-01	4.24E-01	9.30E+00	3.10E+00	N (a)		---
Arsenic	10 / 10	100	1.12E+01	J	2.03E+01	J	4.10E-01	4.98E-01	1.43E+01	3.65E+01	3.90E-01	N (b)		---
Barium	10 / 10	100	2.70E+01		1.16E+02		8.20E-02	9.96E-02	5.12E+01	8.26E+02	1.50E+03	N (a)		---
Beryllium	10 / 10	100	6.56E+00	J	1.03E+01	J	8.20E-02	9.96E-02	8.00E+00	1.00E+00	1.60E+01	N (a)		---
Cadmium	4 / 10	40	2.34E-01	J	3.23E-01	J	2.05E-01	2.49E-01	2.49E-01	NA	7.00E+00	N (a)		---
Calcium	10 / 10	100	2.79E+03		4.58E+04		2.19E+00	4.98E+00	2.92E+04	5.23E+04	Nutrient	N (c)		---
Chromium	10 / 10	100	1.08E+01		1.55E+01		2.05E-01	2.49E-01	1.34E+01	2.90E+01	2.90E-01	N (b)		---
Cobalt	10 / 10	100	8.57E+00		1.73E+01		8.20E-02	1.78E-01	1.15E+01	1.16E+02	2.30E+00	N (b)		---
Copper	10 / 10	100	2.77E+01	J	3.63E+01		2.05E-01	2.49E-01	3.31E+01	5.62E+01	3.10E+02	N (a)		---
Iron	10 / 10	100	2.26E+04		6.56E+04		8.73E-01	4.52E+00	3.22E+04	2.34E+05	5.50E+03	N (b)		---
Lead	10 / 10	100	1.19E+01		1.64E+01		2.05E-01	2.49E-01	1.41E+01	4.86E+01	4.00E+02	N (a)		---
Magnesium	10 / 10	100	3.60E+03	J	1.07E+04	J	8.20E-01	9.96E-01	7.38E+03	1.04E+04	Nutrient	N (c)		---
Manganese	10 / 10	100	2.85E+02		8.33E+02		8.20E-02	9.96E-02	4.29E+02	3.51E+03	1.80E+02	N (b)		---
Mercury	8 / 10	80	1.45E-02	J	2.00E-02	J	9.52E-03	1.23E-02	1.55E-02	8.50E-02	2.30E+00	N (a)		---
Nickel	9 / 10	90	1.41E+01	J	3.97E+01		1.23E-01	1.49E-01	1.86E+01	5.51E+01	1.50E+02	N (a)		---
Potassium	10 / 10	100	7.75E+02		1.67E+03		1.02E+01	1.24E+01	1.11E+03	3.39E+03	Nutrient	N (c)		---
Selenium	4 / 10	40	4.53E-01	J	1.32E+00	J	4.10E-01	4.98E-01	5.82E-01	2.00E+00	3.90E+01	N (a)		---
Sodium	10 / 10	100	6.83E+01		1.62E+02		4.38E+00	9.96E+00	1.07E+02	NA	Nutrient	N (c)		---
Thallium	10 / 10	100	2.65E-01	J	6.97E-01		2.05E-01	2.49E-01	3.93E-01	1.30E+00	7.80E-02	N (b)		---
Vanadium	10 / 10	100	1.55E+01		2.70E+01		8.20E-02	9.96E-02	1.90E+01	4.09E+01	3.90E+01	N (a)		---
Zinc	10 / 10	100	5.30E+01	J	9.94E+01		1.02E+00	1.24E+00	7.25E+01	3.22E+02	2.30E+03	N (a)		---
Polychlorinated biphenyls (PCB)														
Aroclor 1016	1 / 10	10	5.53E-02	J	5.53E-02	J	7.27E-03	8.06E-03	1.25E-02		3.90E-01	N (a)		---
Aroclor 1221	2 / 10	20	6.51E-02	QJ	1.34E-01		7.27E-03	8.06E-03	2.62E-02		1.40E-01	N (a)		---
Explosives														
Amino-2,6-dinitrotoluene, 4-	5 / 33	15	2.09E-01	J	3.78E+00		5.60E-02	1.55E-01	2.97E-01		1.50E+01	N (a)		---
Amino-4,6-dinitrotoluene, 2-	5 / 33	15	1.49E-01	J	9.98E+00		5.60E-02	7.18E-01	5.39E-01		1.50E+01	N (a)		---
Dinitrotoluene, 2,4-	5 / 33	15	2.01E-01	J	3.25E+00		6.80E-02	1.55E-01	2.74E-01		7.20E-01	Y	5.10E-01	5.10E-01
Dinitrotoluene, 2,6-	3 / 33	9	2.17E-01	J	5.29E-01		6.10E-02	1.60E-01	1.60E-01		7.20E-01	N (a)		---
Trinitrobenzene, 1,3,5-	5 / 33	15	9.11E-02	J	1.75E+00		5.60E-02	1.55E-01	2.54E-01		2.20E+02	N (a)		---
Trinitrotoluene, 2,4,6-	9 / 33	27	8.95E-02	J	7.78E+01		5.60E-02	7.61E+00	2.64E+00		3.60E+00	Y	1.33E+01	1.33E+01
Semivolatile Organic Compounds														
Dinitrotoluene, 2,4-	3 / 10	30	8.18E-02	J	4.34E-01		1.29E-02	1.41E-02	7.15E-02		7.20E-01	N (a)		---
Dinitrotoluene, 2,6-	2 / 10	20	4.11E-02	J	1.28E-01	J	8.81E-03	9.64E-03	2.44E-02		7.20E-01	N (a)		---
Phenanthrene	3 / 10	30	5.04E-02	J	8.98E-02	J	8.92E-03	9.76E-03	2.82E-02		1.70E+02 [h]	N (a)		---

COPC - Chemical of potential concern.
BSC - Background screening criterion.
RBSC - Risk-based screening concentration.
VQ - Validation qualifier.

Table F-3

Statistical Summary and COPC Selection of Chemicals Detected in Subsurface Soil
TNTA/WWTP1 Sewer Lines - Minus Potential Hot Spots [a]
Plum Brook Ordnance Works, Sandusky, Ohio

J - The compound/analyte was positively identified; the reported result is the estimated concentration of the compound/analyte detected in the sample analyzed
Q - Estimated due to instrument response below method criteria.
/U - The compound/analyte was positively identified in one sample averaged with a field duplicate that was nondetect (U qualified)
mg/kg - Milligrams per kilogram.

[a] See text for details.
[b] IT Corporation (IT), 1998, ***Site Investigation of Acid Areas*** , Plum Brook Ordnance Works, Sandusky, Ohio, August.
[c] Risk-Based Screening Concentrations based on USEPA Regional Screening Level Table (November 2011) residential soil values and are based on a risk level of 1.0E-06 and a hazard index of 0.1.
[d] N - Chemical is not chosen as a COPC:
(a) - Maximum detected concentration is less than the RBSC.
(b) - Maximum detected concentration is less than the BSC.
(c) - Essential nutrient.
[e] Y - Chemical is chosen as COPC.
[f] 95% UCL (Upper confidence limit) determined using ProUCL Version 4.1 (U.S. Environmental Protection Agency (EPA), 2011, ProUCL Version 4.1, Office of Research and Development, Las Vegas, Nevada, and Technology Support Center, Atlanta, GA, May, on line at http://www.epa.gov/esd/tsc/TSC_form.htm.
[g] Concentration used in risk assessment equal to 95% UCL or maximum detected concentration, whichever is lower.
[h] RBSC based on pyrene.

Table F-4

Statistical Summary and COPC Selection of Chemicals Detected in Total Soil
TNTA/WWTP1 Sewer Lines - Minus Potential Hot Spots [a]
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Detection Frequency	Percent Detection	Range of Values, mg/kg: Detected Concentrations Minimum	VQ	Maximum	VQ	Method Detection Limits Minimum	Maximum	Mean mg/kg	BSC [b] mg/kg	RBSC [c] mg/kg	COPC? [d,e]	95% UCL [f] mg/kg	EPC [g] mg/kg
Inorganics														
Aluminum	16 / 16	100	7.04E+03		1.03E+04		8.77E-01	2.15E+00	8.66E+03	1.55E+04	7.70E+03	N (b)		---
Antimony	13 / 16	81	2.94E-01	J	5.72E-01		2.05E-01	2.69E-01	3.89E-01	9.30E+00	3.10E+00	N (a)		---
Arsenic	16 / 16	100	4.80E+00	J	2.03E+01	J	4.10E-01	5.38E-01	1.16E+01	3.65E+01	3.90E-01	N (b)		---
Barium	16 / 16	100	2.70E+01		1.16E+02		8.20E-02	1.08E-01	5.09E+01	8.26E+02	1.50E+03	N (a)		---
Beryllium	16 / 16	100	5.22E+00	J	1.03E+01	J	8.20E-02	1.08E-01	7.31E+00	1.00E+00	1.60E+01	N (a)		---
Cadmium	6 / 16	38	2.34E-01	J	3.87E-01	J	2.05E-01	2.69E-01	2.62E-01	NA	7.00E+00	N (a)		---
Calcium	16 / 16	100	2.79E+03		4.58E+04		2.19E+00	5.38E+00	2.01E+04	5.23E+04	Nutrient	N (c)		---
Chromium	16 / 16	100	1.08E+01		1.55E+01		2.05E-01	2.69E-01	1.31E+01	2.90E+01	2.90E-01	N (b)		---
Cobalt	16 / 16	100	4.19E+00		1.73E+01		8.20E-02	2.03E-01	9.45E+00	1.16E+02	2.30E+00	N (b)		---
Copper	16 / 16	100	1.54E+01		3.63E+01		2.05E-01	2.69E-01	2.80E+01	5.62E+01	3.10E+02	N (a)		---
Iron	16 / 16	100	1.46E+04		6.56E+04		8.73E-01	4.52E+00	2.69E+04	2.34E+05	5.50E+03	N (b)		---
Lead	16 / 16	100	1.03E+01		2.83E+01		2.05E-01	2.69E-01	1.50E+01	4.86E+01	4.00E+02	N (a)		---
Magnesium	16 / 16	100	1.61E+03	J	1.07E+04	J	8.20E-01	1.08E+00	5.47E+03	1.04E+04	Nutrient	N (c)		---
Manganese	16 / 16	100	1.53E+02		8.33E+02		8.20E-02	1.08E-01	3.49E+02	3.51E+03	1.80E+02	N (b)		---
Mercury	14 / 16	88	1.45E-02	J	4.43E-01		9.52E-03	1.27E-02	4.94E-02	8.50E-02	2.30E+00	N (a)		---
Nickel	15 / 16	94	2.68E+00	J	3.97E+01		1.23E-01	1.61E-01	1.58E+01	5.51E+01	1.50E+02	N (a)		---
Potassium	16 / 16	100	4.61E+02		1.67E+03		1.02E+01	1.35E+01	9.23E+02	3.39E+03	Nutrient	N (c)		---
Selenium	6 / 16	38	4.53E-01	J	1.32E+00	J	4.10E-01	5.38E-01	5.59E-01	2.00E+00	3.90E+01	N (a)		---
Sodium	16 / 16	100	3.11E+01		1.62E+02		4.38E+00	1.08E+01	8.56E+01	NA	Nutrient	N (c)		---
Thallium	11 / 16	69	2.65E-01	J	6.97E-01		2.05E-01	2.69E-01	3.48E-01	1.30E+00	7.80E-02	N (b)		---
Vanadium	16 / 16	100	1.55E+01		2.70E+01		8.20E-02	1.08E-01	1.97E+01	4.09E+01	3.90E+01	N (a)		---
Zinc	16 / 16	100	3.40E+01	J	9.94E+01		1.02E+00	1.35E+00	6.52E+01	3.22E+02	2.30E+03	N (a)		---
Polychlorinated biphenyls (PCB)														
Aroclor 1016	5 / 16	31	1.91E-02	J	8.28E-02	J	7.27E-03	9.24E-03	2.34E-02		3.90E-01	N (a)		---
Aroclor 1221	2 / 16	13	6.51E-02	QJ	1.34E-01		7.27E-03	9.24E-03	1.96E-02		1.40E-01	N (a)		---
Aroclor 1260	1 / 16	6	1.47E-01	J/J	1.47E-01	J/J	7.27E-03	9.24E-03	1.68E-02		2.20E-01	N (a)		---
Explosives														
Amino-2,6-dinitrotoluene, 4-	7 / 39	18	1.63E-01	J/U	3.78E+00		5.60E-02	1.55E-01	2.83E-01		1.50E+01	N (a)		---
Amino-4,6-dinitrotoluene, 2-	6 / 39	15	1.49E-01	J	9.98E+00		5.60E-02	7.18E-01	4.91E-01		1.50E+01	N (a)		---
Dinitrotoluene, 2,4-	5 / 39	13	2.01E-01	J	3.25E+00		6.80E-02	1.55E-01	2.55E-01		7.20E-01	Y	4.62E-01	4.62E-01
Dinitrotoluene, 2,6-	3 / 39	8	2.17E-01	J	5.29E-01		6.10E-02	1.60E-01	1.59E-01		7.20E-01	N (a)		---
Trinitrobenzene, 1,3,5-	5 / 39	13	9.11E-02	J	1.75E+00		5.60E-02	1.55E-01	2.38E-01		2.20E+02	N (a)		---
Trinitrotoluene, 2,4,6-	11 / 39	28	8.95E-02	J	7.78E+01		5.60E-02	7.61E+00	2.27E+00		3.60E+00	Y	1.12E+01	1.12E+01
Semivolatile Organic Compounds														
Benzo(a)anthracene	2 / 16	13	4.70E-02	J	5.81E-02	J	2.41E-02	3.05E-02	2.95E-02		1.50E-01	N (a)		---
Benzo(a)pyrene	1 / 16	6	5.30E-02	J	5.30E-02	J	2.41E-02	3.05E-02	2.80E-02		1.50E-02	Y	3.13E-02	3.13E-02
Benzo(b)fluoranthene	2 / 16	13	7.13E-02	J	9.62E-02	J	6.11E-02	7.74E-02	6.87E-02		1.50E-01	N (a)		---
Benzoic acid	1 / 16	6	6.39E-01	QJ	6.39E-01	QJ	8.94E-02	1.13E-01	1.32E-01		2.40E+04	N (a)		---
Chrysene	2 / 16	13	6.32E-02	J	7.94E-02	J	1.45E-02	1.84E-02	2.28E-02		1.50E+01	N (a)		---
Dinitrotoluene, 2,4-	4 / 16	25	5.63E-02	J	4.34E-01		1.29E-02	1.63E-02	5.30E-02		7.20E-01	N (a)		---
Dinitrotoluene, 2,6-	2 / 16	13	4.11E-02	J	1.28E-01	J	8.81E-03	1.12E-02	1.91E-02		7.20E-01	N (a)		---

Table F-4

Statistical Summary and COPC Selection of Chemicals Detected in Total Soil
TNTA/WWTP1 Sewer Lines - Minus Potential Hot Spots [a]
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Detection Frequency	Percent Detection	Range of Values, mg/kg: Detected Concentrations Minimum	VQ	Maximum	VQ	Method Detection Limits Minimum	Maximum	Mean mg/kg	BSC [b] mg/kg	RBSC [c] mg/kg	COPC? [d,e]	95% UCL [f] mg/kg	EPC [g] mg/kg
Fluoranthene	3 / 16	19	2.61E-02	J/U	1.63E-01	J	7.93E-03	1.00E-02	2.57E-02		2.30E+02	N (a)		---
Phenanthrene	5 / 16	31	4.27E-02	J	1.02E-01	J	8.92E-03	1.13E-02	2.93E-02		1.70E+02 h	N (a)		---
Pyrene	2 / 16	13	7.26E-02	J	1.20E-01	J	1.46E-02	1.85E-02	2.60E-02		1.70E+02	N (a)		---

COPC - Chemical of potential concern.
BSC - Background screening criterion.
RBSC - Risk-based screening concentration.
VQ - Validation qualifier.
J - The compound/analyte was positively identified; the reported result is the estimated concentration of the compound/analyte detected in the sample analyzed
Q - Estimated due to instrument response below method criteria.
/U - The compound/analyte was positively identified in one sample averaged with a field duplicate that was nondetect (U qualified)
mg/kg - Milligrams per kilogram.

[a] See text for details.
[b] IT Corporation (IT), 1998, ***Site Investigation of Acid Areas*** , Plum Brook Ordnance Works, Sandusky, Ohio, August.
[c] Risk-Based Screening Concentrations based on USEPA Regional Screening Level Table (November 2011) residential soil values and are based on a risk level of 1.0E-06 and a hazard index of 0.1.
[d] N - Chemical is not chosen as a COPC:
(a) - Maximum detected concentration is less than the RBSC.
(b) - Maximum detected concentration is less than the BSC.
(c) - Essential nutrient.
[e] Y - Chemical is chosen as COPC.
[f] 95% UCL (Upper confidence limit) determined using ProUCL Version 4.1 (U.S. Environmental Protection Agency (EPA), 2011, ProUCL Version 4.1, Office of Research and Development, Las Vegas, Nevada, and Technology Support Center, Atlanta, GA, May, on line at http://www.epa.gov/esd/tsc/TSC_form.htm.
[g] Concentration used in risk assessment equal to 95% UCL or maximum detected concentration, whichever is lower.
[h] RBSC based on pyrene.

Table F-5

Groundskeeper, Current Scenarios, Exposure to Surface Soil
TNTA/WWTP1 Sewer Lines - Minus Potential Hot Spots
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion				Dermal Contact				
Chemicals of Potential Concern	EPC mg/kg	Cancer Dose mg/kg-day	Noncancer Dose mg/kg-day	ILCR	HQ	Dose Absorbed mg/cm^2-day	Cancer Dose mg/kg-day	Noncancer Dose mg/kg-day	ILCR	HQ
Semivolatile Organic Compounds										
Benzo(a)pyrene	4.13E-02	1.44E-08	4.04E-08	1.05E-07	NA	1.07E-09	1.24E-08	3.47E-08	9.04E-08	NA
Total ILCR or HI				**1.05E-07**	**NA**				**9.04E-08**	**NA**

EPC - Exposure point concentration.
ILCR - Incremental lifetime cancer risk.
HQ - Hazard quotient; HI - Hazard index.
mg/kg - Milligrams per kilogram.
mg/m^3 - Milligrams per cubic meter.

Table F-5

Groundskeeper, Current Scenarios, Exposure to Surface Soil
TNTA/WWTP1 Sewer Lines - Minus Potential Hot Spots
Plum Brook Ordnance Works, Sandusky, Ohio

Chemicals of Potential Concern	Concentration in Air C_a mg/m^3	Inhalation Cancer Dose mg/kg-day	Inhalation Noncancer Dose mg/kg-day	Inhalation ILCR	Inhalation HQ	**All Pathways Total ILCR**	**All Pathways Total HI**
Semivolatile Organic Compounds							
Benzo(a)pyrene	4.13E-09	2.89E-10	8.08E-10	8.95E-10	NA	**1.97E-07**	**NA**
Total ILCR or HI				**8.95E-10**	**NA**	**1.97E-07**	**NA**

EPC - Exposure Point Concentration
ILCR - Incremental Lifetime Cancer Risk
HQ - Hazard Quotient; HI - Hazard Index
mg/kg - milligram per kilogram
mg/m^3 - milligram per cubic meter

Table F-6

Groundskeeper, Future Scenario, Exposure to Total Soil
TNTA/WWTP1 Sewer Lines - Minus Potential Hot Spots
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion				Dermal Contact				
Chemicals of Potential Concern	EPC mg/kg	Cancer Dose mg/kg-day	Noncancer Dose mg/kg-day	ILCR	HQ	Dose Absorbed mg/cm^2-day	Cancer Dose mg/kg-day	Noncancer Dose mg/kg-day	ILCR	HQ
Explosives										
Dinitrotoluene, 2,4-	4.62E-01	1.61E-07	4.52E-07	1.10E-07	2.26E-04	9.42E-09	1.09E-07	3.04E-07	7.39E-08	1.52E-04
Trinitrotoluene, 2,4,6-	1.12E+01	3.92E-06	1.10E-05	1.18E-07	2.20E-02	7.18E-08	8.28E-07	2.32E-06	2.48E-08	4.64E-03
Semivolatile Organic Compounds										
Benzo(a)pyrene	3.13E-02	1.09E-08	3.06E-08	7.98E-08	NA	8.14E-10	9.38E-09	2.63E-08	6.85E-08	NA
Total ILCR or HI				**3.07E-07**	**2.22E-02**				**1.67E-07**	**4.79E-03**

EPC - Exposure point concentration.
ILCR - Incremental lifetime cancer risk.
HQ - Hazard quotient; HI - Hazard index.
mg/kg - Milligrams per kilogram.
mg/m^3 - Milligrams per cubic meter.

Table F-6

Groundskeeper, Future Scenario, Exposure to Total Soil
TNTA/WWTP1 Sewer Lines - Minus Potential Hot Spots
Plum Brook Ordnance Works, Sandusky, Ohio

Chemicals of Potential Concern	Concentration in Air C_a mg/m^3	Inhalation Cancer Dose mg/kg-day	Inhalation Noncancer Dose mg/kg-day	Inhalation ILCR	Inhalation HQ	**All Pathways Total ILCR**	**All Pathways Total HI**
Explosives							
Dinitrotoluene, 2,4-	4.62E-08	3.23E-09	9.04E-09	NA	NA	**1.84E-07**	**3.78E-04**
Trinitrotoluene, 2,4,6-	1.12E-06	7.84E-08	2.20E-07	NA	NA	**1.42E-07**	**2.66E-02**
Semivolatile Organic Compounds							
Benzo(a)pyrene	3.13E-09	2.19E-10	6.13E-10	6.78E-10	NA	**1.49E-07**	**NA**
Total ILCR or HI				**6.78E-10**	**NA**	**4.75E-07**	**2.70E-02**

EPC - Exposure Point Concentration
ILCR - Incremental Lifetime Cancer Risk
HQ - Hazard Quotient; HI - Hazard Index
mg/kg - milligram per kilogram
mg/m^3 - milligram per cubic meter

Table F-7

Indoor Worker, Future Scenario, Exposure to Surface Soil
TNTA/WWTP1 Sewer Lines - Minus Potential Hot Spots
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion					
Chemicals of Potential Concern	EPC mg/kg	Cancer Dose mg/kg-day	Noncancer Dose mg/kg-day	ILCR	HQ	**Total ILCR**	**Total HI**
Semivolatile Organic Compounds							
Benzo(a)pyrene	4.13E-02	7.22E-09	2.02E-08	5.27E-08	NA	**5.27E-08**	**NA**
Total ILCR or HI						**5.27E-08**	**NA**

EPC - Exposure point concentration.
ILCR - Incremental lifetime cancer risk.
HQ - Hazard quotient; HI - Hazard index.
mg/kg - Milligrams per kilogram.

Table F-8

Construction Worker, Current and Future Scenarios, Exposure to Total Soil
TNTA/WWTP1 Sewer Lines - Minus Potential Hot Spots
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion				Dermal Contact				
Chemicals of Potential Concern	EPC mg/kg	Cancer Dose mg/kg-day	Noncancer Dose mg/kg-day	ILCR	HQ	Dose Absorbed mg/cm^2-day	Cancer Dose mg/kg-day	Noncancer Dose mg/kg-day	ILCR	HQ
Explosives										
Dinitrotoluene, 2,4-	4.62E-01	1.07E-08	1.49E-06	7.25E-09	7.44E-04	1.41E-08	3.26E-09	4.55E-07	2.22E-09	2.28E-04
Trinitrotoluene, 2,4,6-	1.12E+01	2.59E-07	3.61E-05	7.76E-09	7.23E-02	1.08E-07	2.48E-08	3.47E-06	7.45E-10	6.94E-03
Semivolatile Organic Compounds										
Benzo(a)pyrene	3.13E-02	7.22E-10	1.01E-07	5.27E-09	NA	1.22E-09	2.82E-10	3.93E-08	2.06E-09	NA
Total ILCR or HI				**2.03E-08**	**7.30E-02**				**5.02E-09**	**7.16E-03**

EPC - Exposure point concentration.
ILCR - Incremental lifetime cancer risk.
HQ - Hazard quotient; HI - Hazard index.
mg/kg - Milligrams per kilogram.
mg/m^3 - Milligrams per cubic meter.

Table F-8

Construction Worker, Current and Future Scenarios, Exposure to Total Soil
TNTA/WWTP1 Sewer Lines - Minus Potential Hot Spots
Plum Brook Ordnance Works, Sandusky, Ohio

Chemicals of Potential Concern	Concentration in Air C_a mg/m^3	Inhalation Cancer Dose mg/kg-day	Inhalation Noncancer Dose mg/kg-day	Inhalation ILCR	Inhalation HQ	**All Pathways Total ILCR**	**All Pathways Total HI**
Explosives							
Dinitrotoluene, 2,4-	1.62E-07	2.26E-10	3.16E-08	NA	NA	**9.46E-09**	**9.71E-04**
Trinitrotoluene, 2,4,6-	3.93E-06	5.49E-09	7.66E-07	NA	NA	**8.51E-09**	**7.92E-02**
Semivolatile Organic Compounds							
Benzo(a)pyrene	1.10E-08	1.53E-11	2.14E-09	4.75E-11	NA	**7.37E-09**	**NA**
Total ILCR or HI				**4.75E-11**	**NA**	**2.53E-08**	**8.02E-02**

EPC - Exposure point concentration.
ILCR - Incremental lifetime cancer risk.
HQ - Hazard quotient; HI - Hazard index.
mg/kg - Milligrams per kilogram.
mg/m^3 - Milligrams per cubic meter.

Table F-9

On-Site Resident, Cancer Risk, Future Scenario, Exposure to Total Soil
TNTA/WWTP1 Sewer Lines - Minus Potential Hot Spots
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion			Dermal Contact				
Chemicals of Potential Concern	EPC mg/kg	Adult Dose mg/kg-day	Child Dose mg/kg-day	Resident ILCR	Adult Dose Absorbed mg/cm^2-day	Adult Dose mg/kg-day	Child Dose Absorbed mg/cm^2-day	Child Dose mg/kg-day	Resident ILCR
Explosives									
Dinitrotoluene, 2,4-	4.62E-01	1.95E-07	4.56E-07	4.43E-07	3.30E-09	8.83E-08	9.42E-09	1.45E-07	1.58E-07
Trinitrotoluene, 2,4,6-	1.12E+01	4.74E-06	1.11E-05	4.74E-07	2.51E-08	6.73E-07	7.18E-08	1.10E-06	5.32E-08
Semivolatile Organic Compounds									
Benzo(a)pyrene	3.13E-02	1.32E-08	3.09E-08	3.22E-07	2.85E-10	7.63E-09	8.14E-10	1.25E-08	1.47E-07
Total ILCR				**1.24E-06**					**3.58E-07**

EPC - Exposure point concentration.
ILCR - Incremental lifetime cancer risk.
mg/kg - Milligrams per kilogram.
mg/cm^2 - Milligrams per square meter.
mg/m^3 - Milligrams per cubic meter.

Table F-9

On-Site Resident, Cancer Risk, Future Scenario, Exposure to Total Soil
TNTA/WWTP1 Sewer Lines - Minus Potential Hot Spots
Plum Brook Ordnance Works, Sandusky, Ohio

Chemicals of Potential Concern	Concentration in Air C_a mg/m^3	Inhalation Adult Dose mg/kg-day	Inhalation Child Dose mg/kg-day	Inhalation Resident ILCR	**All Pathways Total ILCR**
Explosives					
Dinitrotoluene, 2,4-	9.10E-10	8.55E-11	4.99E-11	NA	**6.01E-07**
Trinitrotoluene, 2,4,6-	2.21E-08	2.08E-09	1.21E-09	NA	**5.28E-07**
Semivolatile Organic Compounds					
Benzo(a)pyrene	6.17E-11	5.79E-12	3.38E-12	2.84E-11	**4.69E-07**
Total ILCR				**2.84E-11**	**1.60E-06**

EPC - Exposure point concentration.
ILCR - Incremental lifetime cancer risk.
mg/kg - Milligrams per kilogram.
mg/cm^2 - Milligrams per square meter.
mg/m^3 - Milligrams per cubic meter.

Table F-10

On-Site Child Resident, Noncancer Risk, Future Scenario, Exposure to Total Soil
TNTA/WWTP1 Sewer Lines - Minus Potential Hot Spots
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion		Dermal Contact			Concentration	Inhalation		**All**
	EPC	Child Dose	Child Resident	Dose Absorbed	Child Dose	Child Resident	in Air C_a	Child Dose	Child Resident	**Pathways Total**
Chemicals of Potential Concern	mg/kg	mg/kg-day	HQ	mg/cm^2-day	mg/kg-day	HQ	mg/m^3	mg/kg-day	HQ	**HI**
Explosives										
Dinitrotoluene, 2,4-	4.62E-01	5.32E-06	2.66E-03	9.42E-09	1.69E-06	8.43E-04	9.10E-10	5.82E-10	NA	**3.50E-03**
Trinitrotoluene, 2,4,6-	1.12E+01	1.29E-04	2.58E-01	7.18E-08	1.29E-05	2.57E-02	2.21E-08	1.41E-08	NA	**2.84E-01**
Semivolatile Organic Compounds										
Benzo(a)pyrene	3.13E-02	3.60E-07	NA	8.14E-10	1.46E-07	NA	6.17E-11	3.94E-11	NA	**NA**
Total HI			**2.61E-01**			**2.66E-02**			**NA**	**2.87E-01**

EPC - Exposure point concentration.
HQ - Hazard quotient; HI - Hazard index.
mg/kg - Milligrams per kilogram.
mg/cm^2 - Milligrams per square meter.
mg/m^3 - Milligrams per cubic meter.

Table F-11

On-Site Adult Resident, Noncancer Risk, Future Scenario, Exposure to Total Soil
TNTA/WWTP1 Sewer Lines - Minus Potential Hot Spots
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion		Dermal Contact			Concentration	Inhalation		**All**
	EPC	Adult Dose	Adult Resident	Dose Absorbed	Adult Dose	Adult Resident	in Air C_a	Adult Dose	Adult Resident	**Pathways Total**
Chemicals of Potential Concern	mg/kg	mg/kg-day	HQ	mg/cm^2-day	mg/kg-day	HQ	mg/m^3	mg/kg-day	HQ	**HI**
Explosives										
Dinitrotoluene, 2,4-	4.62E-01	5.70E-07	2.85E-04	3.30E-09	2.58E-07	1.29E-04	9.10E-10	2.49E-10	NA	**4.14E-04**
Trinitrotoluene, 2,4,6-	1.12E+01	1.38E-05	2.77E-02	2.51E-08	1.96E-06	3.92E-03	2.21E-08	6.05E-09	NA	**3.16E-02**
Semivolatile Organic Compounds										
Benzo(a)pyrene	3.13E-02	3.86E-08	NA	2.85E-10	2.22E-08	NA	6.17E-11	1.69E-11	NA	**NA**
Total HI			**2.80E-02**			**4.05E-03**			**NA**	**3.20E-02**

EPC - Exposure point concentration.
HQ - Hazard quotient; HI - Hazard index.
mg/kg - Milligrams per kilogram.
mg/cm^2 - Milligrams per square meter.
mg/m^3 - Milligrams per cubic meter.

Table F-12

Adult Hunter, Future Scenario, Exposure to Surface Soil
TNTA/WWTP1 Sewer Lines - Minus Potential Hot Spots
Plum Brook Ordnance Works, Sandusky, Ohio

		Incidental Ingestion				Dermal Contact				
	EPC	Cancer Dose	Noncancer Dose	Adult Hunter	Adult Hunter	Dose Absorbed	Cancer Dose	Noncancer Dose	Adult Hunter	Adult Hunter
Chemicals of Potential Concern	mg/kg	mg/kg-day	mg/kg-day	ILCR	HQ	mg/cm^2-day	mg/kg-day	mg/kg-day	ILCR	HQ
Semivolatile Organic Compounds										
Benzo(a)pyrene	4.13E-02	9.70E-10	2.26E-09	7.08E-09	NA	1.07E-09	8.32E-10	1.94E-09	6.07E-09	NA
Total ILCR and HI				**7.08E-09**	**NA**				**6.07E-09**	**NA**

EPC - Exposure point concentration.
HQ - Hazard quotient; HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
mg/kg - Milligrams per kilogram.
mg/cm^2 - Milligrams per square meter.

Table F-12

Adult Hunter, Future Scenario, Exposure to Surface Soil
TNTA/WWTP1 Sewer Lines - Minus Potential Hot Spots
Plum Brook Ordnance Works, Sandusky, Ohio

	Concentration in Forage C_p	Concentration in Venison C_v	Consumption of Venison				**All Pathways**	
			Cancer Dose	Noncancer Dose			**Total**	**Total**
Chemicals of Potential Concern	mg/kg	mg/kg	mg/kg-day	mg/kg-day	ILCR	HQ	**ILCR**	**HI**
Semivolatile Organic Compounds								
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	**1.32E-08**	**NA**
Total ILCR and HI					**NA**	**NA**	**1.32E-08**	**NA**

EPC - Exposure point concentration.
HQ - Hazard quotient; HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
mg/kg - Milligrams per kilogram.
mg/cm^2 - Milligrams per square meter.

Table F-13

Hunter's Child, Future Scenario, Exposure to Surface Soil
TNTA/WWTP1 Sewer Lines - Minus Potential Hot Spots
Plum Brook Ordnance Works, Sandusky, Ohio

		Concentration in Forage	Concentration in Venison	Consumption of Venison					
	EPC	C_p	C_v	Cancer Dose	Noncancer Dose			**Total**	**Total**
Chemicals of Potential Concern	mg/kg	mg/kg	mg/kg	mg/kg-day	mg/kg-day	ILCR	HQ	**ILCR**	**HI**
Semivolatile Organic Compounds									
Benzo(a)pyrene	4.13E-02	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Total ILCR and HI						**NA**	**NA**	**NA**	**NA**

EPC - Exposure point concentration.
HQ - Hazard quotient; HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
mg/kg - Milligrams per kilogram.

RESPONSE TO COMMENTS

Response to Ohio Environmental Protection Agency Comments
Draft Baseline Human Health Risk Assessment (BHHRA) and
Draft Screening Level Ecological Risk Assessment (SLERA)
TNT Area A to Waste Water Treatment Plant 1 Sewer Lines
Plum Brook Ordnance Works, Sandusky, Ohio,
Dated February 16, 2012
FUDS Project No. G05OH001826

Comments from Janusz Byczkowski, Ph.D., Toxicologist, Ohio Environmental Protection Agency, Division of Emergency and Remedial Response, Columbus, Ohio, received April 30, 2012.

Comment 1: **BHHRA, Executive Summary, Page ES-1, Line 7; Page ES-2, Line 19, Section 2.4.3.1 Page 2-9, Line 26, etc., and SLERA Executive Summary, Page ES-1, Line 32, etc. These Documents state: In BHHRA: "*…agreements between the Ohio Environmental Protection Agency, the U.S. Army Corps of Engineers Nashville and Huntington Districts, and Shaw Environmental, Inc…*" and then: "*…Plum Brook Project Delivery Team agreement…*"Also in SLERA: "*…based on Plum Brook Project Delivery Team agreements, differs somewhat from the current Ohio Environmental Protection Agency guidance…*"**

The issue of "*agreements*" was already discussed in previous reviews. These Documents should be re-check for misstatements and errors. Please delete any statement claiming "agreement" between OEPA, and ACE or Shaw Environmental Inc. Please note that no legally binding agreement has been made with ACE or Shaw Environmental Inc., regarding risk assessment at the NASA Plum Brook Site. It is highly recommended that either the U.S. EPA RAGS part A or OEPA-DERR risk assessment methodology guidelines should be followed. Ohio EPA may (or may not) concur with the methodology that somewhat differs from OEPA-DERR guidance, based on scientifically sound reasoning and health protectiveness of the outcome, but not based on any informal "*agreement*". Statement regarding such an agreement should be deleted throughout the document, especially in the introductory paragraphs.

Response 1: It is the goal of the Project Delivery Team (PDT), including OEPA, NASA, USACE, and their contractors, to coordinate truly as a team. This includes reaching agreements during PDT meetings and teleconferences that are documented as part of meeting minutes, teleconference notes, and/or email correspondence. These agreements should not be regarded as "informal," as they have included review of the technical staff of all PDT members as appropriate. The PDT members have consistently abided by these PDT agreements and have not unilaterally revised them.

OEPA has requested in previous correspondence that where a specific PDT agreement differs from State guidance that the difference be noted and that the

PDT agreement be cited. This information was included in the TNTA/WWTP1 Sewer Lines BHHRA and SLERA for the agreements cited.

Please note that the RAGS Part A (U.S., Environmental Protection Agency [EPA], 1989), concentration/toxicity approach recommended by the reviewer is not recognized by the U.S. Army Corps of Engineers [USACE] (1999) nor by more recent EPA guidance (e.g., 2001a). This approach was provided as a suggestion in RAGS A prior to the development and of risk-based concentrations tables (EPA Region 3) and preliminary remediation goal tables (EPA Region 9) in the early 1990's, and their subsequent use for screening in baseline risk assessments. The RAGS A concentration/toxicity approach has numerous technical problems, including a lack of consideration for dermal uptake efficiencies, and the reliance on "relative toxicity" among chemicals rather than on predicted, conservative risk-based values at a given concentration (i.e., ILCR of 1E-6 or HQ of 0.1). USACE (1999) risk assessment guidance correctly states that "…it is imperative that these (health-based screening such as Region 9 PRGs and Region 3 RBCs) values be applied within the context that they were developed." (Please note that RSLs are currently used rather than RBCs or PRGs.) The RAGS A method suggests comparing media concentration values (e.g., mg/L) to dose rates (mg/kg-day) or dose-based risk rates $(mg/kg\text{-}day)^{-1}$, where the units and context are dissimilar. The use of dissimilar units is a generally discouraged practice, especially when the measurements goals (concentrations versus dose rates or dose-based risk rates) of these units are quite different. Using consistent units for maximum detected concentrations and human health risk-based screening concentrations is a current, widely accepted practice (e.g., EPA, 2008; 2001a; 1995) that has been used for two decades. In summary, the suggested RAGS A method is not current and is unreliable for screening, as it may identify "COPCs" that truly represent de minimis risk, and it may exclude COPCs that represent a potential human health risk or hazard using current human health risk assessment guidance.

Please note that the remainder of the reviewer's comments apply only to the BHHRA.

Comment 2: Section 2.4.1, _Page 2-6, line 27. This Document states: "*…OEPA (1999) stated that unadjusted tap water PRG values (i.e., HQ=1; ILCR = 1E-6) should be used for screening POBW surface water…*"

The issue of surface water screening was also discussed in prior reviews. The approach described in these documents is inconsistent with the previous reviewer's recommendation. Particularly, the obsolete reference: OEPA (1999) "*email correspondence between Lawrence Sirinek (OEPA Risk Assessor) and Paul Goetchius (Shaw Risk Assessor), March 5*", does not describe currently used methodology (e.g., the PRG values developed by U.S. EPA Region 9 have been since archived and replaced by the harmonized U.S. EPA Regions 3,6,9 RSL values). Please note, that surface water also have to meet the Lake Erie Basin surface water criteria and screening values, developed pursuant to Chapters 3745-1 and 3745-2 of the Ohio Administrative Code http://epa.ohio.gov/dsw/rules/effectiverules.aspx . As recommended before: in

baseline risk assessment, please follow either the U.S. EPA RAGS part A or OEPA-DERR technical guidelines.

Response 2: First, because each of the chemicals analyzed (i.e., nitroaromatics) in TNTA/WWTP1 sewer lines surface water was a nondetect, this comment is a moot point for surface water in the BHHRA. It is agreed that Lake Erie Basin Human Health nondrinking values are used to screen surface water at PBOW. The last sentence of the first paragraph on Page 2-7 will be revised with text that is consistent with the following: "*The surface water RBSCs will be checked against the Lake Erie Basin Tier I and Tier II Nondrinking Values for Human Health. If Lake Erie Basin Human Health value is less than the RSL-based value, then the Lake Erie Basin value will be used as the RBSC.*" Please note that this practice has been followed in past PBOW risk assessments but that the RSL-based values are less than the Lake Erie Basin values for the chemicals detected in PBOW surface water.

The fact that RSLs have replaced Region 9 PRGs, Region 6 HHMSSLs, and Region 3 RBCs as the screening values of choice is documented by the various EPA regions and states which had previously used these former screening values. Use of the new screening values does not in any way change their implementation into risk-based screening, nor the technical basis for a specific hazard quotient level to screen a specific medium. Please note that the EPA Region 4 (2012) Web site states that RSLs replace PRGs for screening. This same Region 4 Web site also lists the Region's RAGS Supplemental HHRA guidance (EPA, 2001b), which includes the use of PRGs, as current guidance. This listing indicates that EPA Region 4 does not consider replacement of PRGs with RSLs as a basis to otherwise change their screening protocol and/or to re-issue their screening guidance. EPA Region 3 (2008) states the following concerning the replacement of RBCs with RSLs: "The Regional Screening table is generally used in the same manner as the Region III RBC Table. Except where noted above, the same national and regional guidance, the same uncertainties and limitations, and the same basic intended uses apply to this update as to previous versions of the Region III RBC Table. It is Region III's general expectation that the Fall 2008 Regional Screening table essentially serves as the Fall 2008 update to the Region III RBC table." It is clear that EPA does not equate a change in screening values with a change in screening protocol. Similarly, the referenced PDT agreement (OEPA, 1999) is not invalidated by a change in screening values.

Comment 3: **Section 4.1, Page 4-2, lines 6 to 31. This Document states: "…*Although […] most human studies have one or more of the following limitations*…" A critic of the carcinogenicity data and/or a list of limitations in the development of carcinogenic slope factors do not belong in the Section 4 "*Toxicity Evaluation*". This information may be re-used in Section 6, in order to discuss uncertainty. Please remove the last sentence of the first paragraph and the following bullets from Page 4-2 and reuse them in the Section 6 "*Uncertainty Analysis*".**

Response 3: The requested text will be removed from the BHHRA. This discussion is a summary of information contained in Sections 7.1 and 7.3 of the EPA (1989) RAGS A guidance that describes considerations of the use of human studies and animal studies in deriving toxicity values. It was included to provide a context so that the readers may gain some understanding as to when human studies and when animal studies are selected as the basis for the slope factor. This text was not intended as a criticism, neither was it included to cast uncertainty on verified slope factor values.

We appreciate the suggestion to include this text in the uncertainty analysis. However, the statements in Section 6.2.6 are regarded as sufficient to express general uncertainties concerning slope factor derivation, especially as no chemical-specific toxicological uncertainties are indentified in the TNTA/WWTP1 BHHRA sewer lines uncertainty analysis.

Comment 4: **Section 5.3.5, Page 5-11, Line 1. This Document states: "…*If the bedrock groundwater use is appropriately excluded, the ILCR for the resident is 2E-5*…" In the residential scenario, an unrestricted land use should be assumed. It includes digging/drilling, using ground water - in addition to the potable purpose – also to water plants/vegetable, to fill up basins/swimming pools, etc. Excluding the bedrock groundwater from BHHRA exposure scenario would necessitate a deed restriction preventing drilling – and thus, restricting the land use. Risk and health hazards associated with any (even hypothetical) groundwater use under unrestricted scenario may be important to risk managers and should not be excluded from BHHRA. Please do not exclude bedrock groundwater use under the unrestricted land use scenario.**

Response 4: This sentence will be revised consistent with the following: "If *use of* the bedrock groundwater is ~~appropriately~~ excluded *from this receptor in recognition that virtually all cancer risks associated with this medium result from naturally occurring constituents*, the ILCR for the resident is 2E-5 (Table 5-2)."

The BHHRA addresses residential risks associated with all pathways including bedrock groundwater use, all pathways including overburden groundwater use, and all pathways excluding groundwater use. The reasons for excluding groundwater use in the latter evaluation are: 1) Naturally poor groundwater quality that is associated with the presence of petroleum hydrocarbons and hydrogen sulfide gas, and 2) low groundwater yield. This poor quality makes future use of the groundwater questionable. Further, even if the groundwater were to be used, the unacceptable cancer risks incurred would not be due to DOD-related contamination.

Given these circumstances, it is best to include all scenarios with respect to groundwater so that risk managers have the most complete risk-related information to factor into their decisions, which may include issues other than risk. Discussions such as the possible need for deed restrictions may be

considered by risks managers, but these risk management issues are not typically included in a BHHRA.

Comment 5: **Table 2-2. This Document states: *"…Vanadium…Range of Detected Concentrations 9 – 40.9 …Range of Reporting Limits 61.7 – 61.7… Background Screening Criterion 40.9…"* There are still unexplained (and unresolved) issues regarding the background concentrations, calculated by the method that "*…differs somewhat from the current Ohio Environmental Protection Agency guidance…*" (see: comment #1, above). Even though this issue was commented and discussed before, it is still difficult to understand, for example, how the analytical method with the reporting limit listed as 61.7 mg/kg can quantify vanadium concentrations between 9 and 40.9 mg/kg to yield a background screening criterion (=MDC) of 40.9 mg/kg. Please explain issues regarding the determination of background concentrations.**

Response 5: After reviewing Table 2-2, we found that the reporting limit ranges that are shown include only those of the nondetects. This omission will be corrected for all inorganics that are affected in the final BHHRA.

For vanadium, the lowest reporting limit was 6.0 mg/kg, which is less than all of the detections of vanadium. All of the other vanadium reporting limits, other than for the nondetect shown in Table 2-2 were between 6.0 and 9.0 mg/kg, which is the lowest detected level. The lone nondetect had an elevated reporting limit of 61.7 mg/kg reflects the 10X dilution that had to be performed because of a matrix interference. Please note that the maximum detected vanadium concentrations in TNT/WWTP1 sewer lines surface soil (26.3 mg/kg) and subsurface soil, (27.0 mg/kg) are less than both the RBSC (39.0 mg/kg) and BSC (40.9 mg/kg). Therefore, vanadium was correctly screened out as a non-COPC in soil.

References Used in these Responses

Ohio Environmental Protection Agency (OEPA), 1999, email correspondence between Lawrence Sirinek (OEPA Risk Assessor) and Paul Goetchius (Shaw Risk Assessor), March 5.

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