Final
Baseline Human Health Risk Assessment

Acid Area 1

Former Plum Brook Ordnance Works
Sandusky, Ohio

Prepared for:

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
NASHVILLE, TENNESSEE
CONTRACT DACW62-03-D-0008-0008

Prepared by:

JACOBS ENGINEERING GROUP, INC.
125 BROADWAY AVENUE
OAK RIDGE, TN 37830

July
2010

200.1e
G05OH001823_03.11_0504_a

Table of Contents

Section ..... **Page**

List of Tables iii

List of Figures iii

List of Appendices iii

List of Acronyms and Abbreviations iv

EXECUTIVE SUMMARY ES-1

1.0 INTRODUCTION 1-1

1.1 FACILITY DESCRIPTION 1-1

1.2 BACKGROUND 1-2

1.3 SITE USE AND GROUNDWATER USE 1-3

1.3.1 Acid Area 1 Land Use 1-3

1.3.2 Groundwater Use 1-3

1.4 PROTOCOL FOR THE BASELINE HUMAN HEALTH RISK ASSESSMENT 1-4

1.5 ORGANIZATION OF THE BASELINE HUMAN HEALTH RISK ASSESSMENT 1-5

2.0 DATA EVALUATION 2-1

2.1 IDENTIFICATION OF COPCS 2-1

2.1.1 Evaluation of Data Quality 2-2

2.1.2 Frequency of Detection 2-3

2.1.3 Risk-Based Screening 2-3

2.1.4 Evaluating Essential Nutrients 2-3

2.1.5 Background Screening 2-4

2.2 DEVELOPING EXPOSURE-POINT CONCENTRATIONS 2-4

2.3 RESULTS OF THE DATA EVALUATION 2-8

3.0 EXPOSURE ASSESSMENT 3-1

3.1 CONCEPTUAL SITE EXPOSURE MODEL 3-1

3.1.1 Physical Setting 3-2

3.1.2 Contaminant Sources, Release Mechanisms, and Migration Pathways 3-4

3.1.3 Receptors and Exposure Pathways 3-4

3.1.3.1 Overburden Groundwater 3-5

3.2 QUANTIFICATION OF EXPOSURE-POINT CONCENTRATIONS 3-12
3.2.1 COPC Concentrations from Dust 3-13
3.2.2 Concentrations in Household Air from Groundwater Use 3-14
3.2.3 Concentrations of VOCs in Groundwater: Resident Dermal Uptake 3-15
3.2.4 Concentrations of COPCs in Venison 3-16
3.3 QUANTIFICATION OF CHEMICAL INTAKES 3-18
3.3.1 Inhalation of COPCs in Air 3-18
3.3.2 Incidental Ingestion of COPCs in Soil and Sediment 3-19
3.3.3 Dermal Contact with COPCs in Soil, Sediment, or Water 3-19
3.3.4 Consumption of Venison 3-20
3.3.5 Ingestion of COPCs in Groundwater and Surface Water 3-21
4.0 TOXICITY ASSESSMENT 4-1
4.1 EVALUATION OF CARCINOGENICITY 4-1
4.2 EVALUATION OF NONCARCINOGENIC EFFECTS 4-2
4.3 DERMAL TOXICITY VALUES 4-3
4.4 TARGET ORGAN TOXICITY 4-4
4.5 SOURCES OF TOXICITY INFORMATION USED IN THE RISK ASSESSMENT ... 4-4
5.0 RISK CHARACTERIZATION 5-1
5.1 CANCER RISK 5-1
5.2 NONCANCER HAZARDS 5-2
5.3 RISK-BASED REMEDIATION LEVEL DEVELOPMENT 5-4
5.4 RISK CHARACTERIZATION RESULTS AND DISCUSSION 5-7
6.0 UNCERTAINTY ANALYSIS 6-1
7.0 SUMMARY AND CONCLUSIONS 7-1
7.1 SAMPLING AND ANALYSIS 7-1
7.2 RISK ASSESSMENT RESULTS 7-1
8.0 REFERENCES 8-1

List of Tables

Table 2-1 Summary Statistics and Identification of COPCs for Constituents Detected in Environmental Media, Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Table 3-1 Receptor/Exposure Scenarios, Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Table 3-2 Variables Used to Estimate Potential Chemical Intakes and Contact Rates for Receptors, Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Table 3-3 Variables Used to Estimate Potential Chemical Intake and Contact Rates from Groundwater at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Table 4-1 Toxicity Values Used in the BHHRA, Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Table 5-1 Summary of Noncancer Hazards and Cancer Risk Estimates from Potential Exposures at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

List of Figures

Figure 1-1 Location Map, Plum Brook Ordnance Works, Sandusky, Ohio

Figure 1-2 Location Map, Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Figure 2-1 Sampling Locations, Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Figure 3-1 Human Health Conceptual Site Exposure Model, Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Figure 5-1 Distribution of COCs Exceeding RSLs in Surface Soil – Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Figure 5-2 Distribution of COCs Exceeding RSLs in Subsurface Soil – Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Figure 5-3 Distribution of COCs Exceeding RSLs in Surface Water – Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Figure 5-4 Distribution of COCs Exceeding RSLs in Sediment – Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Figure 5-5 Distribution of COCs Exceeding RSLs in Bedrock Groundwater – Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

List of Appendices

APPENDIX A Dermal Absorbed Dose Calculations

APPENDIX B Risk Calculations

APPENDIX C Toxicological Profiles for Chemicals of Concern

APPENDIX D ProUCL Calculations for Exposure-Point Concentrations

APPENDIX E Response to Comments on the Draft Baseline Human Health Risk Assessment

List of Acronyms and Abbreviations

5x, 10x	five-times, ten-times
µg/dL	microgram per deciliter
µg/L	microgram per liter
ABS	dermal absorption factor
AF	adherence factor
amsl	above mean sea level
ATSDR	Agency for Toxic Substances and Disease Registry
AT	averaging time
bgs	below ground surface
BHHRA	baseline human health risk assessment
BSC	background screening concentration
BTEX	benzene, toluene, ethylbenzene, and total xylenes
BW	body weight
cm^2	square centimeter
COC	chemical of concern
COPC	chemical of potential concern
CSEM	conceptual site exposure model
CT	central tendency
DA	dose absorbed per unit body surface area per event
DERP	Defense Environmental Restoration Program
DM	dry matter
DNT	dinitrotoluene
DOE	U.S. Department of Energy
DPT	direct push technology
ED	exposure duration
EF	exposure frequency
EPA	U.S. Environmental Protection Agency
EPC	exposure-point concentration
ET	exposure time
FI	fraction of intake
ft	foot/feet
FUDS	Formerly Used Defense Sites
g	gram
g/m^3	grams per cubic meter
g/kg-day	grams per kilogram of body weight per day
GAF	gastrointestinal absorption factor
gpm	gallons per minute
GSA	U.S. General Services Administration
HHEM	Human Health Evaluation Manual
HI	hazard index

HQ	hazard quotient
hr/day	hours per day
IEUBK	integrated exposure-uptake biokinetic
ILCR	incremental lifetime cancer risk
IR	ingestion rate
IRIS	Integrated Risk Information System
IT	IT Corporation
Jacobs	Jacobs Engineering Group
kg	kilogram
kg/g	kilograms per gram
KM	Kaplan-Meier
L	liter
L/day	liters per day
m	meters
m/sec	meters per second
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
MDC	maximum detected concentration
mg	milligram
mg/cm^2	milligrams per square centimeter
mg/day	milligrams per day
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mg/m^3	milligrams per cubic meter
NASA	National Aeronautics and Space Administration
NCRPM	National Council on Radiation Protection and Measurements
OEPA	Ohio Environmental Protection Agency
PAH	polynuclear aromatic hydrocarbon
PBOW	Plum Brook Ordnance Works
PC	permeability coefficient
PCB	polychlorinated biphenyl
PEF	particulate emission factor
PRG	preliminary remediation goal
RA	risk assessment
RBC	risk based criteria
RBRL	risk-based remediation level
RBSC	risk-based screening concentration
RfC	reference concentration
RfD	reference dose
RI	Remedial Investigation

RME	reasonable maximum exposure
RSL	regional screening level
SA	surface area
SAIC	Science Applications International Corporation
SF	slope factor
Shaw	Shaw Environmental, Inc.
SI	Site Investigation
SVOC	semivolatile organic compound
TNT	trinitrotoluene
TRW	Technical Review Workgroup
UCL	upper confidence limit
UCL_{95}	95th percent upper confidence limit on the arithmetic mean
UF	uncertainty factor
USACE	U.S. Army Corps of Engineers
VOC	volatile organic compound

EXECUTIVE SUMMARY

This baseline human health risk assessment (BHHRA) report presents the human health risks from potential exposure to soil, groundwater, surface water and sediment associated with Acid Area 1 located at the former Plum Brook Ordnance Works (PBOW), Sandusky, Erie County, Ohio. This BHHRA was prepared in accordance with the Baseline Human Health Risk Assessment Work Plan (Jacobs, 2009). It is consistent with U.S. Environmental Protection Agency (EPA) and Ohio EPA guidance and with the procedures established in the BHHRA Work Plan for trinitrotoluene (TNT) Areas A & C soil (IT Corporation, 2001a) and the BHHRA work plan for groundwater at PBOW (Shaw Environmental, Inc., 2005a).

The Acid Area 1 site is located in the northwestern portion of PBOW. The site physical features include an open field bounded by a drainage ditch to the south with scattered overgrowth throughout. Two railroad grades run east-west through the site: one on the southern perimeter and one through the northern portion of the site. The original service road encircles the site. The road is in fair condition and clear of vegetation. Buildings (Bldgs) 302, 308, and 310 are the only remaining original structures at the site. All other buildings and tanks have been removed. The National Aeronautics and Space Administration (NASA) constructed a metal building between former Building 301 and Building 302. This building was formerly used by NASA as an incinerator, but is currently used for equipment storage.

Acid Area 1 consisted of eight buildings (Bldgs. 301-304, Bldgs. 306-308, and Bldg. 310), 43 aboveground storage tanks, and two rail lines. No information was obtained during the records review to indicate the type of process conducted at each building; however, identification of five storage areas was determined from the drawings: Oleum Storage (twelve tanks), Concentrating Mix Storage (six tanks), Sulfuric Acid Sales (twelve tanks), TNT Residual Acid Storage (five tanks), and Mixed Storage (8 horizontal tanks). Based on the location of the Oleum Storage, Sulfuric Acid Sales Storage, and Mixed Storage in close proximity to the rail line, the stored material was likely transferred directly to and from tanker cars or containers on a routine basis.

The ground surface at Acid Area 1 is relatively flat, with minimal slope toward the drainage ditches to the north, south, and west. Elevations at the site range from 629 to 640 feet (ft) above mean sea level (amsl). Four drainage features are present at the site. Flowing water has been observed in all four drainage ditches during the wet season in early to mid-spring. All but the northern drainage ditch dry up by mid-summer including the ponded area and the swampy area.

The objective of this BHHRA is to evaluate potential for cancer and noncancer human health effects posed to current and potential future receptors. This objective was met through the process of data evaluation, exposure assessment, toxicity assessment, risk characterization, and uncertainty analysis.

Data evaluation consists of identification of data sources, evaluation of data quality, identification of chemicals of potential concern, and background screening. The exposure assessment consists of development of the conceptual site exposure model including definition of contaminant sources, contaminant release mechanisms, receptors, and exposure pathways; description of exposure-point concentrations (EPCs); and identification of the methods for calculating chemical intake and contact rates. The toxicity assessment defines 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; and identifies the toxicity values that are used in the BHHRA. The risk characterization combines the output of the exposure assessment and toxicity assessment to quantify the risk to each receptor. The uncertainty analysis identifies uncertainties in all phases of the BHHRA and discusses their individual effects on the risk assessment results.

PBOW is currently classified for industrial use, but future residential use was considered in the risk assessment to support evaluation of all plausible receptor scenarios. Groundskeeper, construction worker, and hunter scenarios were evaluated under the current site-use assumptions. Groundskeeper, construction worker, indoor worker, hunter (including a child venison consumer), and on-site residential scenarios were evaluated as plausible future exposure scenarios.

The groundskeeper, hunter, and child venison consumer were evaluated for exposure only to surface soil within Acid Area 1. The total hazard index (HI) estimate for the groundskeeper receptor was 0.2 (Table 5-1). The HI does not exceed the threshold for noncancer effects indicating no potential for adverse effects. The total incremental lifetime cancer risk (ILCR) estimate for the groundskeeper receptor was 1.1E-5. The primary COCs driving the ILCR were arsenic, PCB-1254 and PCB-1260.

Total HI estimates for the adult hunter and the adult and child venison consumer receptors were below the threshold limit of 1. The total ILCR estimate for the adult hunter was 1.0E-6. The primary COC for the ILCR was PCB-1254 from ingestion and dermal contact of surface soil. Total ILCR estimates for the adult and child venison consumer receptors were below 1E-6, defined as the point of departure for significant contribution to cancer risk.

The construction worker was evaluated for exposure to surface, subsurface soil, sediment, and surface water within Acid Area 1. The total HI estimate summed across all media for the construction worker receptor was 0.92 (Table 5-1) which is below the threshold limit of 1. The total ILCR estimate summed across all media for the construction worker was 2.0E-6. The COCs driving the ILCR were arsenic and PCB-1260.

The indoor worker was evaluated for exposure to surface soil and groundwater. Total HI estimates for the indoor worker for groundwater and surface soil were 2.0 and 0.07, respectively (Table 5-1). The ILCR for groundwater and surface soil were 9.0E-5 and 6.0E-6, respectively. The COCs for the ILCR were arsenic and benzene in groundwater, and arsenic and PCB-1260 in surface soil. Vapor intrusion into buildings from subsurface soil was not evaluated, as there were no VOCs detected in subsurface soils.

The adult and child residential receptors were evaluated for exposure to surface and subsurface soil and groundwater. HI sums for groundwater and surface and subsurface soil were 6 and 16 for the adult and child, respectively (Table 5-1). The groundwater COCs driving the residential adult HI were total arsenic, cyanide, and total thallium with surface soil and subsurface soil not being significant contributors to the adult resident HI. For the residential child, groundwater COCs driving the HI are total arsenic, cyanide, total thallium and benzene. The surface soil COC factoring into the elevated child resident HI is PCB-1260. The HI for the adult and child exposed to surface water and sediment during a recreational use scenario are below 1.

The total ILCR estimates summed for groundwater and surface and subsurface soil within Acid Area 1 for adult and child residential receptors were 2.3E-4 and 2.0E-3, respectively. The groundwater COCs driving the ILCR were total arsenic and benzene for both the residential adult and child. The surface soil COCs contributing to the ILCR were arsenic and PCBs for the adult and child resident. Vapor intrusion into dwellings from subsurface soil was not evaluated, as there were no VOCs detected in the subsurface soil. The ILCR for the adult and child exposed to surface water and sediment during a recreational use scenario is 2.5E-6 and 3.2E-6.

HIs for the groundskeeper, construction worker, adult hunter, and adult and child venison consumers were less than 1. The HI for the indoor worker was greater than 1 (HI = 2) from exposure to groundwater with the risk drivers being total arsenic and total thallium in groundwater. The HIs for the adult and child resident exceeded 1 (6 and 16, respectively). The primary contributors to the elevated adult HI include total arsenic, cyanide, and total thallium in groundwater and total arsenic, cyanide, total thallium and benzene in groundwater for the resident child.

Cancer risk estimates were outside the cancer risk range of 1E-6 to 1E-4 for the adult and child resident only. The groundwater COCs driving the ILCR were total arsenic and benzene for both the residential adult and child. The surface soil COCs contributing to the ILCR were arsenic and PCBs for the adult and child resident.

Cancer risk estimates were within the cancer risk range of 1E-6 to 1E-4 for the construction worker and adult and child residential receptors for exposures to surface water and sediment.

1.0 INTRODUCTION

This baseline human health risk assessment (BHHRA) report presents the human health risks from potential exposure to soil, groundwater, surface water, and sediment associated with Acid Area 1 located at the former Plum Brook Ordnance Works (PBOW), Sandusky, Erie County, Ohio.

This BHHRA was prepared by Jacobs Engineering Group (Jacobs) under contract DACW62-03-D-0008, Delivery Order #8. This work is being conducted for the U.S. Army Corp of Engineers (USACE) under the Defense Environmental Restoration Program (DERP) – Formerly Used Defense Sites (FUDS). The Army is the executive agent for the FUDS program and the USACE manages and directs the program's administration. Investigations at PBOW under DERP-FUDS are being managed by the USACE Huntington District and technically overseen by the USACE Nashville District.

This BHHRA was prepared in accordance with the *Baseline Human Health Risk Assessment Work Plan* (Jacobs, 2009). It is consistent with U.S. Environmental Protection Agency (EPA) and Ohio EPA (OEPA) guidance and with the procedures established in the BHHRA Work Plan for trinitrotoluene (TNT) Areas A & C soil (IT Corporation [IT], 2001a) and the BHHRA work plan for groundwater at PBOW (Shaw Environmental, Inc. [Shaw], 2005a).

1.1 Facility 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 area surrounding PBOW is mostly agricultural and residential (IT, 2001b). 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, except during the annual deer hunting season.

The Acid Area 1 site is located in the central portion of PBOW, adjacent to Taylor Road, between Maintenance Road and Fox Road (Figure 1-2) (Jacobs, 2006), covering an area approximately 25 acres in size. The site physical features include an open field bounded by a drainage ditch to the south with scattered overgrowth throughout. Two railroad grades run east-west through the site: one on the southern perimeter and one through the northern portion of the site. The original service road encircles the site. The road is in fair condition and clear of vegetation. Buildings (Bldgs) 302, 308, and 310 are the only remaining original structures at the site. All other buildings and tanks have been removed. The National Aeronautics and Space Administration (NASA) constructed a metal building between former Building 301 and Building 302. This building was formerly used by NASA as an incinerator, but is currently used for equipment storage.

The ground surface at Acid Area 1 is relatively flat, with minimal slope toward the drainage ditches to the north, south, and west. Elevations at the site range from 629 to 640 feet (ft) above mean sea level (amsl). Four drainage features are present at the site. The drainage ditch to the south is located approximately 40 ft south of the service road and drains to the west, parallel to the site, discharging into Ransom Brook west of the site. This drainage feature has

little relief adjacent to the site. Another drainage ditch originates on site on the north central portion of the site and drains to the north. This drainage feature is approximately 30 to 40 ft wide and 15 to 18 ft deep just north of the Acid Area 1 site. A third drainage ditch originates in a low swampy area in the west central portion of the site and drains to the west into Ransom Brook. The fourth drainage ditch originates at a ponded area with a man-made dike in the northwest corner of the site, which also drains west into Ransom Brook. Flowing water has been observed in all four drainage ditches during the wet season in early to mid-spring. All but the northern drainage ditch dry up by mid-summer including the ponded area and the swampy area.

1.2 Background

The 9,009-acre PBOW site was built in early 1941 as a manufacturing plant for TNT, dinitrotoluene (DNT), and pentolite. Production of explosives began in December 1941 and continued until 1945. It is estimated that more than one billion pounds of explosives were manufactured during the four-year operating period.

NASA acquired PBOW in 1963 and presently utilizes about 6,400 acres for conducting space research. The site is operated by NASA as the Plum Brook Station of the John Glenn Research Center, which is headquartered in Cleveland, Ohio. In 1978, NASA declared approximately 2,152 acres of land as excess (IT, 1997). The Perkins Township Board of Education acquired 46 acres of the excess property for use as a bus transportation center. The Ohio National Guard has an agreement with the U.S. General Services Administration (GSA) to use 604 acres of the facility.

The acid production areas were in operation from 1941 to 1945 to produce oleum, sulfuric acid, and nitric acid for the manufacture of TNT. A records review was conducted by IT in preparation for a Site Investigation (SI) of the Acid Areas (IT 1998). The records review indicated that no previous investigations had been conducted at Acid Area 1. Available drawings of the site were used to identify some facility components. A review of the 1958 aerial photographs revealed several buildings and aboveground storage tanks at Acid Area 1. The majority of the site facilities were dismantled between 1958 and 1963. Buildings 302 Sulphuric Acid Concentration Plant, 308 Ammonia Oxidation Plant, and 310 are the only remaining original structures at the site.

Acid Area 1 consisted of eight buildings (Bldgs. 301-304, Bldgs. 306-308, and Bldg. 310), 43 aboveground storage tanks, and two rail lines. No information was obtained during the IT records review to indicate the type of process conducted at each building; however, identification of five storage areas was determined from the drawings: Oleum Storage (twelve tanks), Concentrating Mix Storage (six tanks), Sulfuric Acid Sales (twelve tanks), TNT Residual Acid Storage (five tanks), and Mixed Storage (8 horizontal tanks). Based on the location of the Oleum Storage, Sulfuric Acid Sales Storage, and Mixed Storage in close proximity to the rail line, the stored material was likely transferred directly to and from tanker cars or containers on a routine basis.

An SI was performed at Acid Area 1 in 1998, which identified surface and subsurface soil contamination above U.S. EPA Region III Risk-Based Criteria (RBC). Organic contaminants in surface and subsurface soil exceeding the RBCs included polynuclear aromatic hydrocarbons (PAH), and polychlorinated biphenyls (PCB).

A Remedial Investigation (RI) was performed May 2007 through May 2008 to define the extent of soil contamination and to evaluate impacts to the groundwater, surface water, and sediment in the vicinity of Acid Area 1. Two rounds of groundwater sampling were performed; one in November 2007 and one in early May 2008. The results of the RI at Acid Area 1 are summarized in Section 2.0.

1.3 Site Use and Groundwater Use

Prior to acquisition of the site for construction of the PBOW, the area was largely agricultural. Most of the forested areas were cleared during construction of the PBOW. Today, second generation forests have returned to large portions of the site that are not actively used by NASA. Other undeveloped areas of the site are maintained as open fields. The surrounding area is mostly agricultural and residential.

Potential future uses of portions or all of the facility property include:

1. The continuation of NASA activities at PBOW.
2. Recreational uses such as hunting and fishing. PBOW is open to deer hunters during the hunting season.
3. Selling of portions of the site by GSA to other parties (state or local government or private individual).
4. Agricultural uses.
5. Residential uses.
6. Training area for use by National Guard Units.
7. Construction activities.

Items three through seven are speculative and no negotiations have been scheduled to define future land use.

1.3.1 Acid Area 1 Land Use

The Acid Area 1 site was used for the production and storage of various types of acid used for the production of TNT and DNT. The facility was constructed in 1941 and used through 1945. Most of the buildings and all of the storage tanks were removed between 1958 and 1963. The remaining buildings at Acid Area 1 are used on a limited basis for temporarily storage. No specific future uses of this site have been identified.

1.3.2 Groundwater Use

Two aquifers are utilized for drinking water in the area surrounding PBOW: a carbonate aquifer outcropping in the western portion of Erie County and a shale aquifer outcropping in the eastern portion. PBOW is located within the transition of the two aquifers. Both aquifers are overlain by a veneer of glacial drift, generally less than 20 ft thick, that is considered a poor source of groundwater except in areas of sand and gravel lenses.

Most of PBOW is mapped by the Ohio Department of Natural Resources as an area in which well yields seldom exceed three gallons per minute (gpm) from the shale aquifer and overlying discontinuous sand and gravel deposits. The northwest portion of PBOW, including Acid Area 1, is mapped as an area in which yields of 100 to 500 gpm may be developed from depths of less than 200 ft from cavernous limestone and dolomite. The bedrock monitoring wells installed at Acid Area 1 were completed in limestone with a diverse range in porosity and fracturing. Groundwater yields range from zero gpm from the upgradient well east of Taylor Road to less than a 1 gpm from the downgradient well located at the northwest corner of the site.

Residences to the north and east of PBOW are served by city, county, and rural water departments. Residences south and west of PBOW are supplied by wells. As of 1991, a total of 179 permitted private drinking water wells, listed at the Erie County Health Department, were within a four-mile radius of PBOW (Science Applications International Corporation [SAIC], 1991). The nearest recorded well was at 6115 Schenk Road, approximately 3,800 ft from the site; however, a closer well was observed at 1810 Schenk Road, located approximately 2,250 ft from the site.

1.4 Protocol for the Baseline Human Health Risk Assessment

This BHHRA was prepared based on U.S. EPA, OEPA, and USACE, guidance, including, but not limited to, the following:

- OEPA, 2004a, *Technical Decision Compendium, Methodology for Evaluating Site-specific Background Concentrations of Chemicals* Ohio EPA Division of Emergency and Remedial Response Remedial Response Program, 14 April 2004.

- OEPA, 2004b, *Technical Decision Compendium, Human Health Cumulative Carcinogenic Risk and Non-carcinogenic Hazard Goals for DERR Remedial Response and Office of Federal Facility Oversight* Ohio EPA Division of Emergency and Remedial Response, 28 April 2004

- OEPA, 2005a, *Use of Risk-Based Numbers in the Remedial Response Process Overview* DERR-00-RR-038, June 28, 2005.

- OEPA, 2005b, *Technical Decision Compendium, Assessing Compounds without Formal Toxicity Values Available for Use in Human Health Risk Assessment* Ohio EPA Division of Emergency and Remedial Response Remedial Response Program, August 2005.

- U.S. 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. 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. EPA, 1991b, *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual Part B – Development of Risk-Based Preliminary Remediation Goals*, Interim, Office of Emergency and Remedial Response, Washington, D.C., EPA/540/R-92/003, December.

- U.S. EPA, 1992a, *Supplemental Guidance to RAGS: Calculating the Concentration Term*, Office of Solid Waste and Emergency Response, Washington, D.C., Publication 9285.7-081.

- U.S. EPA, 1992b, *Dermal Exposure Assessment: Principles and Applications*, Interim Report, Office of Research and Development, Washington, D.C., EPA/600/891/011B, including Supplemental Guidance, dated August 18, 1992.

- U.S. EPA, 1992c, "Guidance on Risk Characterization for Risk Managers and Risk Assessors," Memorandum from F. Henry Habicht II, Deputy Administrator, to Assistant Administrators, Regional Administrators, February 26.

- U.S. EPA, 1997a, *Exposure Factors Handbook*, Office of Research and Development, National Center for Environmental Assessment, Washington, D.C., EPA/600/P95/002F, August.

- USACE, 1999, *Risk Assessment Handbook, Volume I: Human Health Evaluation*, Engineer Manual EM 200-1-4.

- U.S. 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.

1.5 Organization of the Baseline Human Health Risk Assessment

This BHHRA report presents the methods used, results generated, and the interpretation of these results. The remainder of this report is organized as follows:

Section 2.0, Data Evaluation: Identifies data sources, evaluates data quality, identifies chemicals of potential concern (COPCs), and provides the background screening.

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

Section 4.0, Toxicity Assessment: 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.

Section 5.0, Risk Characterization: Combines the output of the exposure assessment and toxicity assessment to quantify the risk to each receptor. Risks associated with exposure to all appropriate media were evaluated. This section includes the derivation of risk-based remediation levels (RBRLs), which describes their development based on the methods of the BHHRA and discussion between OEPA and USACE.

Section 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 likely to have the greatest effect on risk estimates and/or risk management decisions.

Section 7.0, Summary and Conclusions: Provides a brief summary of the BHHRA, including quantitative results, uncertainties, and pertinent site information. The summary focuses those results and issues that are most likely to directly affect site management decisions.

Section 8.0, References: Provides a complete list of all references used and cited in the BHHRA.

The text of this document is supported by the following appendices:

Appendix A, Dermal Absorbed Dose Calculations

Appendix B, Risk Calculations

Appendix C, Toxicological Profiles for Chemicals of Concern

Appendix D, ProUCL Calculations for Exposure-Point Concentrations

2.0 DATA EVALUATION

An SI of Acid Area 1 was conducted in 1998 by IT to determine the existence and nature of contamination, and to evaluate potential risks to human health and the environment (IT 1998). Fifteen soil borings were completed to characterize lithology and to collect soil samples for off-site laboratory analysis. Total depths of these borings ranged from 4 to 10 ft below ground surface (bgs).

The SI identified surface and subsurface soil contamination above U.S. EPA Region III RBCs. Organic contaminants in surface and subsurface soil exceeding the RBCs were identified, including the following:

- PAHs: Benzo(a)pyrene
- PCBs: Aroclor 1260 (surface soil only, subsurface soil not analyzed for PCBs)

Inorganic contaminants in surface and subsurface soil exceeding both the RBCs and the established background values were limited to arsenic, aluminum, and beryllium.

An RI was performed by Jacobs from May 2007 through May 2008 to define the extent of soil contamination and to evaluate impacts to the groundwater, surface water, and sediment in the vicinity of Acid Area 1. Two rounds of groundwater sampling were performed, one in November 2007 and the second in May 2008.

A total of 45 soil samples were collected from 23 locations, placed adjacent to buildings and storage tanks. Contaminants in soil exceeding the U.S. EPA Region IX Residential Preliminary Remediation Goals (PRGs) and established background values for inorganics are primarily limited to surface soil. These contaminants include PCBs, PAHs, and lead.

A total of 15 co-located surface water and sediment samples were collected from the drainage ditches. At least one upgradient and one downgradient sample were collected from each of the four drainage ditches. Contaminants exceeding the U.S. EPA Region IX Residential PRGs and established background values for inorganics were primarily limited to sediment. These contaminants include PCBs, PAHs, and lead.

Three shallow groundwater monitoring wells and three bedrock groundwater monitoring wells were installed. Two rounds of groundwater sampling were conducted, one in November 2007 and the other in May 2008. Data from the May 2008 sampling is not yet available. Contaminants in shallow groundwater exceeding the U.S. EPA Region IX Tap Water PRGs were only present in the upgradient well. These contaminants include benzene and xylene. Contaminants in bedrock groundwater exceeding the U.S. EPA Region IX Tap Water PRGs include volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) associated with naturally occurring petroleum and explosives at one well on the north central portion of the site.

2.1 Identification of COPCs

COPCs are the chemicals that are identified as site-related and potentially capable of contributing significantly to risk, and are carried forward to quantitative evaluation in the risk

assessment (RA). The following subsections describe the process for their identification. Prior to initiation of the RA, a list of chemicals present in site samples was compiled. This initial list included all chemicals detected in any site medium. COPCs were selected from this list as discussed in the following sections.

2.1.1 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 data validation that reflect the level of confidence in the data. The following are some of the more common qualifiers and their meanings (U.S. EPA, 1989a):

- U — Chemical was analyzed for but not detected; the associated value is the sample quantitation limit.
- J — Value is estimated, probably below the contract-required quantitation 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 reported sample quantitation limit. However, the reported quantitation 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 — Inorganic chemicals: the concentration is less than the contract-required detection limit but greater than the instrument detection limit. Organic chemicals: the concentration in the sample is not sufficiently higher than the concentration in the blank, using the five-times, ten-times (5x, 10x) rule, whereby a chemical is considered a nondetect unless its concentration exceeds 5 or 10 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 were used in the BHHRA; "R" data and "B" qualified data were not. The handling of "U" qualified data (nondetects) in the BHHRA is described in Section 3.2. Data for which the identity of the chemical was unclear were not used in the BHHRA. When confidence was reasonably high that the chemical was present but the actual concentration was somewhat in question, the data generally were used.

Some chemicals were analyzed under two different analytical programs. For example, the DNT isomers were analyzed by U.S. EPA Method 8330 for nitroaromatics as well as U.S. EPA Method 8270C for SVOCs. Analytical results from U.S. EPA Method 8330 were used to

quantify risks. The potential uncertainties associated with analytical results obtained by U.S. EPA Method 8270C are discussed in the uncertainty analysis (Section 6.0).

2.1.2 Frequency of Detection

As stated above, if confidence was high that a given chemical was present, the data generally were used in the RA. For most chemicals, their identification at concentrations above levels in blanks (considering the 5x, 10x rule) was presumptive evidence of their presence. However, chemicals that were reported infrequently (i.e., in less than 5 percent of the samples) may be artifacts in the data that do not reflect the presence of the chemical in question. Chemicals that were reported only at low concentrations in less than 5 percent of the samples from a given medium were dropped from further consideration unless their presence would be expected based on site historical information.

2.1.3 Risk-Based Screening

Risk-based screening for human health focuses the assessment on the chemicals that may contribute significantly to overall risk and to remove from quantification those chemicals whose contribution is clearly inconsequential. In this screening, the maximum detected concentration (MDC) was compared to the appropriate risk-based screening concentration (RBSC). The units of the MDC and RBSC are the same for each chemical in a given medium.

If the MDC of a chemical was less than or equal to its RBSC, then the chemical in this medium was not considered further in the BHHRA because it is unlikely that chemical concentrations at or below the RBSC would contribute significantly to risk. An analyte was identified as a COPC if its MDC exceeded its RBSC. RBSCs used in this BHHRA were derived from the U.S. EPA Region 3 RSL tables (U.S. EPA, 2010).

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 cancer and non-cancer risk, the RSL values were used directly as RBSCs in the BHHRA because they are based on an ILCR of 1E-6. Acceptable exposure levels are generally concentration levels that represent an increased upper bound lifetime cancer risk to an individual of 1E-6 to 1E-4 (U.S. EPA, 1990). Cancer risks associated with RSL values represent the lower end of this range. For this BHHRA, the RBSC for a chemical that elicited both cancer and noncancer health effects was selected based on either a cancer risk exceeding 1E-6 or an HQ exceeding 1.0, whichever associated concentration was lower.

2.1.4 Evaluating Essential Nutrients

Evaluating 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, iron, magnesium, potassium, and sodium are usually eliminated as COPCs because they are generally considered innocuous in environmental media. Other essential nutrients including chloride, iodine, and phosphorus, may be eliminated as COPCs, provided that their presence in a particular medium is shown to be unlikely to cause adverse effects on-human health. No members of this latter group were selected as site-related chemicals. Therefore, an exposure analysis was not performed.

2.1.5 Background Screening

For background screening, the MDC was compared to the PBOW chemical-specific background screening concentration (BSC) for groundwater and soil. The derivation of groundwater BSCs was described in the 2004 groundwater report (Shaw, 2005b). BSCs were calculated for use at PBOW based on concentrations found in background bedrock monitoring wells installed upgradient of PBOW sources. Each groundwater BSC is either the MDC or the calculated 95 percent upper tolerance limit of the background groundwater data set based on unfiltered samples collected using low-flow sampling, whichever value is lower (Shaw, 2005b). BSCs for soil established as part of the acid areas investigation (IT, 1998) were used for this RA. BSCs for soil were reported as the 95 percent upper tolerance limit for lognormal data sets or the 95th percentile for datasets with a nonparametric distribution.

Background screening also applies to certain organic compounds that are part of normal background concentrations. Such chemicals may include VOCs and PAHs, a class of organic compounds that form from natural or anthropogenic combustion of organic matter including fossil fuels, and are generally ubiquitous in the environment. Airborne PAHs associated with non-Department of Defense sources may be deposited on soil and leach to groundwater. Benzene, toluene, ethylbenzene, and xylenes may also be associated with background due to the presence of natural petroleum-derived compounds present in the vicinity of PBOW.

Background screening was applied to each inorganic constituent whose MDC exceeded the RBSC and that could not be characterized as an infrequently detected analyte. Background screening consisted of comparing the MDC of the site data set to the BSC. Background screening was not used to eliminate COPCs. Comparison of COPC concentrations to background levels are discussed in Section 6.0.

2.2 Developing Exposure-Point Concentrations

The EPC is a conservative estimate of the average concentration of a COPC, statistically calculated from the analytical results of all samples for a particular environmental medium within an exposure unit.

Because of the uncertainty associated with characterizing contamination in environmental media, both the mean and the upper confidence limit (UCL) of the mean are usually estimated for each COPC in each medium of interest. The UCL of the mean computed at a 95 percent confidence level is generally referred to as the 95 percent upper confidence limit of the arithmetic mean (UCL_{95}).

Concentrations of analytes in environmental samples are determined by using established analytical methods and accurately calibrated laboratory instrumentation. These methods and instruments have practical limits in their ability to accurately report very low and very high analyte concentrations. Each laboratory data value is typically reported with two associated limits: a detection limit and a quantitation limit. The detection limit is the minimum concentration of the analyte that can be differentiated from the normal, random noise of an analytical method or instrument. The quantitation limit, sometimes referred to as the reporting limit, is the minimum concentration of the analyte that can be reliably quantitated. Laboratories sometimes report numerical values for analyte concentrations that are greater than the detection limit but

less than the quantitation limit. These values are often referred to as “trace level concentrations” and are only rough approximations of the true analyte concentration.

Very high analyte concentrations can cause serious damage to some analytical instruments. Samples with known or suspected high analyte concentrations may be diluted before analysis to lower the analyte concentrations to levels that can be safely analyzed. The analyzed concentration values are then adjusted by the dilution factor to properly represent the analyte concentration in the original undiluted sample.

When a sample is diluted, the detection limits and quantitation limits for that sample must be adjusted by the dilution factor. For example, if a sample is diluted by a factor of 10 (the sample volume is increased to 10 times the original sample by dilution with a solvent before analysis), then the corresponding detection limit and quantitation limit must be multiplied by a factor of 10.

The detection limits and quantitation limits used in this project have been adjusted for dilutions and are referred to as sample detection limits and sample quantitation limits to indicate that the limits are specific to each individual sample and analytical method. These sample detection and quantitation limits may have also been adjusted by the laboratory for percent moisture in soil and sediment samples. Samples with higher moisture content will have higher sample detection and quantitation limits when the data are reported on a dry-weight basis.

For some analytical methods, the presence of even just one analyte with a very high concentration in a sample may necessitate the use of a large dilution that will result in elevated sample detection and quantitation limits for all analytes in that sample for that analytical method. This is especially true for organic analyses using gas-chromatography and mass-spectrometer methods such as for dioxins/furans, nitroaromatics, PCBs, PAHs, VOCs and SVOCs. For these methods a lower dilution for the non-detected analytes cannot be used without possible damage to the analytical instruments. Large dilutions of 1000 or even 5000 times may be required for some samples from heavily contaminated areas. These large dilutions result in two significant complications for statistical computations.

- Some analytes may be present in a sample at significant concentrations, but are reported as non-detects with elevated sample detection limits because of dilutions.

- Elevated sample detection limits, even for true non-detects, can cause a high-bias in computed UCL_{95} estimates. The magnitude of this high-bias can be significant and is unpredictable for most non-parametric UCL methods.

The proper handling of non-detect data points in statistical computations is critical for the generation of realistic UCL_{95} estimates. Analytical laboratory data sets used for UCL_{95} estimates can be classified as full, left-censored, or interval-censored data sets.

- A full data set is one in which every data point has a value that is assumed, for the purposes of statistical computations, to accurately represent the true analyte concentration in each sample. All data values in a full data set are considered to be positive detections because each reported concentration is greater than the associated sample quantitation limit.

- A left-censored data set is one in which some of the data points cannot be reported with an accurately known value. The non-detects in a laboratory data set are known as censored values. Laboratory data non-detects are called left-censored because the data are reported as "less-than" some value, usually the sample detection limit. These "less-than" data are said to be censored at the detection limit. The only information known about the numerical value of a censored data point is that the true concentration is less than the censoring value.

- Interval-censored data sets contain data points that are reported as being between two censoring values. Many laboratories report estimated data as "trace-level values" with concentrations between the sample detection limit and the sample quantitation limit. These trace-level values are intended to represent concentrations that are believed by the laboratory to be positive detections, above the sample detection limit, but have concentrations too small to be accurately quantified. These interval censored data can be evaluated by some statistical methods as being greater than a lower censoring level (the sample detection limit) and less than higher censoring level (the sample quantitation limit).

The interval-censored data values for this project were evaluated as though they were positive detections. Trace-level values reported as greater than the sample detection limit but less than the sample quantitation limit are assumed to be detected, uncensored values. For this project, all data sets were considered to be either full or left-censored.

The U.S. EPA statistical software package ProUCL Version 4.0 was used to compute estimated UCL_{95} concentrations for all data sets containing four or more distinct detected values (U.S. EPA 2007a and b). ProUCL uses numerous parametric and nonparametric statistical methods to compute UCLs. Parametric methods assume that the data set being evaluated fits closely to a known, predictable data distribution. Nonparametric methods do not rely on the data set fitting a specific distribution.

ProUCL computes parametric UCLs using normal, lognormal, and gamma distributions. Nonparametric UCLs are computed using a variety of methods including maximum likelihood estimation, central limit theorem, jackknife, bootstrap, Kaplan-Meier (KM), and regression on order statistics. Maximum likelihood estimation and regression on order statistics methods are sometimes referred to as semi-parametric methods. These two methods use techniques to estimate or assume temporary surrogate values for censored data points before computing estimated UCLs.

Detailed descriptions of the statistical methods use in ProUCL are available in the following two documents:

- ProUCL Version 4.0 User Guide (EPA/600/R-07/038, April 2007, www.epa.gov)

- ProUCL Version 4.0 Technical Guide (EPA/600/R-07/041, April 2007, www.epa.gov)

The ProUCL User Guide acknowledges that at one time the U.S. EPA recommended using one-half the detection limit as replacement values for non-detects when only a small percentage of the data were non-detects. This has become the traditional approach for many projects and is known as the "DL/2" method. The U.S. EPA now advises against using DL/2 for any statistical

calculations. Several studies have shown that DL/2 frequently results in unrealistic statistical results. Several nonparametric statistical methods are now recommended for data sets with non-detects (censored data sets). Since many work plans still reference the DL/2 method, it has been included in ProUCL Version 4.0 but with the following comment "Note: DL/2 is not a recommended method."

ProUCL computes estimated UCLs using two slightly different approaches depending on whether the data set to be evaluated is a full data set or a censored data set.

Full Data Sets

- Raw statistics are computed (i.e., minimum, maximum, mean, median)
- Data set is tests for normal distribution, lognormal distribution, and gamma distribution
- Parametric UCLs are computed as appropriate
- Nonparametric UCLs are computed as appropriate
- Recommended UCLs are listed based on logic programmed into ProUCL

Censored Data Sets

- Raw statistics are computed based in the detected data points only
- Data set is tested for normal, lognormal and gamma distributions using the detected data points only

Note: For data sets with multiple detection limits for non-detects, all data less than the largest non-detect detection limit are considered non-detects. This includes positive detections with values less than the maximum non-detect detection limit. If non-detects exist for samples with very large dilutions, a large percentage of the detected data may be considered to be non-detect at an elevated detection limit. This approach is known as "censoring at the highest detection limit."

- Parametric UCLs are computed as appropriate, treating all values less than the largest non-detect detection limit as non-detects
- Nonparametric UCLs are computed as appropriate, treating all values less than the largest non-detect detection limit as non-detects --- except for the KM, regression on order statistics, and DL/2 methods. KM and regression on order statistics are able to handle multiple detection limits. The DL/2 method simply uses one-half the sample detection limit for each non-detect value
- Recommended UCLs are listed based on logic programmed into ProUCL

For data sets with multiple detection limits for non-detects, ProUCL (U.S. EPA, 2007a) recommends using the KM method UCLs (Kaplan et al, 1958). For this project, essentially all data sets with more than one non-detect have multiple detection limits for the non-detect

samples. The KM UCLs are therefore recommended for data sets in this project that have more than one non-detect sample.

Analytical data from field duplicates were joined with parent sample results to yield one result for use in the statistical manipulations as follows:

- Use average of field duplicate and parent sample if both are positive detections
- Use average of field duplicate and parent sample detection limits if both are non-detects
- Use detected value if one sample is a positive detection and the other is a non-detect

The UCL_{95} or MDC, whichever is smaller, was selected as the EPC and is understood to represent a conservative estimate of average for use in the RA or in various transport models used to estimate exposure. ProUCL calculations for Acid Area 1 are presented in Appendix D.

2.3 Results of the Data Evaluation

Previous investigations at Acid Area 1 confirmed the presence of soil contamination from former PBOW operations. The objective of the soil investigation conducted under the RI (Jacobs, 2006) was to evaluate the presence of soil contamination at additional former site facilities not previously sampled. The objective of the groundwater investigation was to characterize the shallow and bedrock aquifers and to evaluate the presence of chemical contamination in groundwater in the vicinity of Acid Area 1. Two rounds of groundwater samples were collected from the shallow and bedrock monitoring wells. Surface water and sediment samples were collected from the drainage ditches within and adjacent to Acid Area 1. Sampling locations are provided in Figure 2-1.

Table 2-1 provides the following information for each detected chemical for each medium at Acid Area 1:

- Chemical name
- Frequency of detection
- Range of detected concentrations
- Range of detection limits
- Estimate of the mean of site concentrations including detected and non-detected compounds
- Appropriate RBSC
- Appropriate BSC and
- Selection/exclusion of chemical as a COPC

Surface Soil. A maximum of 38 surface soil samples were collected from surface soil at Acid Area 1. Depths of the samples were from surface to less than two feet bgs. Chemicals detected in surface soil include nitroaromatics, metals, PAHs, PCBs, and VOCs. Specific compounds exceeding the U.S. EPA Region 9 Residential PRGs are identified in Table 2-1.

Subsurface Soil. A maximum of 37 subsurface soil samples were collected from subsurface soils at Acid Area 1. Depths for subsurface soils samples ranged from two feet bgs to a maximum depth of 10 ft bgs. Chemicals detected in surface soil include nitroaromatics, metals, PAHs, PCBs, and VOCs. Specific compounds exceeding the U.S. EPA Region 9 Residential PRGs are identified in Table 2-1.

Bedrock Groundwater. Contaminants detected in 11 bedrock groundwater samples include nitroaromatics, metals, PAHs, and VOCs. PCBs were not detected in 11 groundwater samples. Naphthalene was the most common PAH detected being detected in all 11 groundwater samples. Most PAHs were not detected or detected in only a few groundwater samples. Specific compounds exceeding the U.S. EPA Region 9 Residential PRGs are identified in Table 2-1.

Shallow Groundwater. Contaminants detected in 12 shallow groundwater samples include nitroaromatics (1,3-dichlorobenzene was detected in one sample), metals, and VOCs. PAHs and PCBs were not detected in any of the 12 groundwater samples. Specific compounds exceeding the U.S. EPA Region 9 Residential PRGs are identified in Table 2-1.

Surface Water. Contaminants detected in surface water at Acid Area 1 include nitroaromatics (detected in one of 12 samples), metals, PAHs (methylphenols detected in one of 12 samples), and VOCs. PCBs were not detected in any of the 12 surface water samples. Specific compounds exceeding the U.S. EPA Region 9 residential PRGs (U.S. EPA 2004b) for drinking water are identified in Table 2-1.

Sediment. Contaminants detected in 15 sediment samples include nitroaromatics, metals, PCBs (PCB-1254 and PCB-1260) PAHs, and VOCs. Specific compounds exceeding the U.S. EPA Region 9 Residential PRGs are identified in Table 2-1.

3.0 EXPOSURE ASSESSMENT

Exposure is the contact by 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 (U.S. EPA, 1989a). The following steps are included in an exposure assessment:

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

This BHHRA characterizes potential exposures to COPCs in soil, groundwater, surface water and sediment associated with Acid Area 1. Estimation of risk from potential exposure is described in the risk characterization for each COPC (Section 5.0). The Scope of Work (USACE, 2001) requires the summation of potential risks from all environmental media evaluated in the risk characterization.

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 was constructed from plausible site-use scenarios and the potential exposure pathways. The elements of the CSEM include:

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

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

Figure 3-1 depicts the CSEM used for Acid Area 1. The receptors and pathways on the figure reflect plausible scenarios developed from information on site background and history, topography, climate, and demographics as presented by the site-wide groundwater investigation (IT, 1997). Exposure pathways that are identified as complete on the CSEM will be addressed in the BHHRA, and additional potential receptors not listed on the CSEM figures are briefly discussed in Section 3.1.3.

No current or future exposures by off-site residents will be evaluated. The majority of the off-site residents are serviced by municipal water (from surface water sources), and there are numerous private groundwater wells in the vicinity, including eight within one mile of the facility boundary. Although natural hydrocarbons are known to be present within the bedrock limestone and shale formations, groundwater underlying the sites cannot be summarily excluded for consideration as a tap water source based on natural water quality parameters. 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 regarded as plausible.

3.1.1 Physical Setting

The Acid Area 1 site is located in the central portion of PBOW, adjacent to Taylor Road, between Maintenance Road and Fox Road and covers an area approximately 20 acres in size. The site physical features include an open field bounded by a drainage ditch to the south with scattered overgrowth throughout. Two railroad grades run east-west through the site: one on the southern perimeter and one through the northern portion of the site. The original service road encircles the site. The road is in fair condition and clear of vegetation. Buildings (Bldgs) 302, 308, and 310 are the only remaining original structures at the site. All other buildings and tanks have been removed. The National Aeronautics and Space Administration (NASA) constructed a metal building between former Building 301 and Building 302. This building was formerly used by NASA as an incinerator, but is currently used for equipment storage.

The ground surface at Acid Area 1 is relatively flat, with minimal slope toward the drainage ditches to the north, south, and west. Elevations at the site range from 629 to 640 ft amsl. Four drainage features are present at the site. Flowing water has been observed in all four drainage ditches during the wet season in early to mid-spring. All but the northern drainage ditch dry up by mid-summer including the ponded area and the swampy area.

Geology: Overburden thickness ranges from 20 to 23.5 ft, with thickness tending to increase toward the north. The overburden is characterized as clay or silty clay with a fairly continuous layer of silt and clayey silt near the surface. The top of this silt layer ranges in depth from 5.25 to 8 ft bgs and the bottom of the silt layer ranges from 6.25 to 10 ft bgs. The thickness of the silt layer, where present, ranges from 0.25 to 3 ft, with an average thickness of 1.7 ft. No silt was present at four of the direct push technology (DPT) boring locations. The clay content of this silt layer varies with location and with depth and is generally marked by gradational changes downward from silt to clay. The lower 10 to 15 ft of the overburden is a highly plastic clay, with decreasing plasticity and increasing angular rock fragments near the bedrock interface.

The Plum Brook Shale subcrops beneath these unconsolidated deposits over the entire site. The thickness of this shale ranges from 1.75 ft to 11 ft, with thickness decreasing to the north-northwest. The Delaware Limestone and Columbus Limestone underlie the Plum Brook Shale. Average thickness of the limestone at Acid Area 1 is unknown, since borings extended no further than 41 ft below the top of the formation. Rock cores collected during the monitoring well installation showed few fractures, low porosity, and occasional zones with naturally occurring oil and hydrogen sulfide gas which are common in the Columbus Limestone (Shaw, 2005b).

Groundwater: Groundwater at PBOW includes the shallow overburden and the bedrock aquifers. Numerous wells have been installed across the site to characterize these two water-bearing units (Shaw, 2003). The shallow overburden generally has low yields over most of the site due to the high percentage of silt and clay. Water levels in the shallow overburden range from less than one ft bgs to six ft bgs during wet season and fluctuate up to four ft on a seasonal basis. Shallow water levels generally mirror the local topography and flow is typically toward the local surface drainage features with a general northerly trend. Shallow groundwater is not considered to be a potable water source due to the low yields and poor quality.

Groundwater at Acid Area 1 includes both shallow overburden and the Delaware Limestone aquifers. Groundwater elevations in the shallow overburden range from 634.4 ft amsl to 637.4 ft amsl. Depths to the shallow groundwater during the summer months range from 2.4 to 6.2 ft bgs. Shallow groundwater generally flows to the north toward the drainage ditch.

Groundwater elevation contours for the deeper Delaware Limestone aquifer indicate a linear feature on a regional scale, running northeast-southwest through PBOW, in the vicinity of Acid Area 1, which acts as a preferential flow path (Shaw, 2003). This feature is parallel to the bedrock strike and may represent a fracture system and/or karst development. Groundwater elevations drop steeply toward this zone on either side. Acid Area 1 is located approximately 500 ft northwest of the axis of this feature. Although adequate water level data has not been collected at the site to confirm flow directions, it is likely that groundwater flows from the site in a southeastern direction toward this regional feature.

Bedrock groundwater has been subdivided into two separate units at PBOW: 1) the Plum Brook Shale and Ohio Shale, and 2) the Delaware and Columbus Limestones. Water levels in the Plum Brook Shale and Ohio shale closely match those of the shallow overburden suggesting good vertical communication between the two units. Water levels in the Delaware and Columbus Limestones are on average 30 ft bgs. Water in the limestone typically occurs in fractures, along bedding planes, or in solutionally enlarged openings. The conceptual model indicates that bedrock groundwater flow in the Delaware and Columbus Limestones is dependant on the frequency, orientation, density, and connectivity of the fractures. Bedrock groundwater flow is generally to the north, however there are major fracture zones transecting the site, which influence groundwater flow in several areas (Shaw, 2003). Use of bedrock groundwater at Acid Area 1 is questionable due to the low yields observed during sampling and the possible presence of petroleum deposits.

Surface Water: Four drainage features are present at the site. The drainage ditch to the south is located approximately 40 ft south of the service road and drains to the west, parallel to the site, discharging into Ransom Brook west of the site. This drainage feature has little relief adjacent to the site. Another drainage ditch originates on site on the north central portion of the

site and drains to the north. This drainage feature is approximately 30 to 40 ft wide and 15 to 18 ft deep just north of the Acid Area 1 site. A third drainage ditch originates in a low swampy area in the west central portion of the site and drains to the west into Ransom Brook. The fourth drainage ditch originates at a ponded area with a man-made dike in the northwest corner of the site, which also drains west into Ransom Brook. Flowing water has been observed in all four drainage ditches during the wet season in early to mid-spring. All but the northern drainage ditch dry up by mid-summer including the ponded area and the swampy area.

3.1.2 Contaminant Sources, Release Mechanisms, and Migration Pathways

Numerous buildings, process facilities, and storage tanks were constructed at Acid Area 1 to support the production of oleum, sulfuric acid, and nitric acid used in manufacturing TNT. Contamination resulted from the inadvertent release of oleum, sulfuric acid, nitric acid, contaminants, and residues. Releases occurred to the surface soil as spills and to the subsurface soil from leaking or damaged underground pipes. Releases may also have occurred during decontamination or during the building and equipment removal processes. Runoff and erosion may have spread contamination over the surrounding surface soil and may have carried contaminants to nearby surface water drainages. Infiltration and leaching may have carried contaminants into the subsurface soil and groundwater.

3.1.3 Receptors and Exposure Pathways

Receptors, selected to represent the upper bound on exposure from all plausibly exposed groups of people at Acid Area 1, and the pathways by which they may be exposed to chemicals are summarized in Figure 3-1 and Table 3-1. The exposure variable values used in the contaminant intake models for soil, surface water, and sediment are compiled in Table 3-2. The exposure variable values used in the contaminant intake models for groundwater are compiled in Table 3-3. The receptors to be evaluated in the Human Health Risk Assessment are:

- Current and future groundskeeper
- Current and future construction worker
- Future on-site resident
- Future indoor worker and
- Current and future hunter

Most RAs 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 (U.S. EPA, 1989a, 1991a). It is interpreted as reflecting the 90th to 95th percentile on exposure. In keeping with U.S. EPA (1991a) guidance, variables chosen for a baseline RME scenario for ingestion rate (IR), exposure frequency (EF) and exposure duration (ED) are generally upper bounds. Other variables such as body weight (BW) and exposed skin SA, 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 [PC] and exposure time [ET] for water), only one variable, ABS or PC,

needs to be an upper bound. The conservatism built into the individual variables ensures that the entire estimate for contact rate is sufficiently conservative.

The averaging time (AT) for noncancer evaluation is computed as the product of ED (years) times 365 days per year (days/year), to estimate an average daily dose over the entire exposure period (U.S. EPA, 1989a). For cancer evaluation, AT is computed as the product of 70 years, the assumed human lifetime, times 365 days/year, to estimate an average daily dose prorated over a lifetime regardless of the frequency or duration of exposure. This methodology 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 U.S. EPA policy of carcinogen evaluation (U.S. EPA, 1986), although it introduces considerable uncertainty into the cancer RA.

The chemical intake equations contain a fraction of intake (FI) parameter 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 enough such that a groundskeeper may spend only one-half of his working time at the site, an FI of 0.5 is applied to the soil ingestion and dermal intake equations. An FI is used also if a receptor's exposure is split between two comparable media. For example, if a construction worker is exposed to both soil and sediment, FIs are introduced that apportion his exposure between the two media. The default value of FI is 1.

3.1.3.1 Overburden Groundwater

Shallow groundwater in the vicinity of Acid Area 1 is not regarded as a potential source of potable water because of the high clay content and limited discontinuous permeable zones resulting in low yields. It is possible that a construction worker may be exposed to shallow groundwater via direct contact; however, such exposure would likely be sporadic and of short duration. No monitoring wells were installed in the overburden at Acid Area 1 because of limited porosity in the overlying clays, as agreed to by the PBOW team.

3.1.3.2 Bedrock Groundwater

The following receptors were evaluated to represent the upper bound on bedrock groundwater exposure for all plausibly exposed groups of people at Acid Area 1.

Current on-site. No current on-site exposure to bedrock groundwater exists.

Future on-site. The evaluation of future on-site exposure to bedrock groundwater was based on measured concentrations at Acid Area 1 described in this report. Future receptors were the on-site worker and on-site resident.

If on-site groundwater were to be developed as a tap water source, other potential future groundwater receptors may include short-term (e.g., construction) workers or site visitors. However, the levels of exposure to these would be shorter in duration and/or frequency than that of an on-site worker or resident. Therefore, the on-site worker and resident receptor represent an upper bound on exposure for all potential receptors.

The potential exposure scenarios evaluated for groundwater were the future on-site resident and the future on-site worker. Exposure assumptions and parameter values specific to the

resident and worker are described in the paragraphs that follow. The fraction of tap water intake/exposure attributed to groundwater was 1.0 for each receptor. Exposure parameters and parameter values are summarized in Table 3-3.

Resident. The resident was assumed to be exposed to groundwater as household tap water and, for volatile compounds, to air concentrations associated with groundwater use in the residence. Cancer and noncancer assessments were performed for both an adult and child. The evaluations assumed 30 years of exposure: 24 years as a 70-kilogram (kg) adult (U.S. EPA, 1991a) and 6 years as a 15-kg child (U.S. EPA, 1991a). For cancer effects, the adult and child effects were summed together; for noncancer effects, the child and adult were evaluated separately. An EF of 350 days per year (U.S. EPA, 1991a) was used for adult and child residential pathways.

Drinking water ingestion rates for the adult of 2 liters (L) per day (U.S. EPA, 1991a) and for the child of 1 L/day (U.S. EPA, 1991a) were assumed. Both the child and adult resident were assumed to be dermally exposed to COPCs in groundwater while bathing/showering. The child was assumed to bathe for 20 minutes per day (0.333 hour per day [hr/day]) (U.S. EPA, 2004a). The adult was assumed to shower for 35 minutes per day (0.6 hr/day) (U.S. EPA, 2004a). Inhalation rates of 0.833 cubic meters (m^3)/hour for the adult (U.S. EPA, 1991a) and 0.416 m^3/hour for the child were used. Because the *Exposure Factors Handbook* (U.S. EPA, 1997a) lists a 90th percentile for time spent in a residence as over 23 hr/day, it was conservatively assumed that the resident spends 24 hr/day in the house. Calculations are included in Appendix A.

On-Site Worker. Under the future land-use scenario, a site worker may be exposed to groundwater, which theoretically could be developed as a source of drinking water. His drinking water ingestion rate was assumed to be 1 L/day (U.S. EPA, 1991a). He could also experience dermal contact with groundwater used to clean equipment and to rinse dust or perspiration from his body. For this evaluation, it was assumed that the head, forearms, and hands, comprising approximately 3,300 square centimeters (cm^2) (U.S. EPA, 2004a), would be exposed intermittently for up to 1 hr/day. Dermal absorbed dose was calculated using the spreadsheet model developed by U.S. EPA (U.S. EPA, 2004a) (Appendix A).

3.1.3.3 Surface Soil

The following receptors were evaluated to represent the upper bound on surface soil exposure for all plausibly exposed groups of people at Acid Area 1. Exposure assumptions and parameter values specific to the potential current and future receptors are described in the paragraphs that follow. Exposure parameters and parameter values are summarized in Table 3-2.

Current on-site. Potential current on-site receptors are construction workers, groundskeepers, and hunters. The evaluation of current on-site exposure to surface soil was based on current measured concentrations.

Future on-site. Potential future receptors are construction workers, on-site indoor workers, on-site residents, groundskeepers and hunters. The evaluation of future on-site exposure to surface soil was based on current measured concentrations.

Groundskeeper. Under the current and future land-use scenarios, a groundskeeper may be exposed to surface soil. The groundskeeper scenario was designed to evaluate the upper bound for site worker exposure to surface soil in the current and future site-use scenario. Direct exposure pathways include incidental ingestion and dermal contact. Inhalation of dust raised by operating lawn mowers or other equipment was also evaluated because relatively high dust concentrations may be produced within the groundskeeper's breathing zone, with little opportunity for dilution by ambient air. The groundskeeper was assumed to be a 70-kg adult who works 8 hr/day, approximately 5 days per week (days/week) year-round on site for a total of 250 days/year for 25 years (U.S. EPA, 1991a). The respiratory rate for the groundskeeper was assumed to be 20 m^3/8-hour workday (2.5 m^3/hour), and the soil incidental ingestion rate was assumed to be 100 milligrams per day (mg/day), comparable to that for an agricultural worker.

Recent studies evaluating soil adherence that consider the nature of the activity performed and the different body regions were reviewed by U.S. EPA (1997a). Measurements of soil adherence to hands, arms, legs, feet, and face for 29 groundskeepers revealed AFs ranging from 8E-4 milligrams per square centimeters (mg/cm^2) (legs) to 1.5E-1 mg/cm^2 (hands). The AF weight averaged across these body regions (i.e., adjusted to reflect the different SAs of the different body regions) for males and females is 9E-3 mg/cm^2. The SA of body regions evaluated for groundskeepers includes approximately 11,300 cm^2 (U.S. EPA, 1997a).

Hunter. Under the current and future land-use scenarios, a hunter may be exposed to surface soil. The hunter was assumed to be a 70-kg adult nearby resident with an exposure duration of 30 years (U.S. EPA, 1991a). Small children would be unlikely to accompany the hunter afield. Therefore, the direct exposure pathways evaluated for the hunter (incidental ingestion and dermal contact with soil) were not evaluated for the small child. It was assumed that the hunter would spend his entire 2-week vacation hunting on PBOW; i.e., his EF for incidental soil ingestion and dermal contact was 14 days/year. His incidental soil ingestion rate was assumed to be 100 mg/day (U.S. EPA, 1991a). It was assumed that approximately 25 percent of his body SA, or 4,500 cm^2, would be available for exposure to soil (U.S. EPA, 2004a). A soil AF of 0.2 mg/cm^2 was assumed. Inhalation of airborne dust would be a potential exposure pathway; however, vegetation would reduce dust emissions to insignificant levels, and it was assumed that the hunter would spend virtually all of his time on vegetated rather than bare soil. Therefore, it was assumed that inhalation exposure would contribute much less than incidental ingestion and the inhalation exposure pathway was not evaluated.

Future On-Site Resident. It was assumed that the future on-site resident would be exposed to surface soil. The on-site residential scenario was evaluated using both an adult and a child. Lifetime cancer risk was estimated as the sum of the risks calculated for the adult and the child.

The adult resident was 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) (0.83 m^3/hour) (U.S. EPA, 1991a). Approximately 25 percent of his body SA, or 4,500 cm^2, was assumed as available for exposure to soil (U.S. EPA, 2004a). The adult resident was assumed to be exposed 350 days/year for 24 years (U.S. EPA, 1991a).

The child resident was assumed to be a 1- through 6-year-old with an average BW of 15 kg, a soil ingestion rate of 200 mg/day, and an inhalation rate of 10 m^3/day (U.S. EPA, 1991a). Approximately 25 percent of his body SA, or 1,750 cm^2, was assumed to be available for

exposure to soil (U.S. EPA, 2004a). The child resident was assumed to be exposed for 350 days/year for 6 years (U.S. EPA, 1991a).

An average soil AF of 0.2 mg/cm^2 was adopted for the on-site resident (U.S. EPA, 2004a).

Evaluation of exposure to VOCs from soil by the future on-site resident was addressed during evaluation of airborne dust as described for the groundskeeper, above. It was assumed that 80 percent of the soil surface would be covered with pavement or vegetation for evaluating inhalation to airborne dust. Inhalation of VOCs released from subsurface soil and entrapped in indoor air was not evaluated as there were no VOCs detected in the subsurface soil. Inhalation rates of 20 m^3/day for the adult (U.S. EPA, 1991a) and 10 m^3/day for the child (U.S. EPA, 1991a) were used.

Future On-Site Indoor Worker. Under the future land-use scenario, an on-site worker may be exposed to surface soil. This receptor scenario was developed to evaluate exposure to indoor airborne VOCs entrapped in a building. However, as there were no VOCs detected in the subsurface soil, this pathway was not evaluated. The indoor worker would also be potentially exposed to surface soil via incidental ingestion. Dermal exposure to surface soil and inhalation of airborne dust and VOCs from surface soil, although plausible, were expected to be less significant than incidental ingestion because he would spend his work time indoors. Therefore, dermal contact and inhalation of dust and airborne VOCs from surface soil was not quantified.

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

Construction Worker. Under the current and future land-use scenarios, a construction worker may be exposed to surface soil. The construction worker scenario was developed to evaluate short-term exposure to surface and subsurface soil (total soil) in either the current or future site-use scenario. Construction projects were expected to be infrequent. It was assumed that the construction worker would participate in only one construction project on the site. 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.

The construction worker was assumed to be a 70-kg adult who works 8 hr/day, approximately 5 days per week (days/week) for 6 months. Potential exposure pathways were 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. However, as there were no VOCs detected in the subsurface soil, inhalation of airborne VOCs released from subsurface soil during excavation and grading was not evaluated. Excavation and soil grading activities, which result in intensive soil contact, were assumed to last for 3 months; for the remaining 3 months, construction activities were assumed to result in less intensive soil contact. Soil ingestion rates of 480 mg/day (U.S. EPA 1991a) and 100 mg/day, similar to an agricultural worker, were assumed for the intensive and less intensive contact periods, respectively. The resulting time-weighted average soil ingestion rate was 290 mg/day.

Construction workers would also experience dermal contact with soil adhered as dust or from direct contact with the soil. An AF for soil for the construction worker of 8E-2 mg/cm^2 was estimated using the same method as previously described for the groundskeeper, combining U.S. EPA (1997a) data for construction workers, utility workers, and equipment operators to capture the full range of activities likely to be performed by this receptor. The SA of the body regions evaluated for construction workers total approximately 11,300 cm^2. An inhalation rate of 20 m^3/day (U.S. EPA, 1991a) for potential exposures to VOCs and airborne dusts was assumed.

3.1.3.4 Subsurface Soil

The following receptors were evaluated to represent the upper bound on subsurface soil exposure for all plausibly exposed groups of people at Acid Area 1. Exposure assumptions and parameter values specific to the potential current and future receptors are described in the paragraphs that follow. Exposure parameters and parameter values are summarized in Table 3-2.

Current on-site. The only potential current on-site receptors are construction workers. The evaluation of current on-site exposure to subsurface soil was based on current measured concentrations.

Future on-site. Potential future receptors are construction workers and on-site residents. The evaluation of future on-site exposure to subsurface soil was based on current measured concentrations.

Groundskeeper. Under the current and future land-use scenarios, contact with subsurface soil would be infrequent and sporadic, since such contact would not be part of the groundskeeper's regular duties or activities. Therefore, exposure to subsurface soil was not evaluated.

Future On-Site Resident. Exposure parameters for the future on-site resident are identical to those described above for surface soil (Section 3.1.3.3). Future on-site residents were assumed to be exposed to subsurface soil as a result of residential development that would involve excavation and grading, which would bring subsurface soil to the surface.

Future On-Site Indoor Worker. Under the future land-use scenario, an on-site worker may be exposed 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. However, as there were no VOCs retained as COPCs in the subsurface soil, this pathway was not evaluated. The exposure parameters for the on-site indoor worker are the same as described above for surface soil (Section 3.1.3.3).

Construction Worker. Under the current and future land-use scenarios, a construction worker may be exposed to subsurface soil. Exposure parameters for the construction worker were identical to those described above for surface soil (Section 3.1.3.3).

3.1.3.5 Surface Water

The following receptors were evaluated to represent the upper bound on surface water exposure for all plausibly exposed groups of people at Acid Area 1.

Current on-site: The only potential current on-site receptors were construction workers. The evaluation of current on-site exposure to surface water was based on current measured concentrations.

Future on-site: Potential future receptors were construction workers and on-site residents. Exposure assumptions and parameter values specific to the potential current and future receptors are described in the paragraphs that follow. Exposure parameters and parameter values are summarized in Table 3-1.

Groundskeeper: Under the current and future land-use scenarios, a groundskeeper may be exposed to surface water. However, such exposure would be infrequent and sporadic, since such contact would not be part of the groundskeeper's regular duties or activities. Therefore, exposure to surface water was not quantified.

Hunters: Under the current and future land-use scenarios, a hunter may be exposed to surface water. However, such exposure would be infrequent and sporadic, since such contact would not be part of the hunter's regular or activities. Therefore, exposure to surface water was not quantified.

Future On-Site Resident: The future on-site resident was assumed to be exposed to surface water. The resident could have access to the surface water bodies associated with Acid Area 3. It was assumed that the resident would visit the streams for 8 hours/day, 2 days/week during the warmer half of the year. The resident was assumed to wade for 3 hours/day on 52 days/year. The exposure pathway to be evaluated was dermal contact with surface water. Approximately 30 percent of the adults and child's total body SAs, 5,450 cm^2 and 2,100 cm^2, respectively, are available for exposure to surface water. Dermal absorbed dose was modeled using the spreadsheet model developed by U.S. EPA in conjunction with RAGS Part E (U.S. EPA 2004a) (Appendix C). . Incidental ingestion of surface water in a wading scenario was considered to be less significant than dermal contact and was not quantified. Inhalation of VOC emissions from surface water is also possible, but the large volume of outdoor ambient air and natural air currents would be expected to dilute airborne concentrations, so that this pathway was expected to less significant than dermal contact, which was quantified. For these reasons, inhalation of VOC emissions from surface water was not quantified.

On-Site Indoor Worker: Under the future land-use scenario, an on-site indoor worker would not be expected to be exposed to surface water. Therefore, exposure to surface water was not quantified.

Construction Worker: Under the current and future land-use scenarios, a construction worker may be exposed to subsurface soil. The construction worker may also be exposed to surface water during projects such as installation of underground utilities or rerouting stream flow. Dermal contact is the most significant pathway for exposure to surface water. Incidental ingestion of surface water is also possible, but would be expected to be much less significant than dermal contact. Dermal exposure to surface water was assumed to occur for 4 hours/day, or one-half the normal work day. It was assumed that the arms, forearms and hands (an SA of approximately 3,100 cm^2 [U.S. EPA, 1997a]) were exposed to surface water. Dermal absorbed dose was modeled using the spreadsheet model developed by U.S. EPA in conjunction with RAGS Part E (U.S. EPA 2004a) (Appendix C). Inhalation of VOCs from surface water is also possible, but the large volume of outdoor ambient air and natural air currents would be expected

to dilute airborne concentrations, so that this pathway would be less significant than dermal contact, which was quantified. For these reasons incidental ingestion and inhalation of VOCs from surface water were not quantified.

3.1.3.6 Sediment

The following receptors were evaluated to represent the upper bound on sediment exposure for all plausibly exposed groups of people at Acid Area 1. Exposure assumptions and parameter values specific to the potential current and future receptors are described in the paragraphs that follow. Exposure parameters and parameter values are summarized in Table 3-2.

Current on-site. The only potential current on-site receptors are construction workers. The evaluation of current on-site exposure to sediment was based on current measured concentrations.

Future on-site. Potential future receptors are construction workers and on-site residents. The evaluation of future on-site exposure to sediment was based on current measured concentrations.

Groundskeeper. Under the current and future land-use scenarios, a groundskeeper may be exposed to sediment. However, such exposure would be infrequent and sporadic since contact would not be part of the groundskeeper's regular duties or activities. Therefore, exposure to sediment was not quantified.

Hunters. Under the current and future land-use scenarios, a hunter may be exposed to sediment. However, such exposure would be infrequent and sporadic since contact would not be part of the hunter's regular activities. Therefore, exposure to sediment was not quantified.

Future On-Site Resident. The future on-site resident was assumed to be exposed to sediment. The resident could have access to sediments associated with Acid Area 1 and could be exposed to sediment. It was assumed that the resident would visit the streams for 8 hr/day, 2 days/week during the warmer half of the year. The resident was assumed to wade for 3 hr/day on 52 days/year. The exposure pathway evaluated was dermal contact with sediment. The mechanisms of exposure to soil and sediment are likely to be similar; therefore, the incidental soil ingestion rate of 100 mg/day was also applied to sediment. Approximately 25 percent of the adults and child's total body SAs, 4,500 cm^2 and 1,750 cm^2, respectively, were used.

On-Site Indoor Worker. Under the future land-use scenario, an on-site indoor worker would not be expected to be exposed to sediment. Therefore, exposure to sediment was not quantified.

Construction Worker. Under the current and future land-use scenarios, a construction worker may be exposed to sediment. The construction worker may be exposed to sediment during projects such as installation of underground utilities or rerouting stream flow. Dermal contact would be the most significant pathway for exposure to sediment. Incidental ingestion of sediment would also be possible, but would be expected to be much less significant than dermal contact. Dermal exposure to sediment was assumed to occur for 4 hr/day, or one-half the normal work day. It was assumed that the arms, forearms and hands, an SA of approximately 3,100 cm^2 (U.S. EPA, 1997a), would be exposed to sediment. Inhalation of VOCs from sediment would also be possible; but the large volume of outdoor air and natural air currents would be expected to dilute airborne concentrations such that this pathway would be less

significant than dermal contact, which was quantified. For these reasons, incidental ingestion and inhalation of VOCs from sediment were not quantified.

3.1.3.7 Game Animals

The following receptors were evaluated to represent the upper bound on exposure via ingestion of game animals taken at Acid Area 1.

Current and future on-site. The potential current and future on-site receptors are hunters. The evaluation of current on-site exposure to game animals was based on current measured concentrations.

Exposure assumptions and parameter values specific to the potential current and future receptors are described in the paragraphs that follow. Exposure parameters and parameter values are summarized in Table 3-2.

Hunters. This scenario was developed to evaluate the potential for contaminants in soil to affect food-chain pathways. Acid Area 1 provides habitat for deer and other wildlife, and deer hunting is permitted on the PBOW facility. Therefore, a hunter who consumes his game is a plausible exposure scenario requiring evaluation. Many kinds of game animals may be hunted and consumed including squirrel, pheasant and other upland birds, turkey and deer; however, the deer is the species most likely to contribute meaningfully to the diet. Therefore, the evaluation was limited to a deer hunter.

Data were not located regarding the rate of venison ingestion; therefore, a hypothetical scenario was adapted from the assumptions applied to a similar site in West Virginia (IT, 2000c). A highly conservative but plausible scenario consists of a hunter who kills a deer each year. It was assumed that the hunter eats 10 pounds (4.5 kg) of venison per year (Sharp, 1995). This consumption rate corresponds to 0.013 kg/day (0.186 g/kg-day) of venison for each of the 350 days per year (U.S. EPA, 1991a) that the hunter spends at home.

It is likely that the successful hunter would share his venison with the rest of the family, which may include small children. The hunter's child was referred to as a child venison consumer for the purposes of this evaluation. Data regarding the rate of venison ingestion by small children were not located. It was assumed that venison replaced beef in the diet, and the differences in beef consumption between adults and children were used to estimate a venison ingestion rate for children. U.S. EPA (1997a) provides per capita beef intake data for less than 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). U.S. EPA (1997a) provides per capita beef intake data for 12- to 70+-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 was estimated that the beef consumption of small children, expressed on a BW basis, would be approximately 1.8 times that of an adult. Therefore, a venison ingestion rate of 0.335 g/kg-day was estimated for the young child from the venison ingestion rate of 0.186 g/kg-day for the adult. Assuming that the child is 0 to 6 years old with an average BW of 15 kg (U.S. EPA, 1991a), the child venison ingestion rate may be expressed as 0.005 kg/day.

3.2 Quantification of Exposure-Point Concentrations

The EPC is a conservative estimate of the average concentration of a COPC, statistically calculated from the analytical results of all samples for a particular environmental medium to

which a receptor may be exposed over the duration of the exposure. An EPC may be based on media concentrations that have been directly measured or it may be derived based on environmental medium-to-medium transport modeling. The EPCs of COPCs in soil, groundwater, and sediment at Acid Area 1 were statistically derived values based on measured analytical data. Concentrations of COPCs in air were not measured (and in the case of groundwater volatilization, future exposure scenarios cannot reasonably be measured), but were based on models that use the EPCs of COPCs in groundwater as input values.

3.2.1 COPC Concentrations from Dust

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

$$C_a = (D)(C_{so})(CF_1) \qquad \textbf{Eq. 3.1}$$

where:

C_a = contaminant concentration in air (milligrams per cubic meter [mg/m^3], calculated)

D = dust loading factor (g of soil/m^3 of air)

C_{so} = contaminant concentration in soil (milligrams per kilogram [mg/kg])

CF_1 = conversion factor (1E-3 kilograms per gram [kg/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 [NCRPM], 1984). The value for D of 1E-4 g/m^3 for other activity was used for the groundskeeper. It was assumed that construction activities requiring intimate 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 was estimated for the construction worker.

Airborne concentrations of VOCs estimated by the dust loading model was 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 would be more likely to be exposed to dust arising from wind erosion than from dust-raising activities on the site. U.S. EPA (1996a) derived a model for estimating a dust particulate emission factor based on an "unlimited reservoir" model and the assumption that the source area is square:

$$PEF = Q/C \times \frac{3600}{0.036 \times (1-V) \times \left(U_m/U_t\right)^3 \times F(x)} \qquad \textbf{Eq. 3.2}$$

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 (43.08 g/m^3-second per kg/m^3, site-specific value from Table 3 in U.S. EPA [1996a] [Zone 7, Cleveland, 30-acre site])

3600 = seconds/hour

V = fraction of surface covered with vegetation (0.8, unitless, assumed)

U_m = mean annual wind speed (default, 4.69 meters per second [m/sec])

U_t = equivalent threshold value of wind speed at 7 meters (m) (default, 11.32 m/sec)

F(x) = function dependent on U_m/U_t (default, 0.194)

The concentration of COPCs in air is calculated as follows:

$$C_a = \frac{C_{so}}{PEF} \qquad \textbf{Eq. 3.3}$$

where:

C_a = contaminant concentration in air (mg/m^3, calculated)

C_{so} = contaminant concentration in soil (mg/kg)

PEF = particulate emission factor (m^3/kg)

Airborne concentrations of VOCs estimated by the wind erosion model were 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 Concentrations in Household Air from Groundwater Use

Inhalation of VOCs released from groundwater was evaluated, as applicable, for the on-site resident scenario. Chemicals that have a Henry's Law value exceeding 1E-05 atmospheres per m^3 per mole and a molecular weight less than 200 grams (g) per mole are considered to be VOCs and are subject to evaluation via this pathway. Other groundwater contaminants may be evaluated 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 Human Health Evaluation Manual (HHEM) (U.S. EPA, 1991b) was used in the BHHRA. This model was selected based on correspondence between the OEPA (2004c) and the 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:

$$C_a = C_{gw} x 0.001 \, {}^{mg}\!/_{\mu g} \, x K_{wa} x 1{,}000 \, {}^{L}\!/_{m^3} \qquad \textbf{Eq. 3.4}$$

where:

C_a = Modeled concentration in air (mg/m^3)

C_{gw} = Groundwater EPC (micrograms per liter [µg/L])

K_{wa} = tap water-to-air volatilization constant (0.0005 [unitless]; [U.S. EPA, 1991b])

Implicit in HHEM Part B application of this model are the following: 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 liters per day (L/day); 4) 50 percent of VOCs in tap water volatilize to household air; and 5) the exchange rate of the house is 0.25 cubic meters per hour (m^3/hr) (U.S. EPA, 1991b). The U.S. EPA (1997a) *Exposure Factors Handbook* lists values different from some of these assumed by HHEM Part B. As appropriate, this pathway was evaluated in the BHHRA using alternate values from the *Exposure Factors Handbook*.

3.2.3 Concentrations of VOCs in Groundwater: Resident Dermal Uptake

Volatilization of VOCs from household water reduces the concentration remaining available for dermal contact. As mentioned in Section 3.2.2, 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:

$$C_d = C_{gw} x (1 - F_v) \qquad \textbf{Eq. 3.5}$$

where:

C_d = concentration of VOC in household water available for dermal exposure (milligrams per liter [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, was assumed to be available for contact with the skin during bathing/showering.

3.2.4 Concentrations of COPCs in Venison

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

- 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 were 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 by Acid Area 1; therefore the fraction of total browse consumed from the contaminated site would be expected to be small.

- Indirect food-chain pathways may be significant for metals and for those SVOCs that persist in the environment and have the tendency to bioaccumulate. VOCs are generally mobile in the environment and unstable 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_e, which reflects the areal portion of the site compared to a deer's home range area. These assumptions are captured in the following equation:

$$B_v = 0.20(FI_e)(B_b) \qquad \textbf{Eq. 3.6}$$

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_e = areal portion of site compared to a deer's home range (0.04, unitless, see below)

B_b = biotransfer factor for beef.

Values for B_b for metals are provided in the toxicity profiles in Appendix C. Toxicity profiles were prepared for each of the chemicals of concern (COCs). The toxicity profiles briefly describe the

uses of the chemical, its physical properties, behavior in environmental media, biotransfer capability, and toxicity values.

Acid Area 1 covers approximately 20 acres. The home range of a deer is approximately 630 acres. Therefore, FI_e was set equal to 0.04.

Deer were assumed to be exposed to contaminants by ingesting browse growing on contaminated soil. It was assumed 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 was estimated from the following equation, which was originally developed for estimating the contaminant concentration in forage to which cattle may be exposed (U.S. EPA, 1994a):

$$C_p = (CF_7)(C_{so})(B_p) \qquad \textbf{Eq. 3.7}$$

where:

C_p = concentration of contaminant in (plant) forage DM (mg/kg, calculated)

CF_7 = conversion factor to adjust for soil containing 20 percent moisture (1.25 unitless).

C_{so} = 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 were taken from the toxicity profiles in Appendix C. B_p values for the vegetative parts of plants rather than the reproductive parts of plants were selected, where possible, because deer browse year-round, and the vegetative parts are more available for the greater part of the year.

The concentration of COPC in venison can be estimated from the following equation (adapted from U.S. EPA, 1994a):

$$C_v = (Q_p)(C_p)(B_v) \qquad \textbf{Eq. 3.8}$$

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 Intakes

This section describes the models used to quantify doses or intakes of the COPC by the exposure pathways identified in Section 3.1.3, using the exposure parameter values described in Section 3.1.3. Models are taken or modified from U.S. EPA (1989a) unless otherwise indicated. Intakes were calculated for both cancer and noncancer evaluations. Therefore, the AT variable shown in the following equations is replaced with AT_n for noncancer calculations (365 × ED), and with AT_c (25,550 days) for the cancer calculations. Intake values were based on the EPCs (Section 2.2) and the equations discussed below for the respective exposure pathways.

3.3.1 Inhalation of COPCs in Air

The following equation was used to estimate the inhaled dose of COPC in air for the groundskeeper, construction worker, and on-site resident through inhalation of dust and VOCs in ambient air from surface or total soil; the construction worker through inhalation of VOCs in ambient air from subsurface soil; and the indoor worker and on-site resident through inhalation of VOCs in indoor air from subsurface soil and tap water:

$$I_a = \frac{(C_a)(FI_a)(IR_a)(ET_a)(EF)(ED)}{(BW)(AT)} \qquad \textbf{Eq. 3.9}$$

where:

I_a = inhaled dose of COPC (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/hour)

ET_a = exposure time (hr/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 and Sediment

The ingested dose of COPCs in soil (groundskeeper, construction worker, on-site resident, indoor worker, hunter) and sediment (construction worker and on-site resident) were estimated from the equation:

$$\mathrm{I_{so}} = \frac{(\mathrm{C_{so}})(\mathrm{FI_{so}})(\mathrm{IR_{so}})(\mathrm{EF})(\mathrm{ED})(\mathrm{CF_2})}{(\mathrm{BW})(\mathrm{AT})} \qquad \textbf{Eq. 3.10}$$

where:

I_{so} = ingested dose of COPC in soil (mg/kg-day, calculated)

C_{so} = concentration of COPC in soil (mg/kg)

FI_{so} = fraction of exposure attributed to site soil or sediment (unitless)

$\mathrm{IR_{so}}$ = ingestion rate of soil or sediment (mg/day)

EF = exposure frequency (days/year)

ED = exposure duration (years)

CF_2 = conversion factor (1E-6 kg/mg)

BW = body weight (kg)

AT = averaging time (days).

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

Unlike the methodologies for estimating inhaled or ingested doses of COPCs, 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 equation (U.S. EPA, 2004a):

$$DAD = \frac{(DA)(SA)(EF)(ED)}{(BW)(AT)} \qquad \textbf{Eq. 3.11}$$

where:

DAD = average dermal absorbed dose of COPC (mg/kg-day, calculated)

DA = dose absorbed per unit body surface area per day (mg/cm^2-day)

SA (SA_{so} for soil, SA_{sd} for sediment, SA_w for 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).

DA is calculated differently for dermal uptake from soil or 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. It is calculated from the equation (U.S. EPA, 2004a):

$$DA = (C)(FI)(CF_2)(AF)(ABS) \qquad \textbf{Eq. 3.12}$$

where:

DA = dose absorbed per unit body surface area per day (mg/cm^2-day, calculated)

C (C_{so} for soil, C_{sd} for sediment) = concentration of COPC in medium (mg/kg)

FI (FI_{so} for soil, FI_{sd} for sediment) = fraction of exposure attributed to site medium (unitless)

CF_2 = conversion factor (1E-6 kg/mg)

AF (AF_{so} 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 COC.

Quantification of dermal absorbed dose was modeled using the spreadsheet model developed by U.S. EPA in conjunction with RAGS Part E (U.S. EPA, 2004a) (Appendix A).

3.3.4 Consumption of Venison

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

$$I_v = \frac{(C_v)(IR_v)(EF)(ED)}{(BW)(AT)} \qquad \textbf{Eq. 3.13}$$

where:

I_v = ingested dose of COPC in venison (mg/kg-day, calculated)

C_v = concentration of COPC in venison (mg/kg)

IR_v =venison ingestion rate (kg/day)

EF = exposure frequency (days/year)

ED = exposure duration (years)

BW = body weight (kg)

AT = averaging time (days).

3.3.5 Ingestion of COPCs in Groundwater and Surface Water

The ingested dose of COPCs in groundwater and surface water is estimated from the equation:

$$I_w = \frac{(C_w)(IR_w)(EF)(ED)}{(BW)(AT)} \qquad \textbf{Eq. 3.14}$$

where:

I_w = ingested dose of COPC in groundwater/surface water (mg/kg-day, calculated)

C_w = concentration of COPC in groundwater/surface water (mg/L)

IR_w = drinking water ingestion rate (L/day)

EF = exposure frequency (days/year)

ED = exposure duration (years)

BW = body weight (kg)

AT = averaging time (days)

4.0 TOXICITY ASSESSMENT

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 section.

4.1 Evaluation of Carcinogenicity

A few chemicals are known, and many more are suspected, to be human carcinogens. The carcinogenic slope factors (SFs), inhalation unit risks, and the accompanying weight-of-evidence classification are used to evaluate potential human carcinogenic risks associated with exposures.

In defining the potential carcinogenicity of a chemical to humans, U.S. EPA first evaluates the sufficiency of evidence of carcinogenicity from available animal and human data. If there are sufficient quantitative data and adequate understanding of the carcinogenic process, a biologically based model may be developed to relate dose and response data on an agent-specific basis. Otherwise, as a default procedure, a standard model can be used to curve-fit the data. Once the data are evaluated, the chemical is assigned a weight-of-evidence classification. The U.S. EPA recognizes six weight-of-evidence group classifications for carcinogenicity, which are as follows:

- Group A – Human Carcinogenic: human data are sufficient to identify the chemical as a human carcinogen.

- Group B1 – Probable Human Carcinogen: human data indicate that a causal association is credible, but alternative explanations cannot be dismissed.

- Group B2 – Probable Human Carcinogen: human data are insufficient to support a causal association, but testing data in animals support a causal association.

- Group C – Possible Human Carcinogen: human data are inadequate or lacking, but animal data suggest a causal association, although the studies have deficiencies that limit interpretation.

- Group D – Not Classifiable as to Human Carcinogenicity: human and animal data are lacking or inadequate.

- Group E – Evidence of Non-Carcinogenicity to Humans: human data are negative or lacking, and adequate animal data indicate no association with cancer.

The weight-of-evidence narrative developed to characterize potential carcinogenic hazard summarizes the results of the hazard assessment and provides a conclusion with regard to human carcinogenic potential. The weight-of-evidence narrative includes both a conclusion about the weight of evidence of carcinogenic potential and a summary of the data on which the conclusion rests. The narrative explains the kinds of evidence available and how they fit together in drawing conclusions, and points out significant issues/strengths/limitations of the data and conclusions.

U.S. EPA derives SF and unit risk values for carcinogens. SFs generally represent an upper bound on the average risk in a population or the risk for a randomly selected individual, but not the risk for a highly susceptible individual or group. Some individuals face a higher risk and some face a lower risk. The use of upper bounds generally is considered to be a health-protective approach for covering the risk to susceptible individuals, although the calculation of upper bounds is not based on susceptibility data. The SF defines quantitatively the relationship between dose and response as the plausible upper-bound estimate of the probability of a response (i.e., development of cancer) per unit intake of a potential carcinogen over a lifetime. In general, an inhalation unit risk is developed directly from a dose response analysis using equivalent human concentrations already expressed in units of $\mu g/m^3$.

The SF is derived by U.S. EPA by selecting the most appropriate data set, extrapolating to lower doses, and determining equivalent human doses for the appropriate route of exposure. A nonlinear extrapolation method can be used for cases with sufficient data to ascertain the mode of action and to conclude that it is not linear at low doses but with insufficient data to support a toxicodynamic model that may be either nonlinear or linear at low doses. Nonlinear extrapolation having a significant biological support may be presented in addition to a linear approach when the available data and a weight-of-evidence evaluation support a nonlinear approach, but the data are not strong enough to ascertain the mode of action. The SF is expressed in terms of risk per unit concentration of the chemical (mg) per unit body weight (kg) per unit time (day) or $(mg/kg/day)^{-1}$. Inhalation unit risk estimates express the SF in terms of $\mu g/m^3$ or parts per million air.

Cancer toxicity values and sources are provided in Table 4-1.

4.2 Evaluation of Noncarcinogenic Effects

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

- Qualitative identification of the adverse effect(s) associated with the chemical, which 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 at which adverse effects are not expected to occur, and includes uncertainty of an order of magnitude or greater. Mathematically, it is estimated as the ratio of the threshold dose to the UF. For purposes of risk assessment, chronic exposure is defined as equal to or greater than 7 years, or at least 10 percent of expected lifespan; subchronic exposure is defined as 2 weeks to 7 years.

The U.S. EPA Integrated Risk information System (IRIS) expresses the inhalation noncancer reference value as a reference concentration (RfC) in units of mg/m^3. Because noncancer risk characterization requires a reference value expressed as mg/kg-day, the RfC must be converted to an inhalation RfD. Since 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 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 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 will be 10 times larger than the chronic RfD).

Oral and dermal RfDs (discussed in Section 4.3) and inhalation RfDs are provided in the Table 4-1.

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 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, U.S. EPA assumes dose and effect to be additive for noncarcinogenic effects (U.S. EPA, 1989a). This assumption provides the justification for adding the HQs or hazard indices (HIs) in the risk characterization for noncancer effects (Section 5.2) resulting from exposure to multiple chemicals, pathways, or media. However, U.S. 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, U.S. 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, since 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 the 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. Target organs for the oral and inhalation pathway are provided in the toxicity profiles.

4.5 Sources of Toxicity Information Used in the Risk Assessment

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

- **Tier 1 values**: IRIS (U.S. EPA, 2005) database.

- **Tier 2 values**: U.S. 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**: Other toxicity values from additional U.S. EPA and non-U.S. EPA sources of toxicity information. As stated in the U.S. 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 the EPA's Health Effects Assessment Summary Tables (U.S. EPA, 1997b) and the California Environmental Protection Agency (2005) Office of Environmental Health Hazard Assessment Toxicity Criteria Database.

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

- Oral absorption efficiency data compiled by the National Center for Environmental Assessment for the Superfund Health Risk Technical Support Center of U.S. EPA.

- Federal agency reviews of the empirical data, such as Agency for Toxic Substances and Disease Registry Toxicological Profiles and various U.S. 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 for deriving dermal toxicity values from oral toxicity values. 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.

The most defensible GAF for each chemical was used in the BHHRA.

5.0 RISK CHARACTERIZATION

Risk characterization is the combination of the results of the exposure assessment and toxicity assessment to yield a quantitative expression of risk. Quantitative estimates are developed for individual chemicals, exposure pathways and exposure media for each receptor. The risk characterization is used to guide risk management decisions.

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

Risk characterization is limited to those site-related chemicals selected as COPCs, i.e., present at concentrations that exceed RBSCs (Section 2.1.3).

Up to this point, the term “risk” has been used generically to mean the potential for the occurrence of adverse effects, either cancer or noncancer, to arise from exposure to chemicals. However, at this point in the discussion, it is helpful to define terms more precisely. Therefore, in this section of the document, “risk” is used to describe the likelihood or probability of the occurrence of cancer. The potential for the occurrence of noncancer effects is referred to as noncancer hazard.

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 (U.S. EPA, 1989a):

$$ILCR = (CDI)(SF) \qquad \textbf{Eq. 5.1}$$

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 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 1 E-2. In these cases, cancer risk may be estimated by the one-hit model (U.S. EPA, 1989a):

$$ILCR = 1 - e^{[(CDI)(SF)]} \qquad \textbf{Eq. 5.2}$$

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 risk calculated using Equation 5.1

As a matter of policy, the U.S. 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 (organs of the body) of action. Cancer risk arising from exposure to a given chemical in a given medium by multiple pathways is estimated from the following equation:

$$ILCR_p = ILCR_{chem1} + ILCR_{chem2} + ...ILCR_i \qquad \textbf{Eq. 5.3}$$

where:

$ILCR_p$ = total pathway risk of cancer incidence, calculated

$ILCR_{chemi}$ = individual chemical cancer risk for the pathway

Cancer risk for a given receptor across chemicals and across media is summed in the same manner. For risk management purposes, OEPA considers a total ILCR of 1E-6 to be a point of departure below which cancer risks are considered to be insignificant. ILCR estimates between 1E-6 and 1E-4 are considered to fall within the risk management range. ILCR estimates above 1E-4 are considered to be unacceptable. The OEPA (2004b) policy is consistent with the U.S. EPA (1990) policy of risk management.

5.2 Noncancer Hazards

The noncancer hazards associated with 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 (U.S. EPA, 1989a):

$$HQ = I/RfD \qquad \textbf{Eq. 5.4}$$

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)

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 that the estimated intake is 100 times lower than the RfD. An HQ of unity (1) 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:

$$HI = HQ_1 + HQ_2 + HQ_i \qquad \textbf{Eq. 5.5}$$

where:

HI = hazard index (unitless, calculated)

HQ_i = hazard quotient for the Ith chemical, or for the Ith pathway

An HI may be calculated across all exposure pathways for a given chemical, across all chemicals for a given exposure pathway, across all chemicals and exposure pathways for a given exposure medium, or across all media to yield the total HI for a given receptor.

HQ or HI values below or equal to the threshold value of 1 are interpreted to mean that adverse noncancer effects are unlikely. HQ or HI values greater than 1 are interpreted to mean that there is a likelihood of adverse noncancer effects.

Calculating a total HI as the sum of HQ values is based on the assumption that the potential for noncancer effects is additive. U.S. EPA (1989a), however, acknowledges that the assumption of additivity is probably appropriate only for chemicals that induce adverse effects by the same mechanism (Section 4.2). Therefore, if the total HI for a receptor exceeds 1, individual HI values may be calculated for each target organ as follows:

$$Total\ HI_a = HI_{p1-a} + HI_{p2-a} + ...HI_{pi-a} \qquad \textbf{Eq. 5.6}$$

where:

$Total\ HI_a$ = total hazard index for target organ “a” (unitless, calculated)

HI_{pi-a} = hazard index for target organ “a” via pathway “i”.

Toxicity values are not available for the evaluation of lead. Risk assessment of lead generally consists of estimating blood lead levels in children associated with exposure to the environmental media at the site in question, and comparing the estimate with the threshold level of 10 micrograms per deciliter (µg/dL). Two common exposure scenarios are routinely evaluated. The first is residential, which involves direct exposure of a young child. The U.S. EPA (1994b) integrated exposure-uptake biokinetic (IEUBK) blood lead model for young children is used to predict blood lead levels for children hypothetically exposed at the site. The IEUBK is a self-contained DOS-based computer program. Average lead concentrations in the various media are input in the model; default values provided by the IEUBK are used when site-specific data are not available. Arithmetic mean values, rather than conservative estimates of average, are used because the IEUBK contains a statistical module that addresses individual variation in exposure and physiological parameters. The output is a probability density histogram of predicted blood lead levels. The risk assessment is considered to "pass" if the IEUBK predicts that not more than 5 percent of young children exposed in this manner would experience a mean blood lead level above the 10 µg/dL threshold.

An alternative risk assessment for lead in soil for residential site use may consist of comparing the average concentration with the RBRL of 400 mg/kg. The risk assessment is considered to pass if the average concentration of lead in soil does not exceed 400 mg/kg. Development of the RBRL of 400 mg/kg is described in the next section.

The second common exposure scenario addresses adult exposures to lead in soil in nonresidential exposure scenarios (U.S. EPA, 1996b). The method focuses on the estimation of blood lead concentrations in fetuses carried by women exposed to average concentrations of lead in soil (U.S. EPA, 1999). The method is based on a probability model for blood lead levels in adult women exposed to lead in soil coupled with an estimated constant of proportionality between fetal and maternal blood lead levels, a geometric mean fetal blood lead concentration and empirically determined geometric standard deviation (U.S. EPA, 1999). The statistical terms used in the method permit an equation to be used to establish an average adult blood lead concentration such that a fetus has not more than a 5 percent probability of blood lead concentrations exceeding 10 µg/dL (U.S. EPA, 1996b). The risk assessment is considered to pass if the average adult blood lead level does not predict an excess of 5 percent probability that fetal blood lead levels exceed 10 µg/dL, as interpreted by the Technical Review Workgroup (TRW) for the established cleanup goal to limit childhood risk of exceeding 10 µg/dL to 5 percent (U.S. EPA 1994c, 1996b).

An alternative risk assessment for lead in soil for industrial site use may consist of comparing the average concentration with the RBRL of 750 mg/kg. The risk assessment is considered to pass if the average concentration of lead in soil does not exceed 750 mg/kg. Development of the RBRL of 750 mg/kg is described in the following section.

5.3 Risk-Based Remediation Level Development

RBRLs are derived to provide support for risk management decisions. They are developed only for the COCs in media that are associated with unacceptable risk that may potentially warrant corrective action. RBRLs are site-specific risk-based concentrations that reflect the exposure and toxicity assumptions applied in the baseline RA. Consequently, RBRLs are source-, medium-, receptor-, and chemical-specific. The development of RBRLs involves a balance of

cancer risk and noncancer hazard estimates. The development of RBRLs is an iterative process with on-going discussion between OEPA and the USACE.

The first step in RBRL development is selection of COCs. Either of two conditions results in designation of a COPC as a COC:

- The concentration of the COPC exceeds its medium-specific ARAR, provided one is available.
- The COPC contributes significantly to cancer risk or hazard as described below.

As presented in U.S. EPA 1991b, COCs based on cancer risks are selected for any medium for which the total ILCR for a given receptor (summed across chemicals and exposure pathways) exceeds 1E-4. For an individual COPC in a given medium to be selected as a cancer-based COC, it must have an ILCR (summed across exposure pathways) exceeding 1E-6. COCs based on noncancer hazards are selected for any receptor for which the total HI (summed across chemicals and exposure pathways) exceeds 1. For an individual COPC in any medium to be selected as a noncancer-based COC, it must have an HI (summed across exposure pathways) exceeding 0.1.

RBRLs are risk- or hazard-specific concentrations of chemicals developed only for the COCs in media selected by the criteria described above. RBRLs for cancer COCs are estimated for a given medium from the following equation (U.S. EPA, 2000):

$$RBRL_{coc} = \frac{ST_{coc} TR}{ILCR_{coc}} \qquad \textbf{Eq. 5.7}$$

where:

$RBRL_{coc}$ = risk-based remediation level for a given COC, receptor and source medium (calculated)

ST_{coc} = source-term concentration of the COC in the given medium

TR = target risk level (1E-6, 1E-5)

$ILCR_{coc}$ = total incremental lifetime cancer risk for a given COC, receptor and source medium

RBRLs for noncancer COCs are estimated as follows (U.S. EPA, 2000):

$$RBRL_{coc} = \frac{ST_{coc} THI}{HI_{coc}} \qquad \textbf{Eq. 5.8}$$

where:

$RBRL_{coc}$ = risk-based remediation level for a given COC, receptor and source medium (calculated)

ST_{coc} = source-term concentration of the COC in the given medium

THI = target hazard index (0.1, 1)

HI_{coc} = total hazard index for a given COC, receptor and source medium

Concentration units are not provided in Equations 5.7 or 5.8; the RBRL units are the same as the concentration units of the EPC. RBRLs are not final remedial concentrations. RBRLs are to be used by risk managers as approximate values to give an idea of the magnitude of remediation that may be needed. Final remedial goals based on toxicity, carcinogenicity, number and variety of COCs, and other factors as appropriate would be developed before a feasibility study is initiated.

The procedure described above is not suitable for developing an RBRL for lead. U.S. EPA (1994c,d, 1998, 2001) has considerable experience using the IEUBK to develop screening levels for lead in soil. The concentration of 400 mg/kg in soil has stood the test of time as a screening level. U.S. EPA (1998) recommends applying site-specific data to the IEUBK to develop site-specific cleanup levels or RBRLs. In general, cleanup levels developed with the IEUBK do not exceed the screening level of 400 mg/kg unless site-specific exposure parameters are available that differ substantially from the defaults provided by the model. The residential scenario developed in this BHHRA was based on standard exposure assumptions. Site-specific information is not available that would permit refinement of these assumptions. Therefore, the IEUBK was not used to develop a site-specific RBRL for lead in soil for residential use. Instead, the 400 mg/kg screening level confirmed by U.S. EPA (1998) is adopted as the RBRL.

U.S. EPA (2004b) provides a PRG of 750 mg/kg for lead in soil for industrial sites, based on the recommendations of the TRW for lead. The PRG is appropriately considered a screening value for lead for industrial site use.

Plausible receptor scenarios for industrial site use include the groundskeeper, the indoor worker and the construction worker. Theoretically, the U.S. EPA (1996b) adult blood lead model could be used to develop RBRLs for lead in soil for these exposure scenarios. However, central tendency (CT) or mid-range exposure variable values, including estimates for incidental soil ingestion rate, are not available for these receptors. Therefore, any attempt to refine the screening level or develop a site-specific RBRL would introduce an inordinate amount of uncertainty. Largely for this reason, the U.S. EPA (2004a) PRG of 750 mg/kg for lead in industrial soil is adopted as the RBRL for the groundskeeper, indoor worker, and construction worker for this BHHRA.

5.4 Risk Characterization Results and Discussion

ILCR and HQ estimates for each receptor, medium, and COPC, including sums across exposure routes for each COPC, are compiled in tables in Appendix B.

Considerable uncertainty is associated with ILCR, HQ and HI estimates; therefore, U.S. EPA (1989a) recommends that they be rounded to one significant figure for presentation in an RA. For example, an HI of 1.49E+0 is rounded to 1 and interpreted to mean that the HI does not exceed the threshold level of 1 and that occurrence of adverse noncancer effects is unlikely. An HI of 1.49E+1, for example, is rounded to 15.

COCs are defined as the chemicals that contribute significantly to an ILCR exceeding 1E-4 or an HI exceeding 1. For this discussion, an individual chemical is considered to contribute significantly to the cancer risk estimate if its ILCR summed across all exposure routes exceeds 1E-6. Similarly, an individual chemical is considered to contribute significantly to the noncancer hazard if its HI summed across all exposure routes exceeds 0.1.

When total HI summed across chemicals and/or media exceeds the threshold limit of 1, consideration is given to possible benefit of segregating HI values by target organ, as suggested by U.S. EPA (1989a). Target organ specific HIs were not developed for this BHHRA.

Total HI and ILCR estimates for each receptor and each source medium for Acid Area 1 are summarized in Tables 5-1 and discussed below; detailed results are provided in Appendix B. The uncertainties associated with the HI and ILCR estimates are discussed in Section 6.0.

The groundskeeper, hunter, and child venison consumer were evaluated for exposure only to surface soil within Acid Area 1. The total HI estimate for the groundskeeper receptor was 0.2 (Table 5-1). The HI does not exceed the threshold for noncancer effects indicating no potential for adverse effects. The total incremental ILCR estimate for the groundskeeper receptor was 1.1E-5. The primary COCs driving the ILCR were arsenic, PCB-1254 and PCB-1260.

Total HI estimates for the adult hunter and the adult and child venison consumer receptors were below the threshold limit of 1. The total ILCR estimate for the adult hunter was 1.0E-6. The primary COC for the ILCR was PCB-1254 from ingestion and dermal contact of surface soil. Total ILCR estimates for the adult and child venison consumer receptors were below 1E-6, defined as the point of departure for significant contribution to cancer risk.

The construction worker was evaluated for exposure to surface, subsurface soil, sediment, and surface water within Acid Area 1. The total HI estimate summed across all media for the construction worker receptor was 0.92 (Table 5-1) which is below the threshold limit of 1. The total ILCR estimate summed across all media for the construction worker was 2.0E-6.

The indoor worker was evaluated for exposure to surface soil and groundwater. Total HI estimates for the indoor worker for groundwater and surface soil were 2.0 and 0.07, respectively (Table 5-1). The ILCR for groundwater and surface soil were 9.0E-5 and 6.0E-6, respectively. The COCs for the ILCR were arsenic and benzene in groundwater, and arsenic and PCB-1260 in surface soil. Vapor intrusion into buildings from subsurface soil was not evaluated, as there were no VOCs detected in subsurface soils.

The adult and child residential receptors were evaluated for exposure to surface and subsurface soil and groundwater. HI sums for groundwater and surface and subsurface soil were 6 and 16 for the adult and child, respectively (Table 5-1). The groundwater COCs driving the residential adult HI were total arsenic, cyanide, and total thallium with surface soil and subsurface soil not being significant contributors to the adult resident HI. For the residential child, groundwater COCs driving the HI are total arsenic, cyanide, total thallium and benzene. The surface soil COC factoring into the elevated child resident HI is PCB-1260. The HI for the adult and child exposed to surface water and sediment during a recreational use scenario are below 1.

The total ILCR estimates summed for groundwater and surface and subsurface soil within Acid Area 1 for adult and child residential receptors were 2.3E-4 and 2.0E-3, respectively. The groundwater COCs driving the ILCR were total arsenic and benzene for both the residential adult and child. The surface soil COCs contributing to the ILCR were arsenic and PCBs for the adult and child resident. Vapor intrusion into dwellings from subsurface soil was not evaluated, as there were no VOCs detected in the subsurface soil. The ILCR for the adult and child exposed to surface water and sediment during a recreational use scenario is 2.5E-6 and 3.2E-6.

HIs for the groundskeeper, construction worker, adult hunter, and adult and child venison consumers were less than 1. The HI for the indoor worker was greater than 1 (HI = 2) from exposure to groundwater with the risk drivers being total arsenic and total thallium in groundwater. The HIs for the adult and child resident exceeded 1 (6 and 16, respectively). The primary contributors to the elevated adult HI include total arsenic, cyanide, and total thallium in groundwater and total arsenic, cyanide, total thallium and benzene in groundwater for the resident child.

Cancer risk estimates were outside the cancer risk range of 1E-6 to 1E-4 for the adult and child resident only. The groundwater COCs driving the ILCR were total arsenic and benzene for both the residential adult and child. The surface soil COCs contributing to the ILCR were arsenic and PCBs for the adult and child resident.

Cancer risk estimates were within the cancer risk range of 1E-6 to 1E-4 for the construction worker and adult and child residential receptors for exposures to surface water and sediment.

Figures 5-1 through 5-4 show the distribution of COCs (based on the adult and child residential exposure scenarios) exceeding the PRGs for surface soil, subsurface soil, sediment, and bedrock groundwater, respectively.

6.0 UNCERTAINTY ANALYSIS

This section evaluates the uncertainties inherent in the RA process. Uncertainty is a factor in each step of the data evaluation and exposure and toxicity assessments presented in the preceding sections. Uncertainties associated with early stages of the RA become magnified when they are concatenated with other uncertainties in the latter stages. It is not possible to eliminate all uncertainty, and sometimes not even to reduce it; however, a recognition of the uncertainties is fundamental to the understanding and reasonable use of the RA results.

Generally, risk assessments carry two types of uncertainty. Measurement uncertainty refers to the usual variance that accompanies scientific measurements such as instrument uncertainty (accuracy and precision) associated with contaminant concentrations. The results of the RA incorporate the accumulated variances of the individual measured values. A different kind of uncertainty stems from data gaps, i.e., additional information needed to complete the database for the assessment. Often the data gap is significant, such as imprecision regarding the number of days that a hunter might visit the site or the absence of information on the effects of human exposure to a chemical (U.S. EPA, 1992c).

U.S. EPA (1992c) guidance urges risk assessors to address or provide descriptions of individual risk to include the "high end" portions and "central tendency" of the risk distribution. One way of fulfilling this preference, if either cancer or noncancer risk exceeds generally acceptable limits (cancer risk greater than 1E-4 or target organ-specific HI greater than 1) is to re-calculate the ILCRs or HIs using CT values for as many intake model variables as possible. In contrast to the RME evaluation, which prevails in RAs and uses upper-end values for intake or contact rates, exposure frequency and exposure duration, the CT evaluation uses average or midrange values for these variables (U.S. EPA, 1991a). The intent is to present a quantified risk/hazard estimate more typical for the receptor of interest.

Another method of quantifying uncertainty, called Monte Carlo simulation, provides a more graphic illustration of the uncertainty associated with a risk/hazard estimate, because it presents the risk as a range with probability densities. To be meaningful, however, Monte Carlo simulation requires that the nature of the distributions of the variables that drive the risk assessment be well characterized. However, well characterized distributions are available for few exposure or toxicological variables, in which case the Monte Carlo simulation provides an incomplete or potentially misleading illustration of the magnitude or the distribution of the uncertainty.

Because of the limitations of the CT and Monte Carlo procedures, the uncertainty analysis consists of a qualitative discussion of the sources of uncertainty and their impact on the estimated risk results and their interpretation, as described below.

Sampling and Analytical Limitations. It is not possible to completely characterize the nature and extent of contamination on any site. Uncertainties arise from limits on the number of locations that can be sampled. The sampling protocol used at Acid Area 1, however, was designed to optimize efficiency of the sampling effort and reduce uncertainty by focusing on areas around former process buildings, storage structures, and potential transfer piping. The sampling appears to be sufficient to show that the contamination is largely limited to soil.

The major contaminants in deep groundwater are metals and volatile organic compounds to include benzene, toluene, ethyl benzene, total xylenes, (BTEX), acetone, and bromomethane. Detection of metals in groundwater appears to be associated with sediment entrained in the samples. Specifically, samples with elevated turbidity had higher metals detections, while concentrations of metals in samples with low turbidity levels and filtered samples had low concentrations or were nondetect. BTEX may also be associated with background due to the presence of natural petroleum-derived compounds present in the vicinity of PBOW. Acetone, and bromomethane may be an artifact of the analytical process caused by laboratory equipment (off-gasing of o-rings), but could not be eliminated during data validation.

Selection and Quantification of Chemicals of Potential Concern. Uncertainty associated with the processes used to identify COPCs and estimate EPCs arises from the following:

1. Identifying background chemicals. Metals are judged to be present at concentrations comparable to background if the MDC does not exceed the BSC, or if statistical testing demonstrates that the site data and background data are drawn from the same population. Statistical testing of site data versus background was not performed for this RA. All inorganic constituents detected in environmental media were carried through the risk assessment to provide a conservative estimate of potential risks associated with exposure to site media. The MDCs or UCL_{95} for all metals in soils were generally below their respective background criteria for all risk drivers with the exception of lead. Some organic chemicals, such as PAHs, may be considered to be anthropogenic background. A limited number of PAHs were identified in soil and sediment at Acid Area 1. There are no site-specific background data for the PAHs, and several were selected as COCs. However, PAHs contributed little to the overall risk at Acid Area 1.

2. Estimated EPCs are uncertain. For statistical purposes, if a constituent was positively identified at a site and had at least a single positive hit, all the samples with nondetects were assumed to have a value equal to half the reporting limit and were included in the data set. These procedures may introduce a conservative bias into the risk assessment. Computed UCL_{95} values are only estimates of the actual upper confidence limits associated with each data set. Examples of factors affecting the uncertainty of these estimates include the number of samples, proportion of nondetects, conformance with an assumed mathematical distribution, imprecision of laboratory data, elevated detection limits (from dilutions, matrix interference, etc.), and statistical methodology. The confidence of computed UCLs for this project have been qualitatively evaluated and identified as high, moderate, low and indeterminate. For indeterminate data sets, the MDC was used for the UCL.

3. A limited number of samples may not completely characterize the site because they provide less information about the population from which they are drawn than do larger sample sets. Accordingly, small sets tend to have a greater variability, which results in the calculation of wide confidence intervals on the mean concentration and high EPCs. In some cases, the UCL_{95} was greater than the maximum value; thus, the maximum value was chosen as the EPC. High confidence limits may introduce a conservative bias into the risk assessment.

4. Laboratory analytical techniques have a degree of uncertainty associated with them. These uncertainties are documented by using data qualifiers to reflect the degree of certainty of measurement. For example, some data were estimated (e.g., J-qualified), while other data were rejected (i.e., R-qualified). The direction of bias is unclear.

5. Per U.S. EPA (1992a) guidance, the UCL_{95} was used for the EPC. Therefore, the exposure assessment is likely to underestimate the EPCs in 5 percent of the cases and overestimate exposures in 95 percent of cases, imparting an overall conservative bias to the risk assessment.

Selection of Hypothetical Receptors and Potential Exposure Pathways. The exposure scenarios chosen for evaluation address plausible receptors for the current and projected future site uses previously described. Although the specific uses to which the sites may be put are not entirely certain, the general categories (industrial, recreational, residential) are comprehensive and fairly standard. The receptor scenarios selected for evaluation include the most intensely exposed for each general site-use category; therefore, uncertainty regarding the specific uses has no meaningful effect on interpretation of the RA. For example, the groundskeeper represents the upper bound on exposure for any industrial application. The indoor worker represents the upper bound on any worker indoor exposure, particularly relevant for VOCs that may gain entrance to a building from subsurface soil. The construction worker represents the upper bound on short-term exposure to soil, regardless of the nature of a construction project. The hunter represents a plausible scenario for recreational site use and indirect (food-chain) exposure. Finally, the on-site resident represents the upper bound for residential site use. The resident is generally considered to represent the upper bound for any standard site use.

Another source of uncertainty in the receptor scenarios is the decision not to quantify intake or uptake from certain exposure routes. For example, inhalation of VOCs in outdoor air that volatilized from subsurface soil by the groundskeeper, indoor worker, and hunter is not quantified. It is assumed that overlying soil would attenuate emissions and that the large volume of outdoor air and natural air currents would dilute concentrations in the breathing zone to toxicologically insignificant levels. This assumption is based on considerable experience with volatilization models, and is consistent with the assumption applied by U.S. EPA (2004b) in developing PRGs for soil. Where VOCs were detected, their concentrations were low and did not contribute to the overall risk at Acid Area 1.

As another example, the groundskeeper and hunter were not evaluated for exposure to sediment, even though these receptors spend most of their time outdoors. Since contact with surface water would not be part of their normal activities, it is assumed that any exposure would be sporadic and would not readily lend itself to quantification. Also, such exposures should be viewed as repeated acute rather than chronic, which does not fit the U.S. EPA (1989a) paradigm or the toxicity values developed for an RA.

The indoor worker was not evaluated for inhalation of airborne dust or VOCs from surface soil or for dermal contact with surface soil because these exposure routes are expected to be less significant than incidental ingestion which is quantified. The decision not to quantify inhalation and dermal exposure imparts a non-conservative bias to the RA. However, inhalation and dermal contact were quantified for the groundskeeper, who would be more intensely exposed by these routes. Risk estimates for the groundskeeper from inhalation exposure were negligible. Therefore, it is assumed that inhalation exposure would be negligible for the indoor worker as well, and that the decision not to quantify this route had no meaningful effect on the outcome of the RA or its interpretation.

Other plausible receptors include office workers, delivery personnel, and resident farmers. These receptors would be less intensively exposed to soil than the groundskeeper; therefore,

their exposures were not evaluated. Much of the land around PBOW is used for agriculture, and it is possible that areas of PBOW could be farmed in the future. However, experience has shown that risk from ingestion of home-grown grains, fruits, meat, poultry, eggs, or milk is generally insignificant compared with direct exposure pathways, except for dioxin/furan compounds; therefore, indirect food-chain exposures are not evaluated. Additionally, the increased exposure to soil and ingestion of beef are adequately represented by the evaluations of groundskeeper and ingestion of venison scenarios, respectively.

The uncertainty associated with dermal exposure is not as clear. Dermal risk estimates for the groundskeeper were at the low end of the cancer risk range of 1E-6 to 1E-4 at Acid Area 1. It is expected that the intensity of dermal exposure to soil would be much less for an indoor worker than an outdoor worker. However, dermal exposure parameters were not developed for the indoor worker to test this assumption. Therefore, the decision not to evaluate dermal exposure represents a source of uncertainty that has not been quantified.

The hunter was not evaluated for inhalation of dust from surface soil because this receptor would be expected to spend most of his time on vegetated soil, and because inhalation exposure would be expected to be far less than incidental ingestion of soil, which was quantified. However, inhalation is quantified for the groundskeeper, who would be more intensely exposed. Estimated risk for the groundskeeper from inhalation exposure was negligible. Therefore, it was assumed that inhalation exposure would be negligible for the hunter as well and that the decision not to quantify this route had no meaningful effect on the outcome of the RA or its interpretation.

Quantification of Intakes. Ingestion rates, inhalation rates, EDs, and EFs were based on upper-bound values (U.S. EPA, 1989a, 1991a), even though it is likely that serial multiplication of conservative variable values leads to gross overestimation of COPC intakes (Cogliano, 1997).

Toxicity Assessment. Considerable uncertainty is associated with the qualitative (hazard assessment) and quantitative (dose-response) evaluations of a toxicity assessment. Hazard assessment of carcinogenicity is evaluated as a weight-of-evidence determination (U.S. EPA, 1986). Positive animal cancer test data suggest that humans also contain tissue(s) that may manifest a carcinogenic response; however, the animal data cannot necessarily be used to predict the target tissue in humans. In the hazard assessment of noncancer effects, positive animal data suggest the nature of the effects (i.e., the target tissues and type of effects) anticipated in humans (U.S. EPA, 1989b).

There are many sources of uncertainty in the dose-response evaluation for cancer (i.e., computation of an SF or unit risk) and noncancer effects (i.e., computation of an RfD). First, there is uncertainty regarding interspecies (animal-to-human) extrapolation which, in the absence of quantitative pharmacokinetic, dosimetric, or mechanistic data, is usually based on consideration of interspecies differences in basal metabolic rate. Second, there is uncertainty regarding intraspecies or individual variation. Most toxicity experiments are performed with animals that are very similar in age and genotype, so that intragroup biological variation is minimal, but the human population of concern may reflect wide heterogeneity including unusual sensitivity to the COPC. Even toxicity data from human occupational exposure reflect a bias because only those individuals sufficiently healthy to attend work regularly and those not unusually sensitive to the COPC are likely to be occupationally exposed. Third, uncertainty

arises from expansion from short-term to lifetime exposure such as the construction worker and child on-site resident. Additional uncertainty arises from the potential for children to be more sensitive than adults. Finally, the quality of the key study from which the quantitative estimate is derived and of the database contributes to uncertainty. For cancer studies, the uncertainty associated with some quality factors (e.g., study group size) is expressed within the 95 percent upper-bound of the SF. For noncancer effects, additional uncertainty factors may be applied in the derivation of the RfD to reflect poor quality of the key study or gaps in the database.

Another source of uncertainty regarding quantitative risk estimation for carcinogenicity is the method by which data from high doses in animal studies are extrapolated to the dose range expected for environmentally exposed humans. The linearized multistage model, which is used in most quantitative estimates of human cancer risk from animal data (e.g., PAHs, PCBs), is based on a non-threshold assumption of carcinogenesis. An impressive body of evidence, however, suggests that epigenetic carcinogens as well as many genotoxic carcinogens, have a threshold below which they are noncarcinogenic (Gold, et al., 1992). Therefore, the use of the linearized multistage model is ultraconservative for chemicals that exhibit a threshold for carcinogenicity.

A further source of uncertainty for noncancer effects arises from use of an effect level in the estimation of an RfD or RfC, because this estimation is predicated on the assumption of a threshold below which adverse effects are not expected. Therefore, an additional uncertainty factor is usually applied to estimate a no-effect level. Additional uncertainty arises from estimating RfD values for chronic exposure from less-than-chronic data. Unless empirical data indicate that effects do not worsen with increasing duration of exposure, an additional uncertainty factor is applied to the no-effect level in the less-than-chronic study. Uncertainty also arises from the presence of chemicals (e.g., lead) for which there are no U.S. EPA-approved toxicity values, and for which quantitative risk characterization is not possible. However, the adult blood-lead model and the IEUBK are supported by a considerable body of empirical data, and are considered to be among the best validated of the various models used in risk assessment. In summary, the U.S. EPA methodology for both cancer and noncancer toxicity evaluation is intentionally designed to be protective. However, the extent to which toxicity values may overestimate toxic potency is not clear, and it is possible that the toxicity values for some compounds may not be adequately protective.

Risk Characterization. Risk characterization is the process of quantifying the risk of cancer due to exposure to carcinogens, as well as quantitatively evaluating hazards potentially posed by exposure to noncarcinogenic toxicants. Cancer risk is assumed to be additive for all carcinogens. Noncancer risk is assumed to be additive for chemicals with similar sites of toxicological action. In the event that any combination of these chemicals results in synergistic effects, risk might be underestimated. Conversely, the assumption of additivity would overestimate risk if a combination of these chemicals acted antagonistically or had no combined toxic effect at all.

7.0 SUMMARY AND CONCLUSIONS

This section briefly summarizes the RA protocol and results and interprets the results, in light of the uncertainty associated with their estimation, to draw realistic conclusions regarding risk to human health.

PBOW is currently classified for industrial use, but future residential use was considered in the risk assessment to support evaluation of all plausible receptor scenarios. Groundskeeper, construction worker, and hunter scenarios were evaluated under the current site-use assumptions. Groundskeeper, construction worker, indoor worker, hunter (including a child venison consumer), and on-site residential scenarios were evaluated as plausible future exposure scenarios. The groundskeeper was evaluated for exposure to surface soil. The construction worker was evaluated for exposure to surface and subsurface soil, surface water and sediment. The adult hunter was evaluated for exposure to surface soil by direct contact and indirectly by ingestion of venison (deer graze vegetation growing on contaminated soil). The indoor worker was evaluated for exposure to surface and subsurface soil, and groundwater. The on-site resident was evaluated as the upper bound on exposure to surface and subsurface soil, groundwater, surface water and sediment.

7.1 Sampling and Analysis

Surface and subsurface soil samples were taken from the areas around each of the former process buildings where contamination was thought to have been possible. Surface water and sediment samples were taken from the drainage ditches associated with the site. Groundwater samples were collected from monitoring wells at the site.

The analytical results revealed that the soil contains metals, PCBs, VOCs (PCE in subsurface soils) and PAHs at concentrations exceeding the RSLs; consequently, they were selected as COPCs.

Contaminants detected in deep groundwater were metals and a limited number of explosives, PAHs and VOCs (BTEX and few other VOCs). PCBs were not detected in groundwater. Detection of metals in groundwater appears to be associated with sediment entrained in the samples. Specifically, samples with elevated turbidity had higher metals concentrations while samples with low turbidity levels had low concentrations or were nondetects. Certain VOCs (primarily BTEX) may be associated with background due to the presence of natural petroleum-derived compounds present in the vicinity of PBOW. Other VOCs may be artifacts of the analytical process at the laboratory, but they could not be eliminated during data validation.

Surface water samples had metals and a few VOCs retained as COPCs.

Sediment samples at Acid Area 1 had elevated concentrations of PCBs and a few PAHs retained as COPCs.

7.2 Risk Assessment Results

The groundskeeper, hunter, and child venison consumer were evaluated for exposure only to surface soil within Acid Area 1. The total HI estimate for the groundskeeper receptor was 0.2 (Table 5-1). The HI does not exceed the threshold for noncancer effects indicating no potential

for adverse effects. The total incremental ILCR estimate for the groundskeeper receptor was 1.1E-5. The primary COCs driving the ILCR were arsenic, PCB-1254 and PCB-1260.

Total HI estimates for the adult hunter and the adult and child venison consumer receptors were below the threshold limit of 1. The total ILCR estimate for the adult hunter was 1.0E-6. The primary COC for the ILCR was PCB-1254 from ingestion and dermal contact of surface soil. Total ILCR estimates for the adult and child venison consumer receptors were below 1E-6, defined as the point of departure for significant contribution to cancer risk.

The construction worker was evaluated for exposure to surface, subsurface soil, sediment, and surface water within Acid Area 1. The total HI estimate summed across all media for the construction worker receptor was 0.92 (Table 5-1) which is below the threshold limit of 1. The total ILCR estimate summed across all media for the construction worker was 2.0E-6. The COCs driving the ILCR were arsenic and PCB-1260.

The indoor worker was evaluated for exposure to surface soil and groundwater. Total HI estimates for the indoor worker for groundwater and surface soil were 2.0 and 0.07, respectively (Table 5-1). The ILCR for groundwater and surface soil were 9.0E-5 and 6.0E-6, respectively. The COCs for the ILCR were arsenic and benzene in groundwater, and arsenic and PCB-1260 in surface soil. Vapor intrusion into buildings from subsurface soil was not evaluated, as there were no VOCs detected in subsurface soils.

The adult and child residential receptors were evaluated for exposure to surface and subsurface soil and groundwater. HI sums for groundwater and surface and subsurface soil were 6 and 16 for the adult and child, respectively (Table 5-1). The groundwater COCs driving the residential adult HI were total arsenic, cyanide, and total thallium with surface soil and subsurface soil not being significant contributors to the adult resident HI. For the residential child, groundwater COCs driving the HI are total arsenic, cyanide, total thallium and benzene. The surface soil COC factoring into the elevated child resident HI is PCB-1260. The HI for the adult and child exposed to surface water and sediment during a recreational use scenario are below 1.

The total ILCR estimates summed for groundwater and surface and subsurface soil within Acid Area 1 for adult and child residential receptors were 2.3E-4 and 2.0E-3, respectively. The groundwater COCs driving the ILCR were total arsenic and benzene for both the residential adult and child. The surface soil COCs contributing to the ILCR were arsenic and PCBs for the adult and child resident. Vapor intrusion into dwellings from subsurface soil was not evaluated, as there were no VOCs detected in the subsurface soil. The ILCR for the adult and child exposed to surface water and sediment during a recreational use scenario is 2.5E-6 and 3.2E-6.

HIs for the groundskeeper, construction worker, adult hunter, and adult and child venison consumers were less than 1. The HI for the indoor worker was greater than 1 (HI = 2) from exposure to groundwater with the risk drivers being total arsenic and total thallium in groundwater. The HIs for the adult and child resident exceeded 1 (6 and 16, respectively). The primary contributors to the elevated adult HI include total arsenic, cyanide, and total thallium in groundwater and total arsenic, cyanide, total thallium and benzene in groundwater for the resident child.

Cancer risk estimates were outside the cancer risk range of 1E-6 to 1E-4 for the adult and child resident only. The groundwater COCs driving the ILCR were total arsenic and benzene for both the residential adult and child. The surface soil COCs contributing to the ILCR were arsenic and PCBs for the adult and child resident.

Cancer risk estimates were within the cancer risk range of 1E-6 to 1E-4 for the construction worker and adult and child residential receptors for exposures to surface water and sediment.

8.0 REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR), 1997, Update Toxicological Profile for Polycyclic Aromatic Hydrocarbons (PAHs), U.S. Department of Health and Human Services, Atlanta, GA.

California Environmental Protection Agency, 2005, *Toxicity Criteria Database*, Office of Environmental Health Hazard Assessment, Sacramento, California, http://www.oehha.co.gov/risk/ChemicalDB/index.asp.

Cogliano, V. J., 1997, "Plausible Upper Bounds: Are Their Sums Plausible?" Risk Analysis 17(1): 77-84.

Gold, L. S., N. B. Manley and B. N. Ames, 1992, "Quantitative and Qualitative Extrapolation of Carcinogenesis Between Species," Proceedings of Conference on Chemical Risk Assessment in the Department of Defense (DoD): Science, Policy and Practice, 9 to 1 I April 1991, Dayton, OH, published by American Conference of Governmental Industrial Hygienists, Inc.

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

IT, 2001b, *TNT Areas A and C Remedial Investigation, Volume I – Report of Findings, Final, Former Plum Book Ordnance Works, Sandusky, Ohio,* November.

IT, 2000c, *Draft Baseline Human Health Risk Assessment Work Plan for the Former TNT Manufacturing Area, West Virginia Ordnance Works, Mason Count, West Virginia,* January.

IT, 1998, *Site Investigation of Acid Areas, Former Plum Brook Ordnance Works, Sandusky, Ohio*.

IT, 1997a, *Site-Wide Groundwater Investigation Report, Plum Brook Ordnance Works, Sandusky, Ohio,* September.

IT, 1997b, *Site Investigation of Acid Area 1, Former Plum Brook Ordnance Works, Sandusky, Ohio*.

Jacobs, 2009, *Final Baseline Human Health Risk Assessment Work Plan, Acid Area 1, Former Plum Brook Ordnance Works, Sandusky, Ohio,* April

Jacobs, 2006, *Final Site Characterization Report, Remedial Investigation Part 1, at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio,* January.

Kaplan, E. L., and Paul Meier, June 1958, *Nonparametric Estimation from Incomplete Observations*, American Statistical Association Journal

Mautz, W. W., H. Silver, and J. B. Holter, 1976, "Digestibility and Related Nutritional Data for Seven Northern Deer Browse Species," *Journal of Wildlife Management*, 40(4): 630-638.

National Council on Radiation Protection and Measurements (NCRPM), 1984, *Radiological Assessment: Predicting the Transport, Bioaccumulation, and Uptake by Man of Radionuclides Released to the Environment*, NCRP Report No. 76.

Nutrient Database, 1997, Data compiled from U.S. Department of Agriculture releases, and published nutrient information from 71 chain references, on line, http://www.nutribase.com.)

Ohio Department of Natural Resources, map showing Ground-Water Resources of Erie County by Alfred C. Walker, http://www.dnr.state.oh.us/water/gwrmaps/counties/Erie.htm, accessed April 2007.

Ohio Environmental Protection Agency (OEPA), 2005a, *Use of Risk-Based Numbers in the Remedial Response Process Overview DERR-00-RR-038,* June 28, 2005.

OEPA, 2005b, *Technical Decision Compendium Assessing Compounds without Formal Toxicity Values Available for Use in Human Health Risk Assessment Ohio EPA Division of Emergency and Remedial Response Remedial Response Program,* August 2005.

OEPA, 2004a, *Technical Decision Compendium Methodology for Evaluating Site-specific Background Concentrations of Chemicals Ohio EPA Division of Emergency and Remedial Response Remedial Response Program,* 14 April 2004.

OEPA, 2004b, *Technical Decision Compendium Human Health Cumulative Carcinogenic Risk And Non-Carcinogenic Hazard Goals For DERR Remedial Response And Office Of Federal Facility Oversight Ohio EPA Division Of Emergency And Remedial Response,* 28 April 2004

Sample, B. E., D. M. Opresko, and G. W. Suter II, 1996, *Toxicological Benchmarks for Wildlife: 1996 Revision*, Prepared for the U.S. Department of Energy by Health Sciences Research Division, Oak Ridge National Laboratory.

Science Applications International Corporation (SAIC), 1991, *NASA Plum Brook Station, Preliminary Assessment*, Volume I, Sandusky, Ohio, June.

Sharp, G., 1995, Personal Communication: Telephone conversation between P. Goetchius, IT Corp. and Gary Sharp, Wildlife Biologist, West Virginia Division of Natural Resources, Point Pleasant, West Virginia, 17 February.

Shaw Environmental, Inc. (Shaw), 2005a, *Baseline Human Health Risk Assessment of Groundwater Work Plan, Final, Former Plum Brook Ordnance Works, Sandusky, Ohio*, October.

Shaw, 2005b, *2004 Groundwater Data Summary and Evaluation Report, Final, Former Plum Brook Ordnance Works, Sandusky, Ohio*, April.

Shaw, 2005c, *Technical Memorandum for the Baseline Human Health Risk Assessment for Groundwater at the West Area Red Water Pond, Former Plum Brook Ordnance Works, Sandusky, Ohio*, May.

Shaw, 2003, *2002 Groundwater Data Summary and Evaluation Report, Former Plum Brook Ordnance Works, Sandusky, Ohio*, June.

U.S. Army Corps of Engineers (USACE), 2001, *Scope of Work, Phase II Groundwater Remedial Investigation (RI), TNT and Red Water Ponds Area, Former Plum Brook Ordnance Works, Sandusky, Ohio*, December 10.

USACE, 1999, *Risk Assessment Handbook, Volume I: Human Health Evaluation*, Engineer Manual EM 200-1-4.

U.S. Department of Energy (DOE), 1989, A Manual for Implementing Residual Radioactive Material Guidelines, Argonne National Laboratory, Argonne, IL, ANL/ES-160, DOE/CH/8901.

DOE, 1983, Pathway Analysis and Radiation Dose Estimates for Radioactive Residues at Formerly Utilized MED/AEC Sites, U.S. Dept. of Energy, Oak Ridge Operations Office, Oak Ridge, TN, DOE ORO-832.

U.S. Environmental Protection Agency (EPA), 2010 Regional Screening Level (RSL) Summary Table Mid-Atlantic Risk Assessment, May.

U.S. EPA, 2007a, ProUCL Version 4 User Guide, EPA/600/R-07/038, April.

U.S. EPA, 2007b, ProUCL Version 4 Technical Guide, EPA/600/R-07/041, April.

U.S. EPA, 2005, *Integrated Risk Information System (IRIS)*, National Center for Environmental Assessment, Cincinnati, Ohio, http://www.epa.gov/iris/index.html.

U.S. 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. EPA, 2003b, *Human Health Toxicity Values in Superfund Risk Assessments*, Office of Solid Waste and Emergency Response, Washington, D.C., OSWER Directive 9285.7-53, December.

U.S. EPA, 2001, 40 CFR Part 745, "Lead Identification of Dangerous Levels of Lead; Final Rule," *Federal Register* 66(4): 1206-1240.

U.S. EPA, 2000. Supplemental Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment Bulletins. EPA Region 4, originally published November 1995, Website version last updated May 2000: http://www.epa.gov/region4/waste/ots/healtbul.htm.

U.S. EPA, 1999. Use of the TRW Interim Adult Lead Methodology in Risk Assessment. Pat Van Leeuwen, EPA Region 5, Paul White ORD/NCEA.

U.S. EPA, 1998, "Clarification to the 1994 Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities," Memorandum from T. Fields, Jr. to regional administrators I-X, 27 August.

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

U.S. EPA, 1997b, *Health Effects Assessment Summary Tables, FY 1997 Update,* Office of Solid Waste and Emergency Response, 9200.6-303 (97-1), EPA-540-R-97-036, NTIS No. PB97-921197.

U.S. EPA, 1996a, *Soil Screening Guidance: Technical Background Document*, Office of Solid Waste and Emergency Response, EPA/540/R-95/128, NTIS No. PB96-963502.

U.S. EPA, 1996b, *Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil*, Technical Review Workgroup for Lead, December.

U.S. EPA, 1994a, *Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities,* Office of Solid Waste and Emergency Response, Draft, April, EPA530-R-94-021, including Errata, “Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes,” October, and “Modification of Screening Guidance Fate and Transport Equations,” November.

U.S. EPA, 1994b, *Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children*, Office of Emergency and Remedial Response, Washington, DC, EPA/540/R-93/081. PB93-963510.

U.S. EPA, 1994c, "Guidance on Residential Lead-Based Paint, Lead-Contaminated Dust, and Lead-Contaminated Soil," Memorandum from L.R. Goldman to regional directors, 14 July.

U.S. EPA, 1994d, "Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities," Memorandum from E.P. Laws to regional administrators I-X, 14 July.

U.S. EPA, 1992a, *Supplemental Guidance to RAGS: Calculating the Concentration Term*, Office of Solid Waste and Emergency Response, Washington, D.C., Publication 9285.7-081.

U.S. EPA, 1992b, *Dermal Exposure Assessment: Principles and Applications*, Interim Report, Office of Research and Development, Washington, D.C., EPA/600/8-91/011B, including Supplemental Guidance, dated August 18, 1992.

U.S. EPA, 1992c, "Guidance on Risk Characterization for Risk Managers and Risk Assessors," Memorandum from F. Henry Habicht II, Deputy Administrator, to Assistant Administrators, Regional Administrators, February 26.

U.S. 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. EPA, 1991b, *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual Part B – Development of Risk-Based Preliminary Remediation Goals*, Interim, Office of Emergency and Remedial Response, Washington, D.C., EPA/540/R-92/003, December.

U.S. EPA, 1990, 40 CFR Part 300, "National Oil and Hazardous Substances Pollution Contingency Plan; Final Rule," *Federal Register* 55 (46): 86668865.

U.S. 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. EPA, 1989b, *General Quantitative Risk Assessment Guidelines for Noncancer Health Effects*, Prepared by the Office of Health and Environmental Assessment, Cincinnati, OH for the Risk Assessment Forum, ECAO-CIN-538.

U.S. EPA, 1986, *Guidelines for Carcinogen Risk Assessment*," Federal Register, 51(185): 33992-34003.

TABLES

Table 2-1 Summary Statistics and Identification of COPCs for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
Surface Soil												
GC2	Moisture, Percent	15	15	100	PERCENT		12.1	21.8	17.7			
GC2	Nitrogen, Nitrate (as N)	15	0	0	mg/Kg	5.7 - 6.4			3.04		130000	
GC2	pH	15	15	100	PH_UNITS		6.8	8.1	7.48			
GC2	Sulfate (as SO4)	15	12	80	mg/Kg	12 - 12	13.4	3910	651			
HE	1,3,5-Trinitrobenzene	25	1	4	ug/Kg	80 - 250	300	300	59.3		2200000	
HE	1,3-Dinitrobenzene	25	0	0	ug/Kg	80 - 250			52.3		6100	
HE	2,4,6-Trinitrotoluene	25	1	4	ug/Kg	80 - 250	300	300	59.3		19000	
HE	2,4-Dinitrotoluene	25	4	16	ug/Kg	100 - 250	130	2500	174		120000	
HE	2,6-Dinitrotoluene	24	0	0	ug/Kg	100 - 250			64.8		61000	
HE	2-Amino-4,6-Dinitrotoluene	23	0	0	ug/Kg	120 - 150			68.3		150000	
HE	2-Nitrotoluene	25	0	0	ug/Kg	80 - 250			52.3		2900	
HE	3-Nitrotoluene	25	0	0	ug/Kg	120 - 250			72.8		1200000	
HE	4-Amino-2,6-Dinitrotoluene	25	1	4	ug/Kg	80 - 250	810	810	79.7		150000	
HE	4-Nitrotoluene	23	1	4	ug/Kg	80 - 100	180	180	51.7		30000	
HE	HMX	25	0	0	ug/Kg	80 - 500			62.3		3800000	
HE	Nitrobenzene	25	0	0	ug/Kg	88 - 250			56.1		31000	
HE	RDX	25	0	0	ug/Kg	80 - 500			62.3		5500	
HE	Tetryl	25	0	0	ug/Kg	80 - 650			68.4		240000	
MET	Aluminum	38	38	100	mg/Kg		155	14300	8100	15500	77000	
MET	Antimony	38	1	3	mg/Kg	2.2 - 7.7	9.5	9.5	2.38	9.3	31	
MET	Arsenic	38	37	97	mg/Kg	1.3 - 1.3	1.4	18.1	6.59	36.5	0.39	Y
MET	Barium	38	37	97	mg/Kg	26 - 26	20.4	145	53.6	826	15000	
MET	Beryllium	38	25	66	mg/Kg	0.57 - 0.64	0.23	0.86	0.427	1	160	
MET	Cadmium	38	20	53	mg/Kg	0.23 - 0.64	0.28	1.7	0.48		70	
MET	Calcium	38	38	100	mg/Kg		1040	166000	27200	52300		
MET	Chromium	38	37	97	mg/Kg	1.3 - 1.3	2.3	50.7	14	29	280	
MET	Cobalt	38	33	87	mg/Kg	5.7 - 6.4	1.5	26.5	6.88	116	23	Y
MET	Copper	38	37	97	mg/Kg	2.8 - 2.8	3.7	57.6	16.5	56.2	3100	
MET	Iron	38	38	100	mg/Kg		218	30400	16800	234000	55000	
MET	Lead	38	38	100	mg/Kg		4.1	770	99.6	48.6	400	Y
MET	Magnesium	38	36	95	mg/Kg	570 - 640	858	18100	4200	10400		
MET	Manganese	38	38	100	mg/Kg		3	910	303	3506		
MET	Mercury	38	26	68	mg/Kg	0.013 - 0.042	0.016	0.76	0.0769	0.1	6.7	
MET	Nickel	38	36	95	mg/Kg	4.6 - 5.1	6.2	57.8	15.2	55.1	1600	
MET	Potassium	38	30	79	mg/Kg	570 - 640	461	2580	936	3390		
MET	Selenium	38	3	8	mg/Kg	0.57 - 0.77	0.65	1.1	0.382	2	390	
MET	Silver	38	0	0	mg/Kg	0.22 - 1.3			0.311	11.1	390	

Table 2-1 Summary Statistics and Identification of COPCs for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
Surface Soil (continued)												
MET	Sodium	38	2	5	mg/Kg	220 - 640	263	503	206			
MET	Thallium	38	1	3	mg/Kg	0.38 - 1.3	0.77	0.77	0.39	1.3	5.1	
MET	Vanadium	38	36	95	mg/Kg	5.7 - 6.4	9.4	51.7	23	40.9	550	
MET	Zinc	38	38	100	mg/Kg		6.2	181	61.6	322	23000	
PCB	PCB-1016 (Aroclor 1016)	38	0	0	ug/Kg	3.6 - 800			31.7		3900	
PCB	PCB-1221 (Aroclor 1221)	38	0	0	ug/Kg	3.6 - 800			31.7		170	
PCB	PCB-1232 (Aroclor 1232)	38	0	0	ug/Kg	3.6 - 800			31.7		170	
PCB	PCB-1242 (Aroclor 1242)	38	0	0	ug/Kg	3.6 - 800			31.7		220	
PCB	PCB-1248 (Aroclor 1248)	38	0	0	ug/Kg	3.6 - 800			31.7		220	
PCB	PCB-1254 (Aroclor 1254)	38	22	58	ug/Kg	5.1 - 2900	68	7100	1770		220	Y
PCB	PCB-1260 (Aroclor 1260)	38	31	82	ug/Kg	5.1 - 41	45	18000	3350		220	Y
SV	1,2,4-Trichlorobenzene	38	3	8	ug/Kg	0.12 - 420	0.22	0.74	79.9		87000	
SV	1,2-Dichlorobenzene	38	0	0	ug/Kg	0.25 - 420			80.5		2000000	
SV	1,2-Diphenylhydrazine	23	0	0	ug/Kg	28 - 35			15.8		610	
SV	1,3-Dichlorobenzene	38	0	0	ug/Kg	0.56 - 420			82.2			
SV	1,4-Dichlorobenzene	38	0	0	ug/Kg	0.37 - 420			81.2		2600	
SV	2,4,5-Trichlorophenol	38	0	0	ug/Kg	28 - 420			88.8		6100000	
SV	2,4,6-Trichlorophenol	38	0	0	ug/Kg	37 - 420			91.7		44000	
SV	2,4-Dichlorophenol	38	0	0	ug/Kg	20 - 420			85.9		180000	
SV	2,4-Dimethylphenol	38	0	0	ug/Kg	23 - 420			86.9		1200000	
SV	2,4-Dinitrophenol	38	0	0	ug/Kg	140 - 2100			429		120000	
SV	2,4-Dinitrotoluene	38	3	8	ug/Kg	26 - 420	54	460	97.1		120000	
SV	2,6-Dinitrotoluene	38	0	0	ug/Kg	40 - 420			92.8		61000	
SV	2-Chloronaphthalene	38	0	0	ug/Kg	34 - 420			90.6		6300000	
SV	2-Chlorophenol	38	0	0	ug/Kg	43 - 420			93.8		390000	
SV	2-Methylnaphthalene	38	8	21	ug/Kg	39 - 420	40	410	120		310000	
SV	2-Methylphenol (o-Cresol)	38	0	0	ug/Kg	41 - 420			93.1		3100000	
SV	2-Nitroaniline	38	0	0	ug/Kg	34 - 2100			392			
SV	2-Nitrophenol	38	0	0	ug/Kg	23 - 420			87.1			
SV	3,3'-Dichlorobenzidine	38	0	0	ug/Kg	33 - 2100			392		1100	
SV	3-Methylphenol	23	0	0	ug/Kg	29 - 36			16.1		3100000	
SV	3-Nitroaniline	38	0	0	ug/Kg	50 - 2100			398		18000	
SV	4,6-Dinitro-2-methylphenol	38	0	0	ug/Kg	23 - 2100			389		6100	
SV	4-Bromophenyl phenyl ether	38	0	0	ug/Kg	27 - 420			88.4			
SV	4-Chloro-3-methylphenol	38	0	0	ug/Kg	29 - 420			89.1			
SV	4-Chloroaniline	38	0	0	ug/Kg	51 - 420			96.3		9000	
SV	4-Chlorophenyl phenyl ether	38	0	0	ug/Kg	33 - 420			90.2			

Table 2-1 Summary Statistics and Identification of COPCs for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
Surface Soil (continued)												
SV	4-Methylphenol (p-Cresol)	38	0	0	ug/Kg	28 - 420			88.7		310000	
SV	4-Nitroaniline	38	0	0	ug/Kg	110 - 2100			417		23000	
SV	4-Nitrophenol	38	0	0	ug/Kg	86 - 2100			410			
SV	Acenaphthene	38	0	0	ug/Kg	28 - 420			88.7		3400000	
SV	Acenaphthylene	38	1	3	ug/Kg	21 - 420	150	150	89.9			
SV	Anthracene	38	3	8	ug/Kg	29 - 420	26	120	89.7		17000000	
SV	Benzo(a)anthracene	38	11	29	ug/Kg	40 - 420	36	660	123		150	Y
SV	Benzo(a)pyrene	38	9	24	ug/Kg	25 - 420	21	850	105		15	Y
SV	Benzo(b)fluoranthene	38	6	16	ug/Kg	33 - 420	94	1400	140		150	Y
SV	Benzo(g,h,i)perylene	38	4	11	ug/Kg	77 - 420	88	570	120			
SV	Benzo(k)fluoranthene	38	6	16	ug/Kg	42 - 420	75	580	112		1500	
SV	Benzoic acid	13	0	0	ug/Kg	22 - 26			11.8		240000000	
SV	Benzyl alcohol	23	0	0	ug/Kg	48 - 59			26.6		31000000	
SV	bis(2-Chloroethoxy)methane	38	0	0	ug/Kg	33 - 420			90.3		180000	
SV	bis(2-Chloroethyl)ether (2-Chloroethylether)	38	0	0	ug/Kg	43 - 420			93.8		190	
SV	bis(2-Chloroisopropyl)ether	38	0	0	ug/Kg	54 - 420			97.5		3500	
SV	bis(2-Ethylhexyl)phthalate	38	6	16	ug/Kg	38 - 410	39	210	74.8		35000	
SV	Butylbenzylphthalate	38	0	0	ug/Kg	31 - 420			89.9		260000	
SV	Carbazole	38	0	0	ug/Kg	38 - 420			92.2			
SV	Chrysene	38	12	32	ug/Kg	34 - 420	45	810	136		15000	
SV	Dibenz(a,h)anthracene	38	1	3	ug/Kg	64 - 420	160	160	104		15	Y
SV	Dibenzofuran	38	0	0	ug/Kg	26 - 420			88			
SV	Diethylphthalate	38	0	0	ug/Kg	380 - 880			318		49000000	
SV	Dimethylphthalate	38	0	0	ug/Kg	32 - 420			90.1			
SV	Di-n-butylphthalate	38	0	0	ug/Kg	32 - 420			90.1		6100000	
SV	Di-n-octylphthalate	38	0	0	ug/Kg	28 - 420			88.8			
SV	Fluoranthene	38	15	39	ug/Kg	59 - 420	44	1200	169		2300000	
SV	Fluorene	38	0	0	ug/Kg	28 - 420			88.6		2300000	
SV	Hexachlorobenzene	38	0	0	ug/Kg	37 - 420			91.7		300	
SV	Hexachlorobutadiene	38	0	0	ug/Kg	35 - 420			90.9		6200	
SV	Hexachlorocyclopentadiene	38	0	0	ug/Kg	65 - 2100			403		370000	
SV	Hexachloroethane	38	0	0	ug/Kg	42 - 420			93.3		35000	
SV	Indeno(1,2,3-cd)pyrene	38	3	8	ug/Kg	49 - 420	43	720	106		150	Y
SV	Isophorone	38	0	0	ug/Kg	30 - 420			89.3		510000	
SV	Naphthalene	38	3	8	ug/Kg	34 - 420	64	160	97.5		3900	
SV	Nitrobenzene	38	0	0	ug/Kg	37 - 420			91.6		31000	
SV	N-Nitrosodimethylamine	23	0	0	ug/Kg	100 - 120			56		2.3	
SV	N-Nitroso-di-n-propylamine	38	0	0	ug/Kg	58 - 420			98.9		69	
SV	N-Nitrosodiphenylamine	38	0	0	ug/Kg	34 - 420			90.6		99000	

Table 2-1 Summary Statistics and Identification of COPCs for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
Surface Soil (continued)												
SV	Pentachlorophenol	38	0	0	ug/Kg	36 - 2100			393		3000	
SV	Phenanthrene	38	11	29	ug/Kg	25 - 420	57	580	143			
SV	Phenol	38	1	3	ug/Kg	38 - 420	45	45	92.7		18000000	
SV	Pyrene	38	12	32	ug/Kg	42 - 420	52	960	152		1700000	
VOC	1,1,1-Trichloroethane	38	4	11	ug/Kg	0.6 - 59	1.4	160	7.83		9000000	
VOC	1,1,2,2-Tetrachloroethane	38	0	0	ug/Kg	0.29 - 32			2.74		590	
VOC	1,1,2-Trichloro-1,2,2-Trifluoroethane	23	0	0	ug/Kg	0.37 - 41			3.26		43000000	
VOC	1,1,2-Trichloroethane	38	0	0	ug/Kg	0.23 - 26			2.46		1100	
VOC	1,1-Dichloroethane	38	0	0	ug/Kg	0.36 - 40			3.12		3400	
VOC	1,1-Dichloroethene	38	0	0	ug/Kg	0.8 - 89			5.47		250000	
VOC	1,2,3-Trichlorobenzene	23	0	0	ug/Kg	0.28 - 31			2.46			
VOC	1,2-Dibromo-3-chloropropane	23	0	0	ug/Kg	0.8 - 89			7.05		5.6	
VOC	1,2-Dibromoethane (EDB)	23	0	0	ug/Kg	0.29 - 32			2.55		34	
VOC	1,2-Dichloroethane	38	0	0	ug/Kg	0.31 - 34			2.83		450	
VOC	1,2-Dichloropropane	38	0	0	ug/Kg	0.31 - 34			2.83		930	
VOC	2-Butanone (Methyl ethyl ketone)	38	1	3	ug/Kg	0.94 - 100	20	20	10.2		28000000	
VOC	2-Hexanone	38	0	0	ug/Kg	1.5 - 170			13.1			
VOC	4-Methyl-2-pentanone (Methyl isobutyl ketone)	38	0	0	ug/Kg	0.39 - 43			6.85		5300000	
VOC	Acetone	38	12	32	ug/Kg	8.6 - 150	45	170	38.5		61000000	
VOC	Benzene	38	12	32	ug/Kg	0.43 - 35	0.43	3.8	3.45		1100	
VOC	Bromochloromethane	23	0	0	ug/Kg	0.28 - 31			2.46			
VOC	Bromodichloromethane	38	0	0	ug/Kg	0.2 - 22			2.27		10000	
VOC	Bromoform	38	0	0	ug/Kg	0.67 - 74			4.76		61000	
VOC	Bromomethane	38	0	0	ug/Kg	0.48 - 53			4.95		7900	
VOC	Carbon Disulfide	38	14	37	ug/Kg	1.2 - 96	1.4	30	9.1		670000	
VOC	Carbon tetrachloride	38	0	0	ug/Kg	0.59 - 65			4.33		250	
VOC	Chlorobenzene	38	0	0	ug/Kg	1.7 - 180			10.1		310000	
VOC	Chloroethane	38	0	0	ug/Kg	0.74 - 82			6.31		15000000	
VOC	Chloroform	38	0	0	ug/Kg	0.37 - 41			3.17		300	
VOC	Chloromethane	38	1	3	ug/Kg	0.35 - 39	1.2	1.2	4.26		1700	
VOC	cis-1,2-Dichloroethene	23	0	0	ug/Kg	0.8 - 89			7.05		780000	
VOC	cis-1,3-Dichloropropene	38	0	0	ug/Kg	0.33 - 37			2.99		1700	
VOC	Cyclohexane	23	15	65	ug/Kg	0.5 - 40	0.9	46	8.78		7200000	
VOC	Dibromochloromethane	38	0	0	ug/Kg	0.23 - 25			2.4		5800	
VOC	Dichlorodifluoromethane	23	0	0	ug/Kg	0.74 - 82			6.49		190000	
VOC	Ethylbenzene	38	6	16	ug/Kg	0.5 - 56	0.89	3	4.07		5700	
VOC	Isopropylbenzene (Cumene)	23	0	0	ug/Kg	0.59 - 65			5.17		2200000	
VOC	Methyl Acetate	23	5	22	ug/Kg	1.1 - 120	2.1	460	41.5		78000000	

Table 2-1 Summary Statistics and Identification of COPCs for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
Surface Soil (continued)												
VOC	Methylcyclohexane	23	17	74	ug/Kg	0.28 - 15	0.8	3300	211			
VOC	Methylene Chloride	38	2	5	ug/Kg	0.42 - 46	2.5	3.2	3.45		11000	
VOC	Styrene	38	0	0	ug/Kg	0.23 - 26			2.46		6500000	
VOC	Tert-Butyl Methyl Ether (MTBE)	23	0	0	ug/Kg	0.21 - 24			1.89		39000	
VOC	Tetrachloroethene (PCE)	38	0	0	ug/Kg	0.65 - 72			4.65		570	
VOC	Toluene	38	10	26	ug/Kg	0.79 - 67	1.2	56	6.05		5000000	
VOC	Total 1,2-Dichloroethene	15	0	0	ug/Kg	5.7 - 6.4			3.04		700000	
VOC	trans-1,2-Dichloroethene	23	0	0	ug/Kg	0.74 - 82			6.49		110000	
VOC	trans-1,3-Dichloropropene	38	0	0	ug/Kg	0.21 - 24			2.34		1700	
VOC	Trichloroethene (TCE)	38	2	5	ug/Kg	0.57 - 63	1.2	1.7	4.27		2800	
VOC	Trichlorofluoromethane	23	0	0	ug/Kg	0.64 - 70			5.57		800000	
VOC	Vinyl chloride	38	0	0	ug/Kg	0.74 - 82			6.31		60	
VOC	Xylenes, Total	38	11	29	ug/Kg	0.64 - 42	1.1	200	13.7		600000	
Subsurface Soil												
GC2	Moisture, Percent	15	15	100	PERCENT		15.9	21.2	18.8			
GC2	Nitrogen, Nitrate (as N)	15	1	7	mg/Kg	5.9 - 6.3	58.6	58.6	6.78		130000	
GC2	pH	15	15	100	PH_UNITS		6.3	8	7.53			
GC2	Sulfate (as SO4)	15	11	73	mg/Kg	12 - 13	26.4	5440	806			
HE	1,3,5-Trinitrobenzene	24	0	0	ug/Kg	80 - 250			50.9		2200000	
HE	1,3-Dinitrobenzene	24	0	0	ug/Kg	80 - 250			50.9		6100	
HE	2,4,6-Trinitrotoluene	24	1	4	ug/Kg	80 - 250	150	150	55.5		19000	
HE	2,4-Dinitrotoluene	24	2	8	ug/Kg	100 - 250	120	1800	138		120000	
HE	2,6-Dinitrotoluene	24	0	0	ug/Kg	100 - 250			62.7		61000	
HE	2-Amino-4,6-Dinitrotoluene	22	1	5	ug/Kg	120 - 150	480	480	85		150000	
HE	2-Nitrotoluene	24	0	0	ug/Kg	80 - 250			50.9		2900	
HE	3-Nitrotoluene	24	0	0	ug/Kg	120 - 250			70.8		1200000	
HE	4-Amino-2,6-Dinitrotoluene	24	1	4	ug/Kg	80 - 250	430	430	67.1		150000	
HE	4-Nitrotoluene	22	1	5	ug/Kg	80 - 100	110	110	47.4		30000	
HE	HMX	24	0	0	ug/Kg	80 - 500			61.4		3800000	
HE	Nitrobenzene	24	0	0	ug/Kg	88 - 250			54.8		31000	
HE	RDX	24	0	0	ug/Kg	80 - 500			61.4		5500	
HE	Tetryl	24	0	0	ug/Kg	80 - 650			67.6		240000	
MET	Aluminum	37	37	100	mg/Kg		4700	19900	11900	15500	77000	
MET	Antimony	37	0	0	mg/Kg	2.2 - 7.6			2.34	9.3	31	
MET	Arsenic	37	37	100	mg/Kg		3	15.4	7.87	36.5	0.39	Y
MET	Barium	37	36	97	mg/Kg	24 - 24	26.1	290	71.5	826	15000	
MET	Beryllium	37	25	68	mg/Kg	0.25 - 0.63	0.465	1.1	0.576	1	160	

Table 2-1 Summary Statistics and Identification of COPCs for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
Subsurface Soil (continued)												
MET	Cadmium	37	17	46	mg/Kg	0.25 - 0.63	0.325	6.9	0.589		70	
MET	Calcium	36	36	100	mg/Kg		1290	76800	29900	52300		
MET	Chromium	37	37	100	mg/Kg		10.3	27.5	17.9	29	280	
MET	Cobalt	37	37	100	mg/Kg		1.6	23.6	10.2	116	23	Y
MET	Copper	37	37	100	mg/Kg		5.9	36.9	21.5	56.2	3100	
MET	Iron	37	37	100	mg/Kg		2700	36000	21600	234000	55000	
MET	Lead	37	37	100	mg/Kg		4.2	80.8	14.2	48.6	400	
MET	Magnesium	37	37	100	mg/Kg		908	23700	8980	10400		
MET	Manganese	37	37	100	mg/Kg		39.9	1070	416	3506		
MET	Mercury	37	19	51	mg/Kg	0.015 - 0.042	0.017	0.081	0.0234	0.1	6.7	
MET	Nickel	37	37	100	mg/Kg		5.8	47.2	25	55.1	1600	
MET	Potassium	37	36	97	mg/Kg	600 - 600	643	4820	2030	3390		
MET	Selenium	37	4	11	mg/Kg	0.59 - 1.5	0.78	1.2	0.437	2	390	
MET	Silver	37	0	0	mg/Kg	0.22 - 1.3			0.323	11.1	390	
MET	Sodium	37	4	11	mg/Kg	220 - 640	257	323	214			
MET	Thallium	37	0	0	mg/Kg	0.39 - 1.3			0.401	1.3	5.1	
MET	Vanadium	37	37	100	mg/Kg		15.6	44.5	28.6	40.9	550	
MET	Zinc	37	37	100	mg/Kg		25.8	271	68	322	23000	
PCB	PCB-1016 (Aroclor 1016)	22	0	0	ug/Kg	3.6 - 5.3			2.16		3900	
PCB	PCB-1221 (Aroclor 1221)	22	0	0	ug/Kg	3.6 - 5.3			2.16		170	
PCB	PCB-1232 (Aroclor 1232)	22	0	0	ug/Kg	3.6 - 5.3			2.16		170	
PCB	PCB-1242 (Aroclor 1242)	22	0	0	ug/Kg	3.6 - 5.3			2.16		220	
PCB	PCB-1248 (Aroclor 1248)	22	0	0	ug/Kg	3.6 - 5.3			2.16		220	
PCB	PCB-1254 (Aroclor 1254)	22	8	36	ug/Kg	3.6 - 5.3	3.9	1900	131		220	Y
PCB	PCB-1260 (Aroclor 1260)	22	12	55	ug/Kg	4 - 5.3	4.2	4900	373		220	Y
SV	1,2,4-Trichlorobenzene	37	0	0	ug/Kg	0.15 - 420			83		87000	
SV	1,2-Dichlorobenzene	37	0	0	ug/Kg	0.31 - 420			83.3		2000000	
SV	1,2-Diphenylhydrazine	22	0	0	ug/Kg	29 - 34			16.2		610	
SV	1,3-Dichlorobenzene	37	0	0	ug/Kg	0.7 - 420			84			
SV	1,4-Dichlorobenzene	37	0	0	ug/Kg	0.46 - 420			83.5		2600	
SV	2,4,5-Trichlorophenol	37	0	0	ug/Kg	29 - 420			92.3		6100000	
SV	2,4,6-Trichlorophenol	37	0	0	ug/Kg	37 - 420			95.3		44000	
SV	2,4-Dichlorophenol	37	0	0	ug/Kg	20 - 420			89.5		180000	
SV	2,4-Dimethylphenol	37	0	0	ug/Kg	23 - 420			90.4		1200000	
SV	2,4-Dinitrophenol	37	0	0	ug/Kg	140 - 2000			446		120000	
SV	2,4-Dinitrotoluene	37	2	5	ug/Kg	26 - 420	89	870	116		120000	
SV	2,6-Dinitrotoluene	37	0	0	ug/Kg	40 - 420			96.3		61000	

Table 2-1 Summary Statistics and Identification of COPCs for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
Subsurface Soil (continued)												
SV	2-Chloronaphthalene	37	0	0	ug/Kg	34 - 420			94.3		6300000	
SV	2-Chlorophenol	37	0	0	ug/Kg	44 - 420			97.4		390000	
SV	2-Methylnaphthalene	37	1	3	ug/Kg	38 - 420	52	52	96.2		310000	
SV	2-Methylphenol (o-Cresol)	37	0	0	ug/Kg	41 - 420			96.6		3100000	
SV	2-Nitroaniline	37	0	0	ug/Kg	34 - 2000			410			
SV	2-Nitrophenol	37	0	0	ug/Kg	24 - 420			90.7			
SV	3,3'-Dichlorobenzidine	37	0	0	ug/Kg	34 - 2000			410		1100	
SV	3-Methylphenol	22	0	0	ug/Kg	29 - 35			16.5		3100000	
SV	3-Nitroaniline	37	0	0	ug/Kg	50 - 2000			416		18000	
SV	4,6-Dinitro-2-methylphenol	37	0	0	ug/Kg	23 - 2000			407		6100	
SV	4-Bromophenyl phenyl ether	37	0	0	ug/Kg	28 - 420			92			
SV	4-Chloro-3-methylphenol	37	0	0	ug/Kg	30 - 420			92.7			
SV	4-Chloroaniline	37	0	0	ug/Kg	51 - 420			100		9000	
SV	4-Chlorophenyl phenyl ether	37	0	0	ug/Kg	33 - 420			93.8			
SV	4-Methylphenol (p-Cresol)	37	0	0	ug/Kg	28 - 420			92.3		310000	
SV	4-Nitroaniline	37	0	0	ug/Kg	110 - 2000			434		23000	
SV	4-Nitrophenol	37	0	0	ug/Kg	87 - 2000			428			
SV	Acenaphthene	37	0	0	ug/Kg	28 - 420			92.2		3400000	
SV	Acenaphthylene	37	0	0	ug/Kg	21 - 420			89.8			
SV	Anthracene	37	0	0	ug/Kg	29 - 420			92.5		17000000	
SV	Benzo(a)anthracene	37	1	3	ug/Kg	39 - 420	66.5	66.5	97		150	
SV	Benzo(a)pyrene	37	1	3	ug/Kg	24 - 420	72	72	92.5		15	Y
SV	Benzo(b)fluoranthene	37	0	0	ug/Kg	34 - 420			94.1		150	
SV	Benzo(g,h,i)perylene	37	0	0	ug/Kg	76 - 420			108			
SV	Benzo(k)fluoranthene	37	0	0	ug/Kg	42 - 420			96.9		1500	
SV	Benzoic acid	13	1	8	ug/Kg	21 - 25	140	140	21.7		240000000	
SV	Benzyl alcohol	22	0	0	ug/Kg	48 - 58			27.3		31000000	
SV	bis(2-Chloroethoxy)methane	37	0	0	ug/Kg	33 - 420			93.9		180000	
SV	bis(2-Chloroethyl)ether (2-Chloroethylether)	37	0	0	ug/Kg	44 - 420			97.5		190	
SV	bis(2-Chloroisopropyl)ether	37	0	0	ug/Kg	55 - 420			101		3500	
SV	bis(2-Ethylhexyl)phthalate	37	4	11	ug/Kg	39 - 420	48	140	93.4		35000	
SV	Butylbenzylphthalate	37	0	0	ug/Kg	32 - 420			93.4		260000	
SV	Carbazole	37	0	0	ug/Kg	39 - 420			95.8			
SV	Chrysene	37	1	3	ug/Kg	33 - 420	88.5	88.5	95.8		15000	
SV	Dibenz(a,h)anthracene	37	0	0	ug/Kg	64 - 420			104		15	
SV	Dibenzofuran	37	0	0	ug/Kg	26 - 420			91.5			
SV	Diethylphthalate	37	0	0	ug/Kg	390 - 860			323		49000000	
SV	Dimethylphthalate	37	0	0	ug/Kg	33 - 420			93.7			
SV	Di-n-butylphthalate	37	1	3	ug/Kg	32 - 420	120	120	96.4		6100000	

Table 2-1 Summary Statistics and Identification of COPCs for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
Subsurface Soil (continued)												
SV	Di-n-octylphthalate	37	0	0	ug/Kg	29 - 420			92.4			
SV	Fluoranthene	37	1	3	ug/Kg	57 - 420	120	120	104		2300000	
SV	Fluorene	37	0	0	ug/Kg	28 - 420			92.1		2300000	
SV	Hexachlorobenzene	37	0	0	ug/Kg	37 - 420			95.2		300	
SV	Hexachlorobutadiene	37	0	0	ug/Kg	35 - 420			94.5		6200	
SV	Hexachlorocyclopentadiene	37	0	0	ug/Kg	66 - 2000			421		370000	
SV	Hexachloroethane	37	0	0	ug/Kg	42 - 420			96.9		35000	
SV	Indeno(1,2,3-cd)pyrene	37	0	0	ug/Kg	49 - 420			99.3		150	
SV	Isophorone	37	0	0	ug/Kg	30 - 420			92.9		510000	
SV	Naphthalene	37	0	0	ug/Kg	35 - 420			94.4		3900	
SV	Nitrobenzene	37	0	0	ug/Kg	37 - 420			95.2		31000	
SV	N-Nitrosodimethylamine	22	0	0	ug/Kg	100 - 120			57.8		2.3	
SV	N-Nitroso-di-n-propylamine	37	0	0	ug/Kg	59 - 420			102		69	
SV	N-Nitrosodiphenylamine	37	0	0	ug/Kg	34 - 420			94.3		99000	
SV	Pentachlorophenol	37	0	0	ug/Kg	36 - 2000			411		3000	
SV	Phenanthrene	37	4	11	ug/Kg	28 - 420	75	150	100			
SV	Phenol	37	0	0	ug/Kg	38 - 420			95.7		18000000	
SV	Pyrene	37	2	5	ug/Kg	42 - 420	115	120	102		1700000	
VOC	1,1,1-Trichloroethane	37	5	14	ug/Kg	0.75 - 6.3	6.7	1800	85.8		9000000	
VOC	1,1,2,2-Tetrachloroethane	37	0	0	ug/Kg	0.36 - 22			1.9		590	
VOC	1,1,2-Trichloro-1,2,2-Trifluoroethane	22	0	0	ug/Kg	0.46 - 28			1.41		43000000	
VOC	1,1,2-Trichloroethane	37	1	3	ug/Kg	0.29 - 18	0.8	0.8	1.8		1100	
VOC	1,1-Dichloroethane	37	4	11	ug/Kg	0.45 - 6.3	6	760	24.1		3400	
VOC	1,1-Dichloroethene	37	3	8	ug/Kg	1 - 61	1.5	140	6.16		250000	
VOC	1,2,3-Trichlorobenzene	22	0	0	ug/Kg	0.35 - 21			1.07			
VOC	1,2-Dibromo-3-chloropropane	22	0	0	ug/Kg	1 - 61			3.08		5.6	
VOC	1,2-Dibromoethane (EDB)	22	0	0	ug/Kg	0.36 - 22			1.1		34	
VOC	1,2-Dichloroethane	37	1	3	ug/Kg	0.38 - 24	23	23	2.32		450	
VOC	1,2-Dichloropropane	37	0	0	ug/Kg	0.38 - 24			1.96		930	
VOC	2-Butanone (Methyl ethyl ketone)	37	7	19	ug/Kg	1.2 - 72	2.7	11	7.89		28000000	
VOC	2-Hexanone	37	0	0	ug/Kg	1.9 - 120			8.56			
VOC	4-Methyl-2-pentanone (Methyl isobutyl ketone)	37	0	0	ug/Kg	0.48 - 30			5.9		5300000	
VOC	Acetone	37	16	43	ug/Kg	4 - 85	13	480	52.7		61000000	
VOC	Benzene	37	8	22	ug/Kg	0.42 - 24	0.62	5.3	2.47		1100	
VOC	Bromochloromethane	22	0	0	ug/Kg	0.35 - 21			1.07			
VOC	Bromodichloromethane	37	0	0	ug/Kg	0.25 - 15			1.71		10000	
VOC	Bromoform	37	0	0	ug/Kg	0.83 - 51			2.77		61000	
VOC	Bromomethane	37	0	0	ug/Kg	0.6 - 37			3.6		7900	

Table 2-1 Summary Statistics and Identification of COPCs for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
Subsurface Soil (continued)												
VOC	Carbon Disulfide	37	4	11	ug/Kg	1.2 - 66	2	4.2	3.47		670000	
VOC	Carbon tetrachloride	37	0	0	ug/Kg	0.73 - 45			2.59		250	
VOC	Chlorobenzene	37	0	0	ug/Kg	2.1 - 130			5.15		310000	
VOC	Chloroethane	37	0	0	ug/Kg	0.92 - 56			4.17		15000000	
VOC	Chloroform	37	0	0	ug/Kg	0.46 - 28			2.08		300	
VOC	Chloromethane	37	0	0	ug/Kg	0.43 - 26			3.27		1700	
VOC	cis-1,2-Dichloroethene	22	1	5	ug/Kg	1 - 51	83	83	5.47		780000	
VOC	cis-1,3-Dichloropropene	37	0	0	ug/Kg	0.42 - 26			2.02		1700	
VOC	Cyclohexane	22	10	45	ug/Kg	0.49 - 28	0.92	11	3.63		7200000	
VOC	Dibromochloromethane	37	0	0	ug/Kg	0.28 - 17			1.76		5800	
VOC	Dichlorodifluoromethane	22	0	0	ug/Kg	0.92 - 56			2.83		190000	
VOC	Ethylbenzene	37	3	8	ug/Kg	0.62 - 38	1.4	2.4	2.53		5700	
VOC	Isopropylbenzene (Cumene)	22	0	0	ug/Kg	0.73 - 45			2.26		2200000	
VOC	Methyl Acetate	22	0	0	ug/Kg	1.3 - 82			4.12		78000000	
VOC	Methylcyclohexane	22	9	41	ug/Kg	0.27 - 15	0.26	15	3.41			
VOC	Methylene Chloride	37	2	5	ug/Kg	0.52 - 32	2.3	3.3	2.3		11000	
VOC	Styrene	37	0	0	ug/Kg	0.29 - 18			1.79		6500000	
VOC	Tert-Butyl Methyl Ether (MTBE)	22	0	0	ug/Kg	0.27 - 16			0.825		39000	
VOC	Tetrachloroethene (PCE)	37	2	5	ug/Kg	0.81 - 41	240	1600	51.7		570	Y
VOC	Toluene	37	9	24	ug/Kg	0.78 - 44	1.5	9.5	3.37		5000000	
VOC	Total 1,2-Dichloroethene	15	2	13	ug/Kg	5.9 - 6.3	4	7.4	3.43		700000	
VOC	trans-1,2-Dichloroethene	22	0	0	ug/Kg	0.92 - 56			2.83		110000	
VOC	trans-1,3-Dichloropropene	37	0	0	ug/Kg	0.27 - 16			1.74		1700	
VOC	Trichloroethene (TCE)	37	8	22	ug/Kg	0.77 - 36	1.5	220	9.71		2800	
VOC	Trichlorofluoromethane	22	0	0	ug/Kg	0.79 - 48			2.43		800000	
VOC	Vinyl chloride	37	0	0	ug/Kg	0.92 - 56			4.17		60	
VOC	Xylenes, Total	37	4	11	ug/Kg	0.58 - 36	3.3	6	2.83		600000	
Deep Groundwater												
GC2	Alkalinity, Total (as CaCO3)	7	7	100	mg/L		520	900	710			
GC2	Alkalinity, Carbonate (as CACO3)	4	4	100	mg/L		549	944	691			
GC2	Chloride (as Cl)	11	11	100	mg/L		337	3310	1940			
GC2	Cyanide	11	2	18	ug/L	5 - 10	16.6	594	58.2		730	Y
GC2	Hardness (as CACO3)	11	11	100	mg/L		362	2350	1350			
GC2	Nitrogen, Nitrite	4	4	100	mg/L		0.07	2.9	0.89		3.7	
GC2	Nitrogen, Nitrate (as N)	6	0	0	mg/L	0.05 - 10			0.858		58	
GC2	Nitrogen, Nitrate-Nitrite	5	1	20	mg/L	0.25 - 0.25	0.28	0.28	0.156		3700	
GC2	Sulfate (as SO4)	11	11	100	mg/L		0.57	206	26.4			
GC2	Suspended Solids (residue, Non-filterable)	10	9	90	mg/L	4 - 4	4	330	52.4			
GC2	Total Dissolved Solids	10	10	100	mg/L		730	7100	3590			

Table 2-1 Summary Statistics and Identification of COPCs for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
Deep Groundwater (continued)												
GC2	Total Organic Carbon	11	11	100	mg/L		1.1	16	5.95			
GC2	Turbidity	7	7	100	NTU		1.1	273	85.5			
HE	2-Amino-4,6-Dinitrotoluene	9	2	22	ug/L	0.11 - 0.14	0.46	0.925	0.202		73	
HE	4-Amino-2,6-Dinitrotoluene	11	2	18	ug/L	0.074 - 0.3	0.082	0.55	0.115		73	
HE	1,3-Dinitrobenzene	11	1	9	ug/L	0.074 - 0.33	0.18	0.18	0.0727		3.7	
HE	2,4-Dinitrotoluene	11	1	9	ug/L	0.096 - 0.3	0.23	0.23	0.0832		73	
HE	2,6-Dinitrotoluene	11	3	27	ug/L	0.096 - 0.3	0.21	1.7	0.325		37	
HE	HMX	11	1	9	ug/L	0.074 - 0.75	0.21	0.21	0.117		1800	
HE	2-Nitrotoluene	11	2	18	ug/L	0.074 - 0.56	0.087	1.1	0.174		0.31	Y
HE	3-Nitrotoluene	11	6	55	ug/L	0.11 - 0.3	0.14	0.82	0.243		730	
HE	4-Nitrotoluene	9	1	11	ug/L	0.074 - 0.15	0.15	0.15	0.0635		4.2	
HE	Nitrobenzene	11	2	18	ug/L	0.081 - 0.3	0.24	0.52	0.119		3.4	
HE	RDX	11	5	45	ug/L	0.074 - 0.75	0.14	5.5	1.16		0.61	Y
HE	Tetryl	11	2	18	ug/L	0.074 - 0.3	0.11	2.4	0.283		150	
HE	1,3,5-Trinitrobenzene	11	1	9	ug/L	0.074 - 0.3	3.75	3.75	0.405		1100	
HE	2,4,6-Trinitrotoluene	11	2	18	ug/L	0.074 - 0.3	0.99	2.7	0.394		2.2	Y
MET	Silver	6	0	0	ug/L	1 - 10			2		180	
MET	Silver (total)	11	0	0	ug/L	1 - 10			1.32		180	
MET	Aluminum	6	1	17	ug/L	75 - 200	76.6	76.6	64.9	309	37000	
MET	Aluminum (total)	11	8	73	ug/L	75 - 75	89.9	504	168	309	37000	
MET	Arsenic	6	2	33	ug/L	3 - 30	6.5	19.6	7.6	7.4	0.045	Y
MET	Arsenic (total)	11	4	36	ug/L	3 - 3	4.7	21.2	6.35	7.4	0.045	Y
MET	Barium	6	6	100	ug/L		42.8	2800	1050	11800	7300	
MET	Barium (total)	11	11	100	ug/L		29.6	2950	788	11800	7300	
MET	Beryllium	6	0	0	ug/L	1 - 5			1.17		73	
MET	Beryllium (total)	11	0	0	ug/L	1 - 5			0.864		73	
MET	Calcium	6	6	100	ug/L		81300	363000	244000	316000		
MET	Calcium (total)	11	11	100	ug/L		69800	371000	233000	316000		
MET	Cadmium	6	0	0	ug/L	1 - 5			1.17		18	
MET	Cadmium (total)	11	0	0	ug/L	1 - 5			0.864		18	
MET	Cobalt	6	0	0	ug/L	3 - 50			9.33	12.1	11	
MET	Cobalt (total)	11	0	0	ug/L	3 - 50			5.77	12.1	11	
MET	Chromium	6	1	17	ug/L	2 - 10	2	2	2.5		55000	
MET	Chromium (total)	11	3	27	ug/L	2 - 10	2.85	15.9	3.95		55000	
MET	Copper	6	0	0	ug/L	4 - 25			5.5	19.8	1500	
MET	Copper (total)	11	1	9	ug/L	4 - 25	26.2	26.2	5.15	19.8	1500	
MET	Iron	6	4	67	ug/L	30 - 100	45.7	372	101	1550	26000	

Table 2-1 Summary Statistics and Identification of COPCs for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
Deep Groundwater (continued)												
MET	Iron (total)	11	11	100	ug/L		90.6	2540	821	1550	26000	
MET	Mercury	6	1	17	ug/L	0.08 - 0.2	0.19	0.19	0.085		0.63	
MET	Mercury (total)	11	1	9	ug/L	0.08 - 0.2	0.18	0.18	0.0636		0.63	
MET	Potassium	6	6	100	ug/L		39900	91900	59100	116000		
MET	Potassium (total)	11	11	100	ug/L		36000	95900	62500	116000		
MET	Magnesium	6	6	100	ug/L		49900	348000	197000	217000		
MET	Magnesium (total)	11	11	100	ug/L		45700	351000	176000	217000		
MET	Manganese	6	6	100	ug/L		7	1010	421	636	880	Y
MET	Manganese (total)	11	11	100	ug/L		8.4	1160	287	636	880	Y
MET	Sodium	6	6	100	ug/L		395000	1210000	797000	1390000		
MET	Sodium (total)	11	11	100	ug/L		279000	1420000	816000	1390000		
MET	Nickel	6	0	0	ug/L	3 - 40			7.67	8.6	730	
MET	Nickel (total)	11	0	0	ug/L	3 - 40			4.86	8.6	730	
MET	Lead	6	1	17	ug/L	1.5 - 9	2.5	2.5	1.79			
MET	Lead (total)	11	2	18	ug/L	1.5 - 3	1.6	4.4	1.23			
MET	Antimony	6	0	0	ug/L	5 - 60			11.7		15	
MET	Antimony (total)	11	0	0	ug/L	5 - 60			7.5		15	
MET	Selenium	6	0	0	ug/L	3 - 15			2.67		180	
MET	Selenium (total)	11	2	18	ug/L	3 - 5	3.8	4	2.12		180	
MET	Thallium	6	3	50	ug/L	3 - 30	3.1	3.8	5.36		2.4	Y
MET	Thallium (total)	11	3	27	ug/L	3 - 10	3.5	4.7	2.86		2.4	Y
MET	Vanadium	6	1	17	ug/L	3 - 50	8.7	8.7	10.5		260	
MET	Vanadium (total)	11	2	18	ug/L	3 - 50	4.8	11	6.93		260	
MET	Zinc	6	2	33	ug/L	5 - 5	66.3	82.1	26.4	507	11000	
MET	Zinc (total)	11	7	64	ug/L	5 - 5	5.2	38.3	11.8	507	11000	
PCB	PCB-1016 (Aroclor 1016)	11	0	0	ug/L	0.12 - 20			2.29		0.96	
PCB	PCB-1221 (Aroclor 1221)	11	0	0	ug/L	0.12 - 20			2.29		0.0068	
PCB	PCB-1232 (Aroclor 1232)	11	0	0	ug/L	0.12 - 20			2.29		0.0068	
PCB	PCB-1242 (Aroclor 1242)	11	0	0	ug/L	0.12 - 20			2.29		0.034	
PCB	PCB-1248 (Aroclor 1248)	11	0	0	ug/L	0.12 - 20			1.44		0.034	
PCB	PCB-1254 (Aroclor 1254)	11	0	0	ug/L	0.12 - 20			1.44		0.034	
PCB	PCB-1260 (Aroclor 1260)	11	0	0	ug/L	0.12 - 20			1.44		0.034	
SV	Acenaphthene	11	0	0	ug/L	0.59 - 110			6.26		2200	
SV	Acenaphthylene	11	0	0	ug/L	0.44 - 110			5.98			
SV	Anthracene	11	0	0	ug/L	0.72 - 110			6.5		11000	
SV	Butylbenzylphthalate	11	0	0	ug/L	0.77 - 110			6.56		35	
SV	bis(2-Chloroethoxy)methane	11	0	0	ug/L	0.48 - 110			6.09		110	

Table 2-1 Summary Statistics and Identification of COPCs for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
Deep Groundwater (continued)												
SV	bis(2-Chloroethyl)ether (2-Chloroethylether)	11	0	0	ug/L	0.42 - 110			5.97		0.012	
SV	bis(2-Chloroisopropyl)ether	11	0	0	ug/L	0.79 - 110			6.61		0.32	
SV	bis(2-Ethylhexyl)phthalate	11	4	36	ug/L	1.2 - 36	2	28	6.97		4.8	Y
SV	4-Bromophenyl phenyl ether	11	0	0	ug/L	0.53 - 110			6.15			
SV	Benzo(a)anthracene	11	0	0	ug/L	0.85 - 110			6.73		0.029	
SV	Benzoic acid	9	0	0	ug/L	0.37 - 11			0.78		150000	
SV	Benzo(a)pyrene	11	0	0	ug/L	0.56 - 110			6.21		0.0029	
SV	Benzo(b)fluoranthene	11	0	0	ug/L	0.66 - 110			6.38		0.029	
SV	Benzo(g,h,i)perylene	11	0	0	ug/L	1.4 - 110			7.61			
SV	Benzo(k)fluoranthene	11	0	0	ug/L	0.47 - 110			6.04		0.29	
SV	Benzyl alcohol	9	0	0	ug/L	0.7 - 21			1.49		18000	
SV	4-Chloro-3-methylphenol	11	0	0	ug/L	0.54 - 110			6.16			
SV	Carbazole	11	0	0	ug/L	0.64 - 110			6.38			
SV	Chrysene	11	0	0	ug/L	0.94 - 110			6.85		2.9	
SV	4-Chloroaniline	11	0	0	ug/L	0.89 - 110			6.79		1.2	
SV	2-Chlorophenol	11	0	0	ug/L	0.55 - 110			6.21		180	
SV	2-Chloronaphthalene	11	0	0	ug/L	0.54 - 110			6.16		2900	
SV	4-Chlorophenyl phenyl ether	11	0	0	ug/L	0.83 - 110			6.67			
SV	Dibenz(a,h)anthracene	11	0	0	ug/L	1.6 - 110			8		0.0029	
SV	Dibenzofuran	11	0	0	ug/L	0.61 - 110			6.27			
SV	3,3'-Dichlorobenzidine	11	0	0	ug/L	0.83 - 530			27.6		0.15	
SV	1,2-Dichlorobenzene	12	0	0	ug/L	0.17 - 110			5		370	
SV	1,3-Dichlorobenzene	12	0	0	ug/L	0.21 - 110			5.2			
SV	1,4-Dichlorobenzene	12	0	0	ug/L	0.12 - 110			4.96		0.43	
SV	2,4-Dichlorophenol	11	0	0	ug/L	0.41 - 110			5.93		110	
SV	Diethylphthalate	11	0	0	ug/L	0.95 - 110			6.9		29000	
SV	2,4-Dimethylphenol	11	4	36	ug/L	0.66 - 110	1.2	20	8.39		730	
SV	Dimethylphthalate	11	0	0	ug/L	0.69 - 110			6.44			
SV	4,6-Dinitro-2-methylphenol	11	0	0	ug/L	0.69 - 530			27.3		3.7	
SV	Di-n-butylphthalate	11	0	0	ug/L	1.2 - 110			7.35		3700	
SV	Di-n-octylphthalate	11	0	0	ug/L	0.31 - 110			5.77			
SV	2,4-Dinitrophenol	11	0	0	ug/L	0.79 - 530			27.5		73	
SV	2,4-Dinitrotoluene	6	0	0	ug/L	0.46 - 110			10.9		73	
SV	2,6-Dinitrotoluene	6	0	0	ug/L	0.62 - 110			11.3		37	
SV	1,2-Diphenylhydrazine	9	0	0	ug/L	0.64 - 20			1.4		0.084	
SV	Fluorene	11	0	0	ug/L	0.51 - 110			6.15		1500	
SV	Fluoranthene	11	0	0	ug/L	0.65 - 110			6.38		1500	
SV	Hexachlorobutadiene	11	0	0	ug/L	0.87 - 110			6.73		0.86	
SV	Hexachlorocyclopentadiene	11	0	0	ug/L	0.83 - 530			27.6		220	

Table 2-1 Summary Statistics and Identification of COPCs for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
Deep Groundwater (continued)												
SV	Hexachlorobenzene	11	0	0	ug/L	0.44 - 110			5.98		0.042	
SV	Hexachloroethane	11	0	0	ug/L	0.43 - 110			5.98		4.8	
SV	Indeno(1,2,3-cd)pyrene	11	0	0	ug/L	1.3 - 110			7.53		0.029	
SV	Isophorone	11	1	9	ug/L	0.51 - 16	2.9	2.9	1.64		71	
SV	2-Methylphenol (o-Cresol)	11	0	0	ug/L	0.78 - 110			6.56		1800	
SV	3-Methylphenol	9	1	11	ug/L	0.72 - 22	8.4	8.4	2.44		1800	
SV	4-Methylphenol (p-Cresol)	11	1	9	ug/L	0.72 - 110	8.4	8.4	7.23		180	
SV	2-Methylnaphthalene	11	11	100	ug/L		0.81	290	42.8		150	Y
SV	Naphthalene	11	11	100	ug/L		1.3	93	22.7		0.14	Y
SV	N-Nitrosodimethylamine	9	0	0	ug/L	0.84 - 25			1.77		0.00042	
SV	N-Nitrosodiphenylamine	11	0	0	ug/L	0.43 - 110			5.98		14	
SV	N-Nitroso-di-n-propylamine	11	0	0	ug/L	0.84 - 110			6.68		0.0096	
SV	2-Nitroaniline	11	0	0	ug/L	1.1 - 530			28.1			
SV	3-Nitroaniline	11	0	0	ug/L	0.98 - 530			27.9		3.2	
SV	4-Nitroaniline	11	0	0	ug/L	1.9 - 530			29.5		3.2	
SV	Nitrobenzene	6	0	0	ug/L	0.58 - 110			11.2		3.4	
SV	2-Nitrophenol	11	0	0	ug/L	0.69 - 110			6.44			
SV	4-Nitrophenol	11	0	0	ug/L	0.78 - 530			27.5			
SV	Pentachlorophenol	11	0	0	ug/L	0.93 - 530			27.8		0.56	
SV	Phenanthrene	11	2	18	ug/L	0.72 - 110	2.3	46	9.43			
SV	Phenol	11	3	27	ug/L	0.43 - 13	8.2	37	6.2		11000	
SV	Pyrene	11	0	0	ug/L	0.61 - 110			6.27		1100	
SV	1,2,4-Trichlorobenzene	12	0	0	ug/L	0.14 - 110			5.28		8.2	
SV	2,4,5-Trichlorophenol	11	0	0	ug/L	0.47 - 110			6.04		3700	
SV	2,4,6-Trichlorophenol	11	0	0	ug/L	0.68 - 110			6.44		6.1	
VOC	Acetone	10	3	30	ug/L	1.1 - 250	6.2	32.5	19.3		22000	
VOC	Bromodichloromethane	11	0	0	ug/L	0.086 - 25			1.51		1.1	
VOC	Bromochloromethane	9	0	0	ug/L	0.3 - 1.6			0.388			
VOC	Bromomethane	11	0	0	ug/L	0.26 - 50			3.03		8.7	
VOC	Benzene	11	11	100	ug/L		9.5	140	52.5	2.4	0.41	Y
VOC	Toluene	11	11	100	ug/L		24	240	86.3	1.7	2300	
VOC	Carbon Disulfide	11	2	18	ug/L	0.13 - 0.75	59	63	11.3		1000	
VOC	Methylcyclohexane	9	9	100	ug/L		44	490	180			
VOC	Chlorobenzene	11	0	0	ug/L	0.2 - 25			1.62		91	
VOC	Chloroethane	11	0	0	ug/L	0.28 - 50			3.08		21000	
VOC	Chloromethane	11	0	0	ug/L	0.4 - 50			3.2		1.8	
VOC	Carbon tetrachloride	11	0	0	ug/L	0.14 - 25			1.54		0.2	
VOC	Cyclohexane	9	9	100	ug/L		140	530	301		13000	

Table 2-1 Summary Statistics and Identification of COPCs for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
Deep Groundwater (continued)												
VOC	Dibromochloromethane	11	0	0	ug/L	0.08 - 25			1.52		0.8	
VOC	1,2-Dibromo-3-chloropropane	9	0	0	ug/L	0.18 - 1.4			0.303		0.00032	
VOC	1,1-Dichloroethane	11	0	0	ug/L	0.15 - 25			1.54		2.4	
VOC	1,2-Dichloroethane	11	0	0	ug/L	0.15 - 25			1.56		0.15	
VOC	Dichlorodifluoromethane	9	0	0	ug/L	0.24 - 1.2			0.414		390	
VOC	1,1-Dichloroethene	11	0	0	ug/L	0.26 - 25			1.73		340	
VOC	cis-1,2-Dichloroethene	9	0	0	ug/L	0.28 - 2.2			0.474		370	
VOC	trans-1,2-Dichloroethene	9	0	0	ug/L	0.3 - 2			0.453		110	
VOC	Total 1,2-Dichloroethene	2	0	0	ug/L	5 - 25			7.5		330	
VOC	cis-1,3-Dichloropropene	11	0	0	ug/L	0.13 - 25			1.51		0.43	
VOC	trans-1,3-Dichloropropene	11	0	0	ug/L	0.22 - 25			1.6		0.43	
VOC	1,2-Dichloropropane	11	0	0	ug/L	0.18 - 25			1.56		0.39	
VOC	Ethylbenzene	11	11	100	ug/L		7.45	140	44	0.87	1.5	Y
VOC	1,2-Dibromoethane (EDB)	9	0	0	ug/L	0.07 - 0.7			0.187		0.0065	
VOC	Trichlorofluoromethane	9	0	0	ug/L	0.15 - 0.75			0.23		1300	
VOC	1,1,2-Trichloro-1,2,2-Trifluoroethane	9	0	0	ug/L	0.22 - 1.1			0.275		59000	
VOC	2-Hexanone	10	0	0	ug/L	0.36 - 120			6.74			
VOC	Isopropylbenzene (Cumene)	9	9	100	ug/L		4	28	13		680	
VOC	Methyl Acetate	9	0	0	ug/L	0.72 - 4.4			1.02		37000	
VOC	2-Butanone (Methyl ethyl ketone)	10	0	0	ug/L	1.2 - 120			8.09		7100	
VOC	4-Methyl-2-pentanone (Methyl isobutyl ketone)	11	0	0	ug/L	0.7 - 120			7.78		2000	
VOC	Methylene Chloride	11	4	36	ug/L	0.26 - 6.3	1.4	7.75	2.16		4.8	Y
VOC	1,1,2,2-Tetrachloroethane	11	0	0	ug/L	0.07 - 25			1.51		0.067	
VOC	Tetrachloroethene (PCE)	11	0	0	ug/L	0.14 - 25			1.53		0.11	
VOC	Styrene	11	0	0	ug/L	0.18 - 25			1.57		1600	
VOC	Bromoform	11	0	0	ug/L	0.24 - 25			1.62		8.5	
VOC	Tert-Butyl Methyl Ether (MTBE)	9	0	0	ug/L	0.17 - 0.85			0.227		12	
VOC	1,1,1-Trichloroethane	11	0	0	ug/L	0.15 - 25			1.55		9100	
VOC	1,1,2-Trichloroethane	11	0	0	ug/L	0.17 - 25			1.55		0.24	
VOC	1,2,3-Trichlorobenzene	9	0	0	ug/L	0.16 - 2.8			0.652			
VOC	Trichloroethene (TCE)	11	1	9	ug/L	0.28 - 25	1.8	1.8	1.84		1.7	Y
VOC	Chloroform	11	0	0	ug/L	0.1 - 25			1.53		0.19	
VOC	Vinyl chloride	11	0	0	ug/L	0.19 - 50			3		0.016	
VOC	Xylenes, Total	11	11	100	ug/L		140	930	411	5.5	200	Y
Surface Water												
HE	2-Amino-4,6-Dinitrotoluene	12	1	8	ug/L	0.11 - 0.13	0.24	0.24	0.0738		73	
HE	4-Amino-2,6-Dinitrotoluene	12	1	8	ug/L	0.074 - 0.086	0.4	0.4	0.0694		73	
HE	1,3-Dinitrobenzene	12	0	0	ug/L	0.072 - 0.086			0.0391		3.7	
HE	2,4-Dinitrotoluene	12	0	0	ug/L	0.094 - 0.11			0.0503		73	

Table 2-1 Summary Statistics and Identification of COPCs for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
Surface Water (continued)												
HE	2,6-Dinitrotoluene	12	0	0	ug/L	0.094 - 0.11			0.0503		37	
HE	HMX	12	0	0	ug/L	0.072 - 0.086			0.0391		1800	
HE	2-Nitrotoluene	12	0	0	ug/L	0.072 - 0.086			0.0391		0.31	
HE	3-Nitrotoluene	12	0	0	ug/L	0.11 - 0.2			0.0613		730	
HE	4-Nitrotoluene	12	0	0	ug/L	0.072 - 0.086			0.0391		4.2	
HE	Nitrobenzene	12	0	0	ug/L	0.079 - 0.095			0.043		3.4	
HE	RDX	12	3	25	ug/L	0.074 - 0.086	0.081	0.5	0.116		0.61	
HE	Tetryl	12	1	8	ug/L	0.072 - 0.086	0.24	0.24	0.0558		150	
HE	1,3,5-Trinitrobenzene	12	0	0	ug/L	0.072 - 0.086			0.0391		1100	
HE	2,4,6-Trinitrotoluene	12	0	0	ug/L	0.072 - 0.086			0.0391		2.2	
MET	Silver	12	0	0	ug/L	1 - 1			0.5		180	
MET	Aluminum	12	8	67	ug/L	100 - 100	317	10200	1300		37000	
MET	Arsenic	12	3	25	ug/L	3 - 3	4	49.3	6		0.045	Y
MET	Barium	12	12	100	ug/L		11.6	194	59.2		7300	
MET	Beryllium	12	0	0	ug/L	1 - 1			0.5		73	
MET	Calcium	12	12	100	ug/L		84500	271000	152000			
MET	Cadmium	12	0	0	ug/L	1 - 1			0.5		18	
MET	Cobalt	12	4	33	ug/L	3 - 3	6.15	12.8	4.05		11	Y
MET	Chromium	12	2	17	ug/L	2 - 2	2.1	12.7	2.07		55000	
MET	Copper	12	1	8	ug/L	4 - 4	21.9	21.9	3.66		1500	
MET	Iron	12	12	100	ug/L		76.7	50000	6170		26000	Y
MET	Mercury	12	1	8	ug/L	0.08 - 0.08	0.11	0.11	0.0458		0.63	
MET	Potassium	12	12	100	ug/L		957	46200	7360			
MET	Magnesium	12	12	100	ug/L		18100	64600	33600			
MET	Manganese	12	12	100	ug/L		64.6	8840	1330		880	Y
MET	Sodium	12	12	100	ug/L		3430	19300	7780			
MET	Nickel	12	9	75	ug/L	3 - 3	3.4	51.7	13.9		730	
MET	Lead	12	5	42	ug/L	1.5 - 1.5	1.6	29.9	3.96			
MET	Antimony	12	0	0	ug/L	5 - 5			2.5		15	
MET	Selenium	12	1	8	ug/L	3 - 3	3.8	3.8	1.69		180	
MET	Thallium	12	2	17	ug/L	3 - 3	3.7	4.3	1.92		2.4	Y
MET	Vanadium	12	2	17	ug/L	3 - 3	3.3	19	3.11		260	
MET	Zinc	12	7	58	ug/L	5 - 5	7	71.6	15.8		11000	
PCB	PCB-1016 (Aroclor 1016)	12	0	0	ug/L	0.1 - 0.12			0.0517		0.96	
PCB	PCB-1221 (Aroclor 1221)	12	0	0	ug/L	0.1 - 0.12			0.0517		0.0068	
PCB	PCB-1232 (Aroclor 1232)	12	0	0	ug/L	0.1 - 0.12			0.0517		0.0068	
PCB	PCB-1242 (Aroclor 1242)	12	0	0	ug/L	0.1 - 0.12			0.0517		0.034	

Table 2-1 Summary Statistics and Identification of COPCs for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
Surface Water (continued)												
PCB	PCB-1248 (Aroclor 1248)	12	0	0	ug/L	0.1 - 0.12			0.0517		0.034	
PCB	PCB-1254 (Aroclor 1254)	12	0	0	ug/L	0.1 - 0.12			0.0517		0.034	
PCB	PCB-1260 (Aroclor 1260)	12	0	0	ug/L	0.1 - 0.12			0.0517		0.034	
SV	Acenaphthene	12	0	0	ug/L	0.58 - 0.62			0.296		2200	
SV	Acenaphthylene	12	0	0	ug/L	0.44 - 0.46			0.222			
SV	Anthracene	12	0	0	ug/L	0.71 - 0.75			0.362		11000	
SV	Butylbenzylphthalate	12	0	0	ug/L	0.76 - 0.8			0.386		35	
SV	bis(2-Chloroethoxy)methane	12	0	0	ug/L	0.48 - 0.51			0.244		110	
SV	bis(2-Chloroethyl)ether (2-Chloroethylether)	12	0	0	ug/L	0.42 - 0.44			0.212		0.012	
SV	bis(2-Chloroisopropyl)ether	12	0	0	ug/L	0.79 - 0.83			0.4		0.32	
SV	bis(2-Ethylhexyl)phthalate	12	0	0	ug/L	1.2 - 1.3			0.602		4.8	
SV	4-Bromophenyl phenyl ether	12	0	0	ug/L	0.53 - 0.56			0.269			
SV	Benzo(a)anthracene	12	0	0	ug/L	0.84 - 0.89			0.428		0.029	
SV	Benzoic acid	7	1	14	ug/L	0.37 - 0.39	3.7	3.7	0.69		150000	
SV	Benzo(a)pyrene	12	0	0	ug/L	0.56 - 0.59			0.284		0.0029	
SV	Benzo(b)fluoranthene	12	0	0	ug/L	0.66 - 0.7			0.335		0.029	
SV	Benzo(g,h,i)perylene	12	0	0	ug/L	1.4 - 1.5			0.702			
SV	Benzo(k)fluoranthene	12	0	0	ug/L	0.46 - 0.49			0.235		0.29	
SV	Benzyl alcohol	8	1	12	ug/L	0.69 - 0.74	2.3	2.3	0.598		18000	
SV	4-Chloro-3-methylphenol	9	0	0	ug/L	0.54 - 0.57			0.274			
SV	Carbazole	12	0	0	ug/L	0.64 - 0.68			0.325			
SV	Chrysene	12	0	0	ug/L	0.94 - 0.99			0.475		2.9	
SV	4-Chloroaniline	12	0	0	ug/L	0.88 - 0.93			0.448		1.2	
SV	2-Chlorophenol	8	0	0	ug/L	0.55 - 0.58			0.28		180	
SV	2-Chloronaphthalene	12	0	0	ug/L	0.54 - 0.57			0.274		2900	
SV	4-Chlorophenyl phenyl ether	12	0	0	ug/L	0.82 - 0.87			0.418			
SV	Dibenz(a,h)anthracene	12	0	0	ug/L	1.6 - 1.7			0.806		0.0029	
SV	Dibenzofuran	12	0	0	ug/L	0.6 - 0.64			0.306			
SV	3,3'-Dichlorobenzidine	12	0	0	ug/L	0.82 - 0.87			0.418		0.15	
SV	1,2-Dichlorobenzene	12	0	0	ug/L	0.17 - 0.17			0.085		370	
SV	1,3-Dichlorobenzene	12	0	0	ug/L	0.21 - 0.21			0.105			
SV	1,4-Dichlorobenzene	12	0	0	ug/L	0.12 - 0.12			0.06		0.43	
SV	2,4-Dichlorophenol	8	0	0	ug/L	0.41 - 0.43			0.208		110	
SV	Diethylphthalate	12	0	0	ug/L	0.94 - 1			0.478		29000	
SV	2,4-Dimethylphenol	8	0	0	ug/L	0.66 - 0.7			0.336		730	
SV	Dimethylphthalate	12	0	0	ug/L	0.68 - 0.72			0.347			
SV	4,6-Dinitro-2-methylphenol	7	0	0	ug/L	0.68 - 0.72			0.35		3.7	
SV	Di-n-butylphthalate	12	0	0	ug/L	1.2 - 1.3			0.606		3700	

Table 2-1 Summary Statistics and Identification of COPCs for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
Surface Water (continued)												
SV	Di-n-octylphthalate	12	0	0	ug/L	0.3 - 0.32			0.154			
SV	2,4-Dinitrophenol	7	0	0	ug/L	0.79 - 0.83			0.403		73	
SV	2,4-Dinitrotoluene	12	0	0	ug/L	0.45 - 0.48			0.23		73	
SV	2,6-Dinitrotoluene	12	0	0	ug/L	0.61 - 0.65			0.311		37	
SV	1,2-Diphenylhydrazine	12	0	0	ug/L	0.64 - 0.68			0.325		0.084	
SV	Fluorene	12	0	0	ug/L	0.51 - 0.54			0.259		1500	
SV	Fluoranthene	12	0	0	ug/L	0.65 - 0.69			0.33		1500	
SV	Hexachlorobutadiene	12	0	0	ug/L	0.86 - 0.91			0.438		0.86	
SV	Hexachlorocyclopentadiene	12	0	0	ug/L	0.82 - 0.87			0.418		220	
SV	Hexachlorobenzene	12	0	0	ug/L	0.44 - 0.46			0.222		0.042	
SV	Hexachloroethane	12	0	0	ug/L	0.42 - 0.45			0.215		4.8	
SV	Indeno(1,2,3-cd)pyrene	12	0	0	ug/L	1.3 - 1.4			0.66		0.029	
SV	Isophorone	8	0	0	ug/L	0.51 - 0.54			0.26		71	
SV	2-Methylphenol (o-Cresol)	9	1	11	ug/L	0.77 - 0.81	0.95	0.95	0.455		1800	
SV	3-Methylphenol	9	2	22	ug/L	0.71 - 0.75	13	18	3.73		1800	
SV	4-Methylphenol (p-Cresol)	9	2	22	ug/L	0.71 - 0.75	13	18	3.73		180	
SV	2-Methylnaphthalene	12	0	0	ug/L	0.63 - 0.67			0.321		150	
SV	Naphthalene	12	0	0	ug/L	0.42 - 0.44			0.212		0.14	
SV	N-Nitrosodimethylamine	12	0	0	ug/L	0.83 - 0.88			0.423		0.00042	
SV	N-Nitrosodiphenylamine	12	0	0	ug/L	0.42 - 0.45			0.215		14	
SV	N-Nitroso-di-n-propylamine	12	0	0	ug/L	0.83 - 0.88			0.423		0.0096	
SV	2-Nitroaniline	12	0	0	ug/L	1.1 - 1.2			0.556			
SV	3-Nitroaniline	12	0	0	ug/L	0.97 - 1			0.493		3.2	
SV	4-Nitroaniline	12	0	0	ug/L	1.9 - 2			0.963		3.2	
SV	Nitrobenzene	12	0	0	ug/L	0.57 - 0.61			0.291		3.4	
SV	2-Nitrophenol	8	0	0	ug/L	0.68 - 0.72			0.349			
SV	4-Nitrophenol	7	0	0	ug/L	0.77 - 0.81			0.394			
SV	Pentachlorophenol	7	0	0	ug/L	0.92 - 0.98			0.473		0.56	
SV	Phenanthrene	12	0	0	ug/L	0.71 - 0.75			0.362			
SV	Phenol	9	1	11	ug/L	0.42 - 0.45	0.65	0.65	0.264		11000	
SV	Pyrene	12	0	0	ug/L	0.6 - 0.64			0.306		1100	
SV	1,2,4-Trichlorobenzene	12	0	0	ug/L	0.14 - 0.14			0.07		8.2	
SV	2,4,5-Trichlorophenol	8	0	0	ug/L	0.46 - 0.49			0.236		3700	
SV	2,4,6-Trichlorophenol	7	0	0	ug/L	0.68 - 0.72			0.347		6.1	
VOC	Acetone	12	5	42	ug/L	1.1 - 1.1	2.9	22	4.08		22000	
VOC	Bromodichloromethane	12	0	0	ug/L	0.086 - 0.086			0.043		1.1	
VOC	Bromochloromethane	12	0	0	ug/L	0.31 - 0.31			0.155			
VOC	Bromomethane	12	0	0	ug/L	0.33 - 0.33			0.165		8.7	
VOC	Benzene	12	0	0	ug/L	0.11 - 0.11			0.055		0.41	

Table 2-1 Summary Statistics and Identification of COPCs for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
Surface Water (continued)												
VOC	Toluene	12	0	0	ug/L	0.18 - 0.32			0.0958		2300	
VOC	Carbon Disulfide	12	0	0	ug/L	0.13 - 0.13			0.065		1000	
VOC	Methylcyclohexane	12	0	0	ug/L	0.2 - 0.2			0.1			
VOC	Chlorobenzene	12	0	0	ug/L	0.28 - 0.28			0.14		91	
VOC	Chloroethane	12	0	0	ug/L	0.38 - 0.38			0.19		21000	
VOC	Chloromethane	12	0	0	ug/L	0.4 - 0.4			0.2		1.8	
VOC	Carbon tetrachloride	12	1	8	ug/L	0.14 - 0.14	0.46	0.46	0.103		0.2	Y
VOC	Cyclohexane	12	0	0	ug/L	0.18 - 0.18			0.09		13000	
VOC	Dibromochloromethane	12	0	0	ug/L	0.08 - 0.08			0.04		0.8	
VOC	1,2-Dibromo-3-chloropropane	12	0	0	ug/L	0.28 - 0.28			0.14		0.00032	
VOC	1,1-Dichloroethane	12	2	17	ug/L	0.15 - 0.15	2.6	3.9	0.604		2.4	Y
VOC	1,2-Dichloroethane	12	0	0	ug/L	0.15 - 0.15			0.075		0.15	
VOC	Dichlorodifluoromethane	12	0	0	ug/L	0.24 - 0.24			0.12		390	
VOC	1,1-Dichloroethene	12	0	0	ug/L	0.42 - 0.42			0.21		340	
VOC	cis-1,2-Dichloroethene	12	1	8	ug/L	0.44 - 0.44	0.91	0.91	0.278		370	
VOC	trans-1,2-Dichloroethene	12	0	0	ug/L	0.4 - 0.4			0.2		110	
VOC	cis-1,3-Dichloropropene	12	0	0	ug/L	0.13 - 0.13			0.065		0.43	
VOC	trans-1,3-Dichloropropene	12	0	0	ug/L	0.22 - 0.22			0.11		0.43	
VOC	1,2-Dichloropropane	12	0	0	ug/L	0.18 - 0.18			0.09		0.39	
VOC	Ethylbenzene	12	0	0	ug/L	0.14 - 0.14			0.07		1.5	
VOC	1,2-Dibromoethane (EDB)	12	0	0	ug/L	0.07 - 0.07			0.035		0.0065	
VOC	Trichlorofluoromethane	12	0	0	ug/L	0.15 - 0.15			0.075		1300	
VOC	1,1,2-Trichloro-1,2,2-Trifluoroethane	12	0	0	ug/L	0.22 - 0.22			0.11		59000	
VOC	2-Hexanone	12	0	0	ug/L	0.83 - 0.83			0.415			
VOC	Isopropylbenzene (Cumene)	12	0	0	ug/L	0.034 - 0.034			0.017		680	
VOC	Methyl Acetate	12	0	0	ug/L	0.87 - 0.87			0.435		37000	
VOC	2-Butanone (Methyl ethyl ketone)	12	1	8	ug/L	1.2 - 1.2	2.5	2.5	0.758		7100	
VOC	4-Methyl-2-pentanone (Methyl isobutyl ketone)	12	0	0	ug/L	1.4 - 1.4			0.7		2000	
VOC	Methylene Chloride	12	0	0	ug/L	0.26 - 0.26			0.13		4.8	
VOC	1,1,2,2-Tetrachloroethane	12	0	0	ug/L	0.07 - 0.07			0.035		0.067	
VOC	Tetrachloroethene (PCE)	12	0	0	ug/L	0.14 - 0.14			0.07		0.11	
VOC	Styrene	12	0	0	ug/L	0.22 - 0.22			0.11		1600	
VOC	Bromoform	12	0	0	ug/L	0.24 - 0.24			0.12		8.5	
VOC	Tert-Butyl Methyl Ether (MTBE)	12	0	0	ug/L	0.17 - 0.17			0.085		12	
VOC	1,1,1-Trichloroethane	12	2	17	ug/L	0.15 - 0.15	4.9	14	1.64		9100	
VOC	1,1,2-Trichloroethane	12	0	0	ug/L	0.17 - 0.17			0.085		0.24	
VOC	1,2,3-Trichlorobenzene	12	0	0	ug/L	0.16 - 0.16			0.08			
VOC	Trichloroethene (TCE)	12	2	17	ug/L	0.28 - 0.28	1.7	4.9	0.667		1.7	Y
VOC	Chloroform	12	1	8	ug/L	0.1 - 0.1	0.15	0.15	0.0583		0.19	

Table 2-1 Summary Statistics and Identification of COPCs for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
Surface Water (continued)												
VOC	Vinyl chloride	12	0	0	ug/L	0.19 - 0.19			0.095		0.016	
VOC	Xylenes, Total	12	0	0	ug/L	0.21 - 0.21			0.105		200	
Sediment												
HE	2-Amino-4,6-Dinitrotoluene	15	0	0	ug/Kg				65.5		150000	
HE	4-Amino-2,6-Dinitrotoluene	15	0	0	ug/Kg				43.8		150000	
HE	1,3-Dinitrobenzene	15	0	0	ug/Kg				43.8		6100	
HE	2,4-Dinitrotoluene	15	2	13	ug/Kg		240	490	98.3		120000	
HE	2,6-Dinitrotoluene	15	0	0	ug/Kg				56.3		61000	
HE	HMX	15	0	0	ug/Kg				43.8		3800000	
HE	2-Nitrotoluene	15	0	0	ug/Kg				43.8		2900	
HE	3-Nitrotoluene	15	0	0	ug/Kg				65.5		1200000	
HE	4-Nitrotoluene	15	2	13	ug/Kg		110	320	66.2		30000	
HE	Nitrobenzene	15	0	0	ug/Kg				48		31000	
HE	RDX	15	3	20	ug/Kg		100	920	117		5500	
HE	Tetryl	15	1	7	ug/Kg		100	100	47.8		240000	
HE	1,3,5-Trinitrobenzene	15	0	0	ug/Kg				43.8		2200000	
HE	2,4,6-Trinitrotoluene	15	2	13	ug/Kg		230	590	93.1		19000	
MET	Silver	15	0	0	mg/Kg				0.161	11.1	390	
MET	Aluminum	15	15	100	mg/Kg		5610	47600	14700	15500	77000	
MET	Arsenic	15	15	100	mg/Kg		1.7	20.8	7.47	36.5	0.39	Y
MET	Barium	15	15	100	mg/Kg		4.4	105	64.9	826	15000	
MET	Beryllium	15	15	100	mg/Kg		0.36	13.8	1.79	1	160	
MET	Calcium	15	15	100	mg/Kg		3140	114000	19600	52300		
MET	Cadmium	15	11	73	mg/Kg		0.33	3.7	0.764		70	
MET	Cobalt	15	15	100	mg/Kg		2.8	77.3	14.7	116	23	Y
MET	Chromium	15	15	100	mg/Kg		2	34.4	16.4	29	280	
MET	Copper	15	15	100	mg/Kg		9.8	51.7	21.5	56.2	3100	
MET	Iron	15	15	100	mg/Kg		1470	54600	20000	234000	55000	
MET	Mercury	15	15	100	mg/Kg		0.0205	2.2	0.202	0.1	6.7	
MET	Potassium	15	14	93	mg/Kg		1090	4360	1820	3390		
MET	Magnesium	15	15	100	mg/Kg		482	16200	5250	10400		
MET	Manganese	15	15	100	mg/Kg		18.9	722	306	3506		
MET	Sodium	15	0	0	mg/Kg				144			
MET	Nickel	15	15	100	mg/Kg		9.2	243	43.4	55.1	1600	
MET	Lead	15	15	100	mg/Kg		5.6	77.3	27.7	48.6	400	
MET	Antimony	15	0	0	mg/Kg				1.58	9.3	31	
MET	Selenium	15	2	13	mg/Kg		0.94	1.5	0.565	2	390	
MET	Thallium	15	0	0	mg/Kg				0.197	1.3	5.1	

Table 2-1 Summary Statistics and Identification of COPCs for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
Sediment (continued)												
MET	Vanadium	15	15	100	mg/Kg		2	48.6	26.8	40.9	550	
MET	Zinc	15	15	100	mg/Kg		28.5	286	93.9	322	23000	
PCB	PCB-1016 (Aroclor 1016)	15	0	0	ug/Kg				2.35		3900	
PCB	PCB-1221 (Aroclor 1221)	15	0	0	ug/Kg				2.35		170	
PCB	PCB-1232 (Aroclor 1232)	15	0	0	ug/Kg				2.35		170	
PCB	PCB-1242 (Aroclor 1242)	15	0	0	ug/Kg				2.35		220	
PCB	PCB-1248 (Aroclor 1248)	15	0	0	ug/Kg				2.35		220	
PCB	PCB-1254 (Aroclor 1254)	15	14	93	ug/Kg		4.6	750	186		220	Y
PCB	PCB-1260 (Aroclor 1260)	15	14	93	ug/Kg		6.5	1800	268		220	Y
SV	Acenaphthene	15	0	0	ug/Kg				18.9		3400000	
SV	Acenaphthylene	15	0	0	ug/Kg				14			
SV	Anthracene	15	2	13	ug/Kg		41	61	23.5		17000000	
SV	Butylbenzylphthalate	15	0	0	ug/Kg				21.2		260000	
SV	bis(2-Chloroethoxy)methane	15	0	0	ug/Kg				22.1		180000	
SV	bis(2-Chloroethyl)ether (2-Chloroethylether)	15	0	0	ug/Kg				29.1		190	
SV	bis(2-Chloroisopropyl)ether	15	0	0	ug/Kg				36.7		3500	
SV	bis(2-Ethylhexyl)phthalate	15	3	20	ug/Kg		50	56	31.9		35000	
SV	4-Bromophenyl phenyl ether	15	0	0	ug/Kg				18.5			
SV	Benzo(a)anthracene	15	8	53	ug/Kg		104	350	121		150	Y
SV	Benzoic acid	15	0	0	ug/Kg				13.9		240000000	
SV	Benzo(a)pyrene	15	6	40	ug/Kg		91	310	77.9		15	Y
SV	Benzo(b)fluoranthene	15	12	80	ug/Kg		59	500	164		150	Y
SV	Benzo(g,h,i)perylene	15	1	7	ug/Kg		180	180	59.3			
SV	Benzo(k)fluoranthene	15	10	67	ug/Kg		68	380	146		1500	
SV	Benzyl alcohol	15	0	0	ug/Kg				32.2		31000000	
SV	4-Chloro-3-methylphenol	15	0	0	ug/Kg				19.9			
SV	Carbazole	15	0	0	ug/Kg				25.9			
SV	Chrysene	15	10	67	ug/Kg		50	410	154		15000	
SV	4-Chloroaniline	15	0	0	ug/Kg				34.3		9000	
SV	2-Chlorophenol	15	0	0	ug/Kg				29.1		390000	
SV	2-Chloronaphthalene	15	0	0	ug/Kg				22.8		6300000	
SV	4-Chlorophenyl phenyl ether	15	0	0	ug/Kg				22			
SV	Dibenz(a,h)anthracene	15	0	0	ug/Kg				43		15	
SV	Dibenzofuran	15	1	7	ug/Kg		91	91	22			
SV	3,3'-Dichlorobenzidine	15	0	0	ug/Kg				22.5		1100	
SV	1,2-Dichlorobenzene	15	0	0	ug/Kg				0.257		2000000	
SV	1,3-Dichlorobenzene	15	0	0	ug/Kg				0.582			

Table 2-1 Summary Statistics and Identification of COPCs for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
Sediment (continued)												
SV	1,4-Dichlorobenzene	15	0	0	ug/Kg				0.382		2600	
SV	2,4-Dichlorophenol	15	0	0	ug/Kg				13.5		180000	
SV	Diethylphthalate	15	0	0	ug/Kg				477		49000000	
SV	2,4-Dimethylphenol	15	0	0	ug/Kg				15.2		1200000	
SV	Dimethylphthalate	15	0	0	ug/Kg				21.8			
SV	4,6-Dinitro-2-methylphenol	15	0	0	ug/Kg				15.6		6100	
SV	Di-n-butylphthalate	15	0	0	ug/Kg				34.9		6100000	
SV	Di-n-octylphthalate	15	0	0	ug/Kg				19.2			
SV	2,4-Dinitrophenol	15	0	0	ug/Kg				94.8		120000	
SV	2,4-Dinitrotoluene	15	2	13	ug/Kg		93	460	52		120000	
SV	2,6-Dinitrotoluene	15	0	0	ug/Kg				27.1		61000	
SV	1,2-Diphenylhydrazine	15	0	0	ug/Kg				19		610	
SV	Fluorene	15	0	0	ug/Kg				18.6		2300000	
SV	Fluoranthene	15	9	60	ug/Kg		100	640	223		2300000	
SV	Hexachlorobutadiene	15	0	0	ug/Kg				23.4		6200	
SV	Hexachlorocyclopentadiene	14	0	0	ug/Kg				44.2		370000	
SV	Hexachlorobenzene	15	0	0	ug/Kg				24.8		300	
SV	Hexachloroethane	15	0	0	ug/Kg				28		35000	
SV	Indeno(1,2,3-cd)pyrene	15	3	20	ug/Kg		240	360	89.6		150	Y
SV	Isophorone	15	0	0	ug/Kg				20.3		510000	
SV	2-Methylphenol (o-Cresol)	15	0	0	ug/Kg				27.6		3100000	
SV	3-Methylphenol	15	1	7	ug/Kg		270	270	36.2		3100000	
SV	4-Methylphenol (p-Cresol)	15	1	7	ug/Kg		270	270	35.7		310000	
SV	2-Methylnaphthalene	15	1	7	ug/Kg		280	280	41.5		310000	
SV	Naphthalene	15	1	7	ug/Kg		210	210	35.2		3900	
SV	N-Nitrosodimethylamine	15	0	0	ug/Kg				67.5		2.3	
SV	N-Nitrosodiphenylamine	15	0	0	ug/Kg				22.8		99000	
SV	N-Nitroso-di-n-propylamine	15	1	7	ug/Kg		620	620	78.3		69	Y
SV	2-Nitroaniline	15	0	0	ug/Kg				23			
SV	3-Nitroaniline	15	0	0	ug/Kg				33.8		18000	
SV	4-Nitroaniline	15	0	0	ug/Kg				71.8		23000	
SV	Nitrobenzene	15	0	0	ug/Kg				24.7		31000	
SV	2-Nitrophenol	15	0	0	ug/Kg				15.8			
SV	4-Nitrophenol	15	0	0	ug/Kg				57.6			
SV	Pentachlorophenol	15	0	0	ug/Kg				24.1		3000	
SV	Phenanthrene	15	9	60	ug/Kg		46	310	95.3			
SV	Phenol	15	0	0	ug/Kg				25.8		18000000	
SV	Pyrene	15	10	67	ug/Kg		65	540	205		1700000	
SV	1,2,4-Trichlorobenzene	15	0	0	ug/Kg				0.125		87000	

Table 2-1 Summary Statistics and Identification of COPCs for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
Sediment (continued)												
SV	2,4,5-Trichlorophenol	15	0	0	ug/Kg				19.1		6100000	
SV	2,4,6-Trichlorophenol	15	0	0	ug/Kg				24.9		44000	
VOC	Acetone	15	8	53	ug/Kg		19	260	72		61000000	
VOC	Bromodichloromethane	15	0	0	ug/Kg				0.209		10000	
VOC	Bromochloromethane	15	0	0	ug/Kg				0.295			
VOC	Bromomethane	15	0	0	ug/Kg				0.499		7900	
VOC	Benzene	15	6	40	ug/Kg		0.76	7.8	1.36		1100	
VOC	Toluene	15	5	33	ug/Kg		2.9	20	2.67		5000000	
VOC	Carbon Disulfide	15	7	47	ug/Kg		2.6	30	5.59		670000	
VOC	Methylcyclohexane	15	7	47	ug/Kg		0.55	37	4.82			
VOC	Chlorobenzene	15	0	0	ug/Kg				1.74		310000	
VOC	Chloroethane	15	4	27	ug/Kg		2	9.65	2		15000000	
VOC	Chloromethane	15	0	0	ug/Kg				0.362		1700	
VOC	Carbon tetrachloride	15	0	0	ug/Kg				0.612		250	
VOC	Cyclohexane	15	7	47	ug/Kg		1.4	29	3.77		7200000	
VOC	Dibromochloromethane	15	0	0	ug/Kg				0.237		5800	
VOC	1,2-Dibromo-3-chloropropane	15	0	0	ug/Kg				0.835		5.6	
VOC	1,1-Dichloroethane	15	1	7	ug/Kg		2.3	2.3	0.48		3400	
VOC	1,2-Dichloroethane	15	0	0	ug/Kg				0.321		450	
VOC	Dichlorodifluoromethane	15	0	0	ug/Kg				0.772		190000	
VOC	1,1-Dichloroethene	15	0	0	ug/Kg				0.835		250000	
VOC	cis-1,2-Dichloroethene	15	1	7	ug/Kg		2.8	2.8	0.975		780000	
VOC	trans-1,2-Dichloroethene	15	0	0	ug/Kg				0.772		110000	
VOC	cis-1,3-Dichloropropene	15	0	0	ug/Kg				0.349		1700	
VOC	trans-1,3-Dichloropropene	15	0	0	ug/Kg				0.223		1700	
VOC	1,2-Dichloropropane	15	0	0	ug/Kg				0.321		930	
VOC	Ethylbenzene	15	3	20	ug/Kg		0.835	3.5	0.747		5700	
VOC	1,2-Dibromoethane (EDB)	15	0	0	ug/Kg				0.301		34	
VOC	Trichlorofluoromethane	15	0	0	ug/Kg				0.658		800000	
VOC	1,1,2-Trichloro-1,2,2-Trifluoroethane	15	0	0	ug/Kg				0.382		43000000	
VOC	2-Hexanone	15	0	0	ug/Kg				1.6			
VOC	Isopropylbenzene (Cumene)	15	0	0	ug/Kg				0.612		2200000	
VOC	Methyl Acetate	15	0	0	ug/Kg				1.11		78000000	
VOC	2-Butanone (Methyl ethyl ketone)	15	7	47	ug/Kg		2.7	53	7.38		28000000	
VOC	4-Methyl-2-pentanone (Methyl isobutyl ketone)	15	0	0	ug/Kg				0.402		5300000	
VOC	Methylene Chloride	15	0	0	ug/Kg				0.431		11000	
VOC	1,1,2,2-Tetrachloroethane	15	0	0	ug/Kg				0.301		590	
VOC	Tetrachloroethene (PCE)	15	0	0	ug/Kg				0.682		570	

Table 2-1 Summary Statistics and Identification of COPCs for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
Sediment (continued)												
VOC	Styrene	15	0	0	ug/Kg				0.244		6500000	
VOC	Bromoform	15	0	0	ug/Kg				0.693		61000	
VOC	Tert-Butyl Methyl Ether (MTBE)	15	0	0	ug/Kg				0.223		39000	
VOC	1,1,1-Trichloroethane	15	0	0	ug/Kg				0.627		9000000	
VOC	1,1,2-Trichloroethane	15	0	0	ug/Kg				0.244		1100	
VOC	1,2,3-Trichlorobenzene	15	0	0	ug/Kg				0.295			
VOC	Trichloroethene (TCE)	15	2	13	ug/Kg		2	4	0.88		2800	
VOC	Chloroform	15	0	0	ug/Kg				0.382		300	
VOC	Vinyl chloride	15	0	0	ug/Kg				0.772		60	
VOC	Xylenes, Total	15	3	20	ug/Kg		1.7	12	1.41		600000	

Table 3-1
Receptor/Exposure Scenarios
Acid Area 1
Plum Brook Ordnance Works, Sandusky, Ohio

Source Medium	Model	Exposure Medium	Exposure Pathway
	Groundskeeper		
Surface soil	None	Soil	Incidental ingestion Dermal contact
	Volatilization from soil	Ambient air	Inhalation
	Dust emissions based on activity	Ambient air	Inhalation
Total soil	Not quantified[a]		
Groundwater	Not quantified[a]		
Surface water	Not quantified[b]		
Sediment	Not quantified[b]		
	Indoor Worker		
Surface soil	None	Soil	Incidental ingestion Dermal contact
Subsurface soil	Volatilization from soil	Indoor air	Inhalation
Total soil	Not quantified[a]		
Groundwater	None	Groundwater	Ingestion Dermal contact
Surface water	Not quantified[a]		
Sediment	Not quantified[a]		
	Construction Worker		
Total soil	None	Soil	Incidental ingestion Dermal contact
	Volatilization from soil	Ambient air	Inhalation
	Dust emissions based on activity	Ambient air	Inhalation
Groundwater	Not quantified[b]		
Surface water	None	Surface water	Incidental ingestion Dermal contact
	Volatilization from water	Ambient air	Inhalation
Sediment	None	Sediment	Incidental ingestion Dermal contact
	On-Site Resident		
Total soil	None	Soil	Incidental ingestion Dermal contact
	Volatilization from soil	Ambient air	Inhalation
	Dust emissions based on wind erosion	Ambient air	Inhalation
Subsurface soil	Volatilization from soil	Indoor air	Inhalation

Table 3-1
Receptor/Exposure Scenarios
Acid Area 1
Plum Brook Ordnance Works, Sandusky, Ohio

Source Medium	Model	Exposure Medium	Exposure Pathway
Groundwater	None	Groundwater	Ingestion Dermal contact
	Volatilization from groundwater	Ambient air	Inhalation
Surface water	None	Surface water	Incidental Ingestion Dermal contact
	Volatilization from water	Ambient air	Inhalation
Sediment	None	Sediment	Incidental ingestion Dermal contact
	Hunter		
Surface soil	None	Soil	Incidental ingestion Dermal contact
	Dust, volatilization	Ambient air	Inhalation
	Bio uptake	Venison	Venison consumption
Groundwater	Not quantified[a]		

a There is no plausible pathway for exposure to this medium.

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

Table 3-2
Variables Used to Estimate Potential Chemical Intakes and Contact Rates for Receptors
Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Pathway Variable	Grounds -keeper	Construction Worker	On-Site Resident	Indoor Worker	Hunter
General Variables Used in All Intake Models					
Body weight (BW), kg	70[a]	70[a]	Child: 15[b] Adult: 70[a]	70[a]	Child: 15[b] Adult: 70[a]
Averaging time, noncancer (AT), day_{sd}	9125	183	Child: 2190 Adult: 8760	9125	Child: 2190 Adult: 10950
Averaging time, cancer (AT), day_{se}	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[a]	20[a]	Child: 10[b] Adult: 20[a]	NA	NA
Exposure frequency (EF), days/year	250[a]	250[a]	350[a]	NA	NA
Exposure duration (ED), years	25[a]	0.5[b]	Child: 6[b] Adult: 24[b]	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: 6.8[c] Adult: 13.7[c]	20[a]	NA
Exposure frequency (EF), days/year	NA	NA	350[a]	250[a]	NA
Exposure duration (ED), years	NA	NA	Child: 6[b] Adult: 24[b]	25[a]	NA
Incidental Ingestion of Soil					
Fraction exposed to contaminated medium(FI_{so}), unitless	1[c]	1[c]	0.9[c]	1[c]	1[c]
Soil incidental ingestion rate (IR_{so}), mg/day	100[a]	290[c]	Child: 200[b] Adult: 100[a]	50[a]	Child: NA Adult: 100[a]
Exposure frequency (EF), days/year	250[a]	250[a]	350[a]	250[a]	14[c]
Exposure duration (ED), years	25[a]	0.5[c]	Child: 6[b] Adult: 24[b]	25[a]	30[a]
Incidental Ingestion of Sediment					
Fraction exposed to contaminated medium(FI_{sd}), unitless	NA	1[c]	0.1[c]	NA	NA
Sediment incidental ingestion rate (IR_{sd}),mg/day	NA	290[c]	Child: 200[b] Adult: 100[a]	NA	NA
Exposure frequency (EF), days/year	NA	250[a]	350[a]	NA	NA
Exposure duration (ED), years	NA	0.5[c]	Child: 6[b] Adult: 24[b]	NA	NA

Table 3-2
Variables Used to Estimate Potential Chemical Intakes and Contact Rates for Receptors
Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Pathway Variable	Grounds -keeper	Construction Worker	On-Site Resident	Indoor Worker	Hunter
Dermal Contact with Soil					
Fraction exposed to contaminated medium (FI_{so}), unitless	1[c]	1[c]	0.9[c]	NA	1[c]
Body surface area exposed to soil (SA_{so}), cm^2	11,300[f]	11,300[f]	Child: 1750[g] Adult: 4550[g]	NA	Child: NA Adult: 4550[g]
Soil-to-skin adherence factor (AF_{so}),mg/cm^2	0.009[f]	0.08[f]	0.2[g]	NA	0.2[g]
Dermal absorption factor (ABS), unitless	csv	csv	csv	NA	csv
Exposure frequency (EF), days/year	250[a]	250[a]	350[a]	NA	14[c]
Exposure duration (ED), years	25a	0.5[c]	Child: 6[b] Adult: 24[b]	NA	30[a]
Dermal Contact with Sediment					
Fraction exposed to contaminated medium(FI_{sd}), unitless	NA	1[c]	0.1[c]	NA	NA
Body surface area exposed to sediment(SA_{sd}), cm^2	NA	3100[f]	Child: 1750[g] Adult: 4550[g]	NA	NA
Sediment-to-skin adherence factor (AF_{sd}),mg/cm^2	NA	0.24[f]	0.2[g]	NA	NA
Dermal absorption factor (ABS), unitless	NA	csv	csv	NA	NA
Exposure frequency (EF), days/year	NA	250[a]	350[a]	NA	NA
Exposure duration (ED), years	NA	0.5[c]	Child: 6[b] Adult: 24[b]	NA	NA
Dermal Contact with Surface Water					
Body surface area exposed to surface water (SA_{sw}), cm^2	NA	3100[f]	Child: 2100[g] Adult: 5450[g]	NA	NA
Permeability coefficient (PC), cm/hour	NA	csv	csv	NA	NA
Exposure time (ET_{sw}), hour/day	NA	4[c]	3[c]	NA	NA
Exposure frequency (EF), days/year	NA	250[a]	52[c]	NA	NA
Exposure duration (ED), years	NA	0.5[c]	Child: 6[b] Adult: 24[b]	NA	NA
Venison Consumption					
Venison ingestion rate (IR_v), kg/day	NA	NA	NA	NA	Child: 0.005[c] Adult: 0.013[c]
Exposure frequency (EF), days/year	NA	NA	NA	NA	350[a]
Exposure duration (ED), years	NA	NA	NA	NA	Child: 6[b] Adult: 30[a]

Table 3-2
Variables Used to Estimate Potential Chemical Intakes and Contact Rates for Receptors
Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

a 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.

b U.S. Environmental Protection Agency (EPA), 1999, *EPA Region 9: Preliminary Remediation Goals (PRGs) 1999*, 3 December, on-line.

c Assumed; see text.

d Calculated as the product of ED (years) x 365 days/year.

e Calculated as the product of 70 years (assumed human lifetime) x 365 days/year.

f U.S. Environmental Protection Agency (EPA), 1997b, *Exposure Factors Handbook*, Final, National Center for Environmental Assessment, Washington, DC, EPA/600/P-95/002Fa, August.

g U.S. Environmental Protection Agency (EPA), 1992b, *Dermal Exposure Assessment: Principles and Applications*, Interim Report, Office of Research and Development, Washington, DC, EPA/600/8-91/011B, including Supplemental Guidance dated August 18, 1992.

NA = not applicable to this receptor; csv = chemical-specific value.

Table 3-3
Variables Used to Estimate Potential Chemical Intake and Contact Rates from Groundwater
Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Pathway Variable	On-site Worker	Resident
General Variables		
Exposure duration (ED), years	25[a]	Child: 6[b] Adult: 24[b]
Body weight (BW), kg	70[a]	Child: 15[b] Adult: 70[a]
Averaging time, noncancer (AT), days[c]	9125	Child: 2190 Adult: 8760
Averaging time, cancer (AT), days[c]	25550	25550
Inhalation of VOCs from Groundwater		
Exposure time (ET), hours/day	NA	24[d]
Inhalation rate (IR_a), m^3/hour	NA	Child: 0.416[b] Adult: 0.833[b]
Exposure frequency (EF), days/year	250[a]	350[a]
Drinking Water Ingestion of Groundwater		
Fraction exposed to contaminated medium (FI_{gw}), unitless	1[f]	1[f]
Drinking water ingestion rate (IR_{gw}), L/day	1[a]	Child: 1[b] Adult: 2[a]
Exposure frequency (EF), days/year	250[a]	350[a]
Dermal Contact with Groundwater		
Fraction exposed to contaminated medium (FI_{gw}), unitless	1[e]	1[e]
Body surface area exposed to water (Sa_{gw}), cm^2	3300[g]	Child: 6600[f] Adult: 20000[f]
Permeability coefficient (PC), cm/hour	csv	csv
Exposure time (ET_{gw}), hours/day	1[f]	Child: 0.333[g] Adult: 0.2[d]
Exposure frequency (EF), days/year	250[a]	350[a]

cm - Centimeter.
cm^2 - Square centimeter.
csv - Chemical-specific value.
kg - Kilogram.
L - Liters.
m^3 - Cubic meters.
NA - Not applicable to this receptor.
VOC - Volatile organic compound.

[a] U.S. Environmental Protection Agency (EPA), 1991a, *Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual Supplemental Guidance, Standard Default Exposure Factors* , Interim Final, Office of Solid Waste and Emergency Response, OSWER Directive: 9285.603.

[b] U.S. Environmental Protection Agency (EPA), 2004c, *User's Guide and Background Technical Document for EPA Region 9 Preliminary Remediation Goals (PRG) Table* , Region 9, San Francisco, California, October.

[c] Calculated as the product of ED (years) x 365 days/year.

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

Table 3-3
Variables Used to Estimate Potential Chemical Intake
and Contact Rates from Groundwater
Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

[e] Assumed; see text.

[f] U.S. Environmental Protection Agency (EPA), 2004a, *Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual (Part E - Supplemental Guidance for Dermal Risk Assessment)* , Final, Office of Superfund Remediation and Technology Innovation, Washington, D.C., July, EPA/540/R-99/005.

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

References

Foster, S. A. and P. C. Chrostowski, 1987, "Inhalation Exposures to Volatile Organic Contaminants in the Shower," Presentation at the ***80th Annual Meeting of the Air Pollution Control Association***, June 21-28.

Ohio Environmental Protection Agency (OEPA), 2004, e-mail correspondence from L. Moore (OEPA Risk Assessor) to L. Long (USACE Risk Assessor), December 15.

U.S. Environmental Protection Agency (EPA), 2004a, ***Risk-Based Concentration Table***, memorandum from Jennifer Hubbard (Region 3 Toxicologist) to RBC Table users, Philadelphia, Pennsylvania, April, <http://www.epa.gov/reg3hwmd/risk/human/index.htm>.

U.S. Environmental Protection Agency (EPA), 2004b, ***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.pdg>.

U.S. Environmental Protection Agency (EPA), 1995, ***Supplemental Guidance to RAGS: Region 4 Bulletins Human Health Risk Assessment***, Waste Management Division, Atlanta, Georgia, November.

U.S. Environmental Protection Agency (EPA), 1991b, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals), Interim***, Office of Emergency and Remedial Response, Washington, D.C., December (EPA/540/R-92/003).

Table 4-1 Toxicity Values for Human Health Risk Assessment at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Analyte	(mg/kg/day)			(mg/kg/day)-1			Dermal Absorption Factor
	Oral	Dermal	Inhalation	Oral	Dermal	Inhalation	
RDX	3.00E-03	3.00E-03	3.00E-03	1.10E-01	1.10E-01	1.10E-01	--
Arsenic	3.00E-04	3.00E-04	--	1.50E+00	1.50E+00	1.51E+01	3.00E-02
Cobalt	2.00E-02	2.00E-02	5.71E-06	--	--	9.80E+00	--
Cyanide	2.00E-02	2.00E-02	--	--	--	--	--
Iron	7.00E-01	7.00E-01	--	--	--	--	--
Lead	--	--	--	--	--	--	--
Manganese	4.67E-02	4.67E-02	1.40E-05	--	--	--	--
Thallium	7.00E-05	7.00E-05	--	--	--	--	--
PCB-1254	2.00E-05	2.00E-05	2.00E-05	2.00E+00	2.00E+00	2.00E+00	1.40E-01
PCB-1260	--	--	--	2.00E+00	2.00E+00	2.00E+00	1.40E-01
Benz[a]anthracene	--	--	--	7.30E-01	7.30E-01	3.10E-01	1.30E-01
Benzo[b]fluoranthene	--	--	--	7.30E-01	7.30E-01	3.10E-01	1.30E-01
Benzo[a]pyrene	--	--	--	7.30E+00	7.30E+00	3.10E+00	1.30E-01
Dibenz[ah]anthracene	--	--	--	7.30E+00	7.30E+00	3.10E+00	1.30E-01
Indeno[1,2,3-cd]pyrene	--	--	--	7.30E-01	7.30E-01	3.10E-01	1.30E-01
Naphthalene	2.00E-02	2.00E-02	8.57E-04	--	--	--	1.00E-01
Bis(2-ethylhexyl)phthalate	2.00E-02	2.00E-02	2.00E-02	1.40E-02	1.40E-02	1.40E-02	--
N-Nitroso di-n-propylamine	--	--	--	7.00E+00	7.00E+00	7.00E+00	--
2-Nitrotoluene	1.00E-02	1.00E-02	--	2.30E-01	2.30E-01	--	--
2-Methylnaphthalene	2.00E-02	2.00E-02	8.57E-04	--	--	--	1.00E-01
2,4,6-Trinitrotoluene	5.00E-04	5.00E-04	5.00E-04	3.00E-02	3.00E-02	3.00E-02	--
Benzene	4.00E-03	4.00E-03	8.57E-03	5.50E-02	5.50E-02	2.70E-02	--
Carbon tetrachloride	7.00E-04	7.00E-04	5.71E-04	1.30E-01	1.30E-01	5.25E-02	--
1,1-Dichloroethane	2.00E-01	2.00E-01	2.00E-01	--	--	--	1.00E-01
Ethylbenzene	1.00E-01	1.00E-01	2.90E-01	--	--	--	1.00E-01
Methylene chloride	6.00E-02	6.00E-02	8.57E-01	7.50E-03	7.50E-03	1.65E-03	1.00E-01
Tetrachloroethene (PCE)	1.00E-02	1.00E-02	1.14E-01	5.40E-01	5.40E-01	2.07E-02	--
Trichloroethene (TCE)	3.00E-04	3.00E-04	1.14E-02	4.00E-01	4.00E-01	4.00E-01	1.00E-01
Xylenes, total	2.00E-01	2.00E-01	2.86E-02	--	--	--	--

Table 5-1 Summary of Human Health Hazard Quotient and Excess Cancer Risk Estimates at Acid Area 1, Plum Brook rdnance Works, Sandusky, Ohio

Adult Residential Risks From Exposure to Groundwater		
Exposure Route	**Hazard Quotient**	**Excess Cancer Risk**
Ingestion	5.E+00	2.E-04
Dermal Contact	4.E-01	1.E-05
Inhalation	5.E-01	6.E-06
Total	6.E+00	2.E-04

Adult Residential Risks From Exposure to Surface Soil		
Exposure Route	**Hazard Quotient**	**Excess Cancer Risk**
Ingestion	2.E-01	1.E-05
Dermal Contact	2.E-01	1.E-05
Inhalation	9.E-05	4.E-09
Total	4.E-01	3.E-05

Adult Residential Risks From Exposure to Subsurface Soil		
Exposure Route	**Hazard Quotient**	**Excess Cancer Risk**
Ingestion	2.E-01	4.E-07
Dermal Contact	7.E-02	1.E-07
Inhalation	6.E-10	1.E-14
Total	3.E-01	5.E-07

Adult Recreational Risks From Exposure to Surface Water		
Exposure Route	**Hazard Quotient**	**Excess Cancer Risk**
Ingestion	NA	NA
Dermal Contact	1.E-02	5.E-07
Inhalation	NA	NA
Total	1.E-02	5.E-07

Adult Recreational Risks From Exposure to Sediment		
Exposure Route	**Hazard Quotient**	**Excess Cancer Risk**
Ingestion	8.E-03	1.E-06
Dermal Contact	5.E-03	4.E-07
Inhalation	NA	NA
Total	1.E-02	2.E-06

Table 5-1 Summary of Human Health Hazard Quotient and Excess Cancer Risk Estimates at Acid Area 1, Plum Brook rdnance Works, Sandusky, Ohio

Child Residential Risks From Exposure to Groundwater		
Exposure Route	**Hazard Quotient**	**Excess Cancer Risk**
Ingestion	1.E+01	1.E-04
Dermal Contact	7.E-01	6.E-06
Inhalation	1.E+00	4.E-06
Total	1.E+01	1.E-04

Child Residential Risks From Exposure to Surface Soil		
Exposure Route	**Hazard Quotient**	**Excess Cancer Risk**
Ingestion	2.E+00	3.E-05
Dermal Contact	4.E-01	5.E-06
Inhalation	2.E-04	2.E-09
Total	2.E+00	4.E-05

Child Residential Risks From Exposure to Subsurface Soil		
Exposure Route	**Hazard Quotient**	**Excess Cancer Risk**
Ingestion	1.E+00	2.E-05
Dermal Contact	2.E-01	3.E-06
Inhalation	3.E+00	2.E-03
Total	4.E+00	2.E-03

Child Recreational Risks From Exposure to Surface Water		
Exposure Route	**Hazard Quotient**	**Excess Cancer Risk**
Ingestion	NA	NA
Dermal Contact	2.E-02	2.E-07
Inhalation	NA	NA
Total	2.E-02	2.E-07

Child Recreational Risks From Exposure to Sediment		
Exposure Route	**Hazard Quotient**	**Excess Cancer Risk**
Ingestion	7.E-02	3.E-06
Dermal Contact	1.E-02	2.E-07
Inhalation	NA	NA
Total	8.E-02	3.E-06

Table 5-1 Summary of Human Health Hazard Quotient and Excess Cancer Risk Estimates at Acid Area 1, Plum Brook rdnance Works, Sandusky, Ohio

Indoor Worker Risks From Exposure to Groundwater		
Exposure Route	**Hazard Quotient**	**Excess Cancer Risk**
Ingestion	2.E+00	8.E-05
Dermal Contact	6.E-02	3.E-06
Inhalation	NA	NA
Total	2.E+00	9.E-05

Indoor Worker Risks From Exposure to Surface Soil		
Exposure Route	**Hazard Quotient**	**Excess Cancer Risk**
Ingestion	7.E-02	6.E-06
Dermal Contact	NA	NA
Inhalation	NA	NA
Total	7.E-02	6.E-06

Adult Hunter Risks From Exposure to Surface Soil		
Exposure Route	**Hazard Quotient**	**Excess Cancer Risk**
Ingestion	8.E-03	7.E-07
Dermal Contact	9.E-03	7.E-07
Inhalation	NA	NA
Total	0.E+00	0.E+00

Adult Hunter Risks From Ingestion of Venison		
Exposure Route	**Hazard Quotient**	**Excess Cancer Risk**
Ingestion	8.E-05	2.E-09
Dermal Contact	NA	NA
Inhalation	NA	NA
Total	8.E-05	2.E-09

Child Risks From Ingestion of Venison		
Exposure Route	**Hazard Quotient**	**Excess Cancer Risk**
Ingestion	1.E-04	7.E-10
Dermal Contact	NA	NA
Inhalation	NA	NA
Total	1.E-04	7.E-10

Table 5-1 Summary of Human Health Hazard Quotient and Excess Cancer Risk Estimates at Acid Area 1, Plum Brook rdnance Works, Sandusky, Ohio

Groundskeeper Risks From Exposure to Surface Soil		
Exposure Route	**Hazard Quotient**	**Excess Cancer Risk**
Ingestion	1.E-01	1.E-05
Dermal Contact	2.E-02	1.E-06
Inhalation	7.E-05	4.E-09
Total	2.E-01	1.E-05

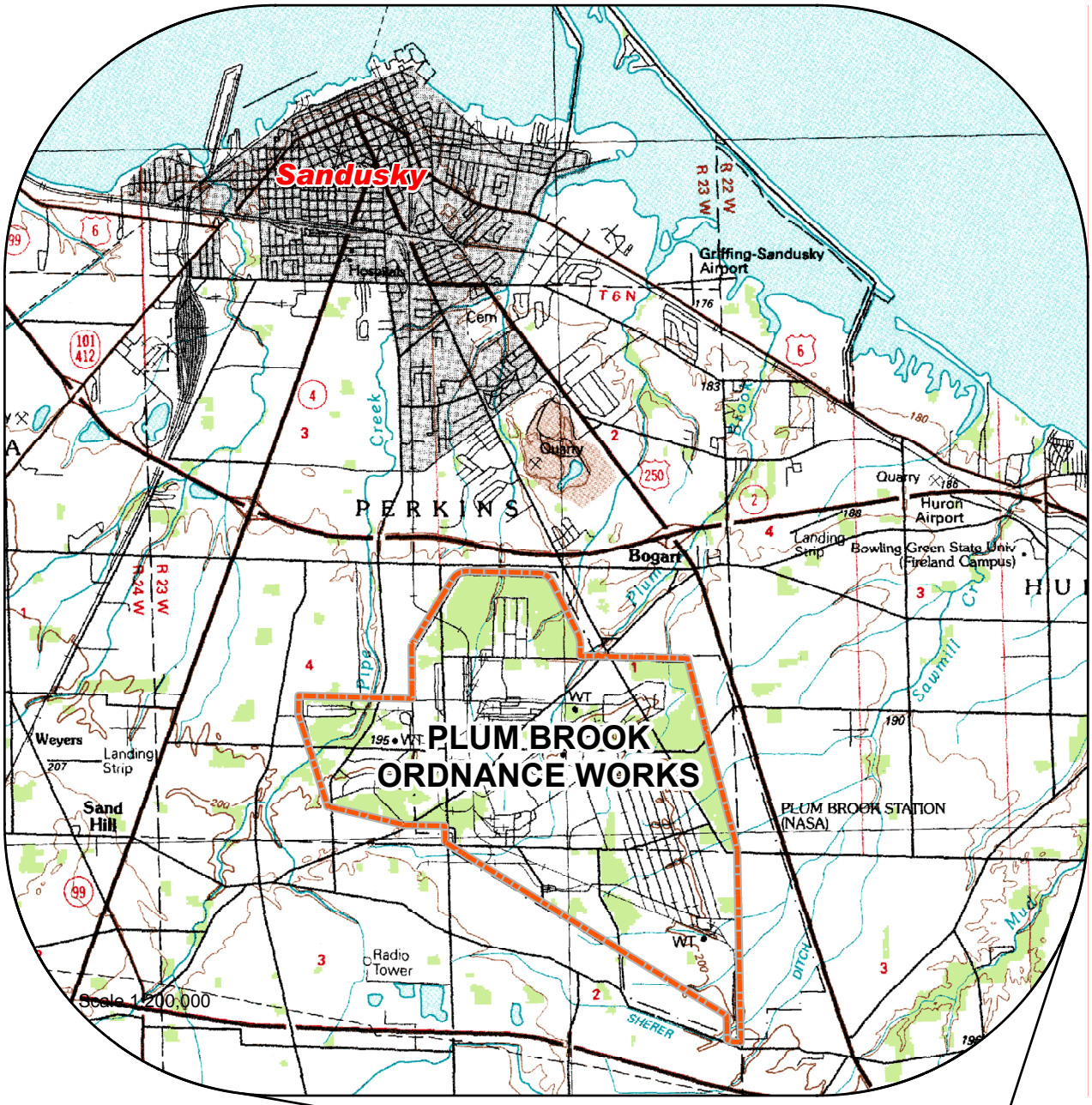
Construction Worker Risks From Exposure to Surface Soil		
Exposure Route	**Hazard Quotient**	**Excess Cancer Risk**
Ingestion	4.E-01	6.E-07
Dermal Contact	1.E-01	2.E-07
Inhalation	7.E-05	7.E-11
Total	5.E-01	8.E-07

Construction Worker Risks From Exposure to Subsurface Soil		
Exposure Route	**Hazard Quotient**	**Excess Cancer Risk**
Ingestion	2.E-01	4.E-07
Dermal Contact	7.E-02	1.E-07
Inhalation	6.E-10	1.E-14
Total	3.E-01	5.E-07

Construction Worker Risks From Exposure to Surface Water		
Exposure Route	**Hazard Quotient**	**Excess Cancer Risk**
Ingestion	NA	NA
Dermal Contact	3.E-02	3.E-08
Inhalation	NA	NA
Total	3.E-02	3.E-08

Construction Worker Risks From Exposure to Sediment		
Exposure Route	**Hazard Quotient**	**Excess Cancer Risk**
Ingestion	8.E-02	2.E-07
Dermal Contact	2.E-02	3.E-08
Inhalation	NA	NA
Total	9.E-02	2.E-07

FIGURES



Legend

Plum Brook Ordnance Works Boundary

N

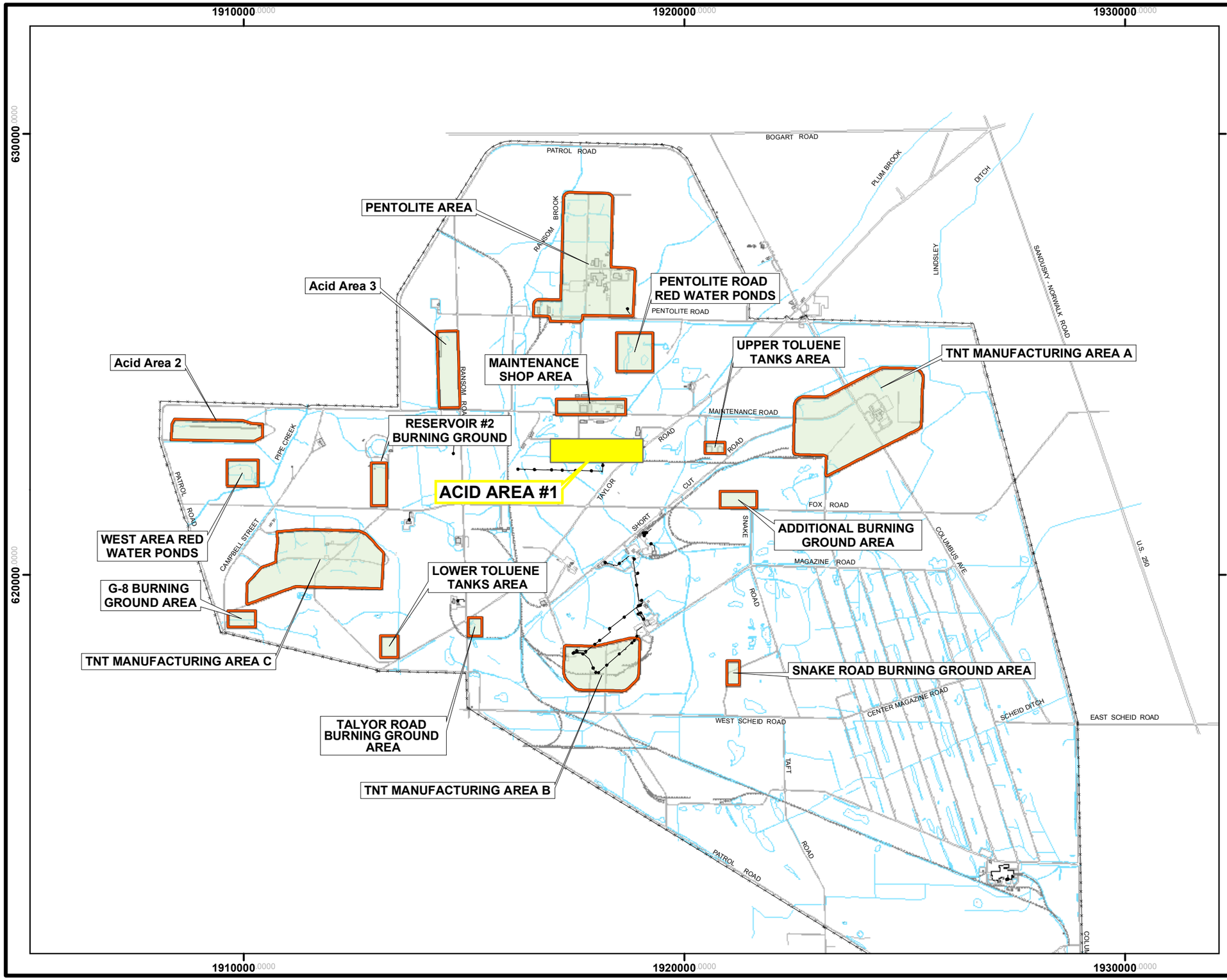
JACOBS™

Location Map,
Plum Brook Ordnance Works
Sandusky, Ohio

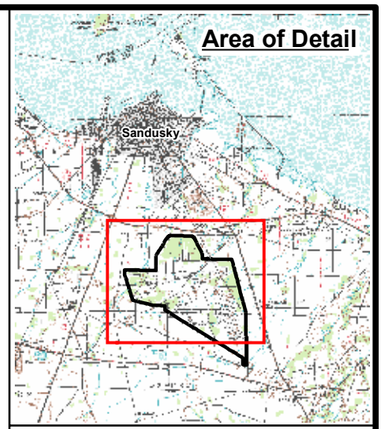
Plumbrook Ordnance Works
Sandusky, Ohio

11/20/08 JP X:/GIS/Projects/Plumbrook/Projects/AA1_Draft_RI/ArcGIS/PBOW_Site_Location_AA1.mxd

Figure 1-1



Area of Detail



Legend

Area of Concern

Creek, Ditch, Conveyance

Sources

Data mapped to Ohio State Plane North NAD83, map grid units in feet.

N
W
E
S

0 2,000 4,000 Feet

JACOBS™

Location Map
Acid Area 1

Plum Brook Ordnance Works
Sandusky, Ohio

11/20/08 JP X:/GIS/Projects/Plumbrook/Projects/AA1_Draft_RI/ArcGIS/Acid_Area1_LocMap.mxd

Figure 1-2

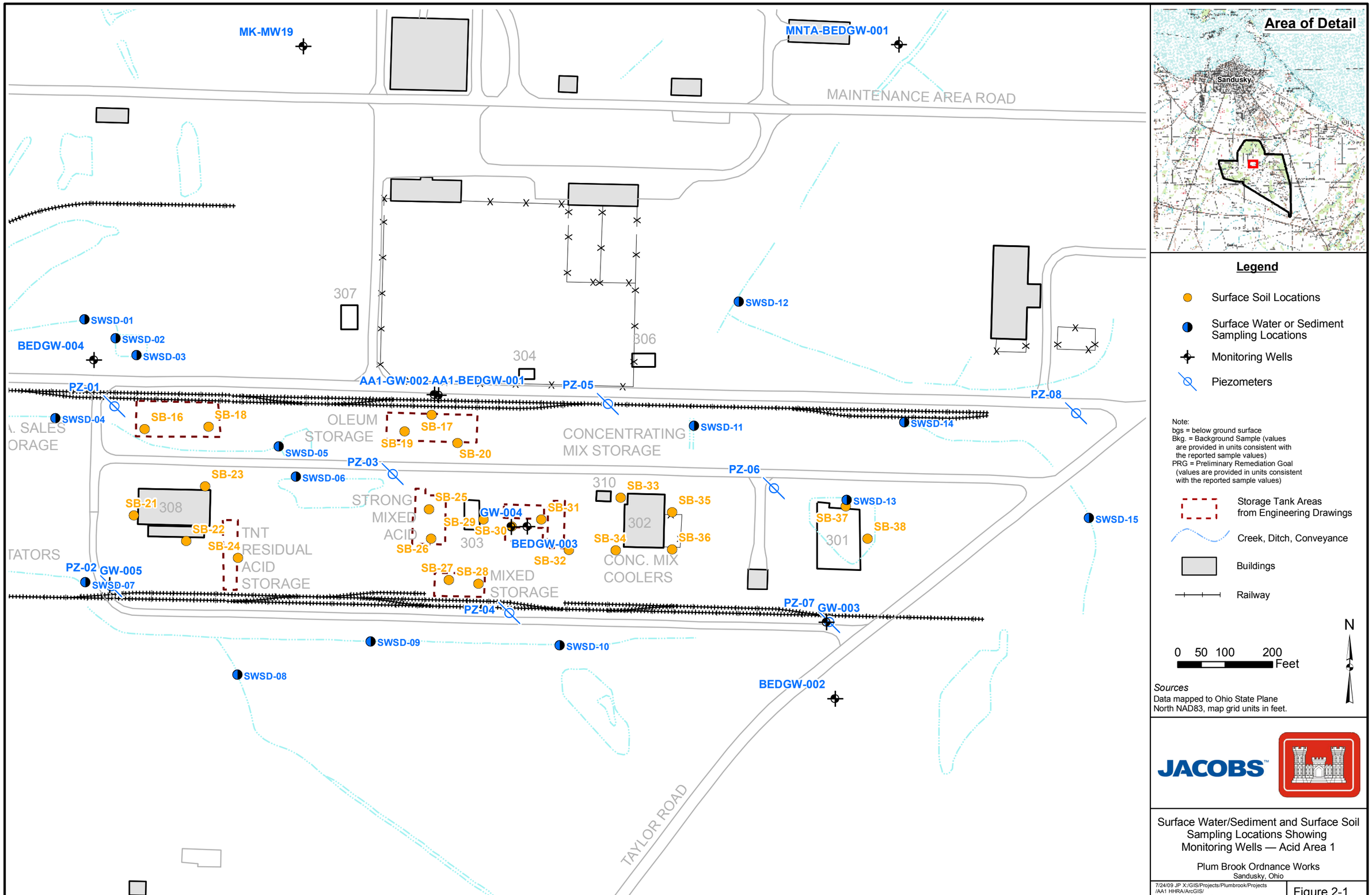
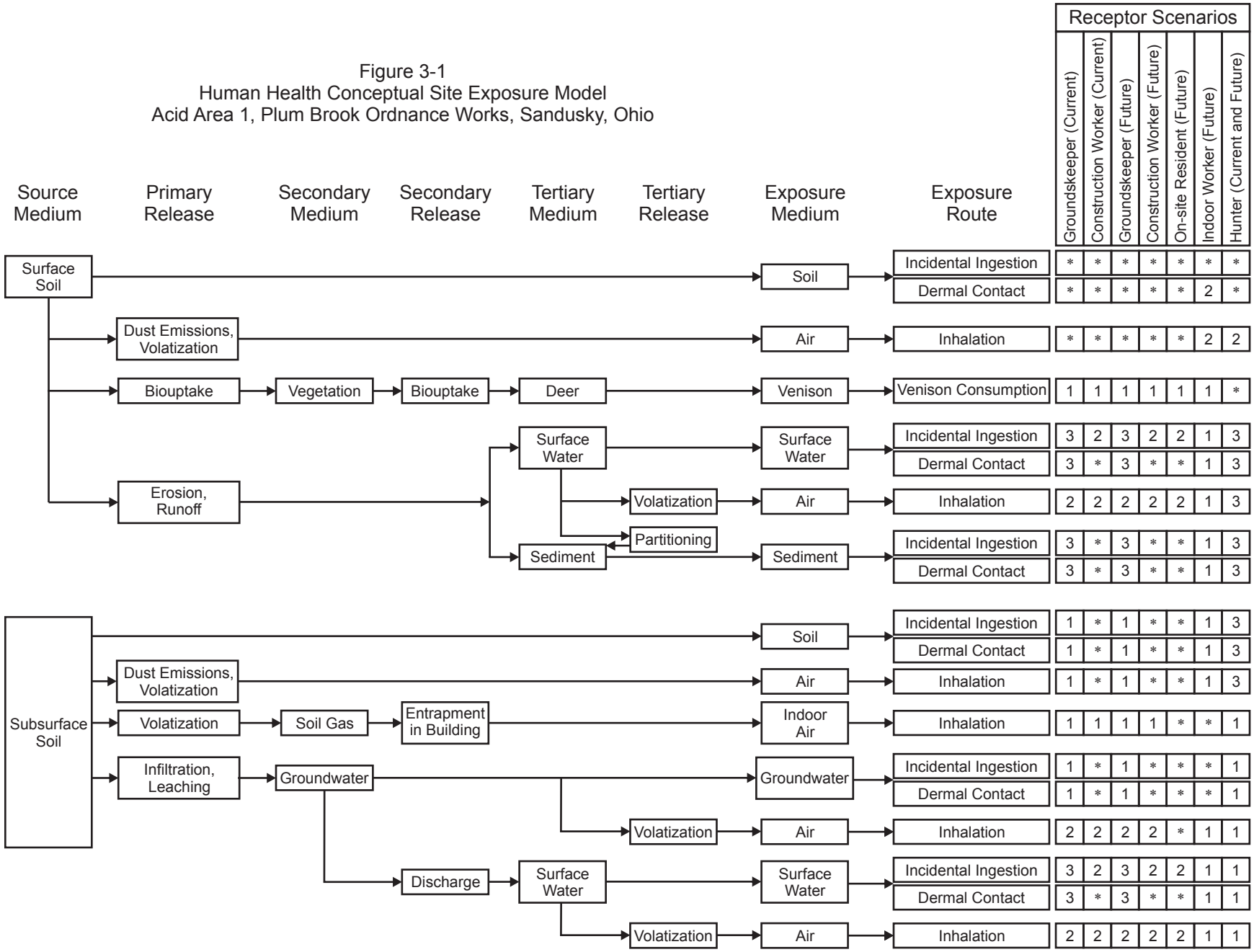
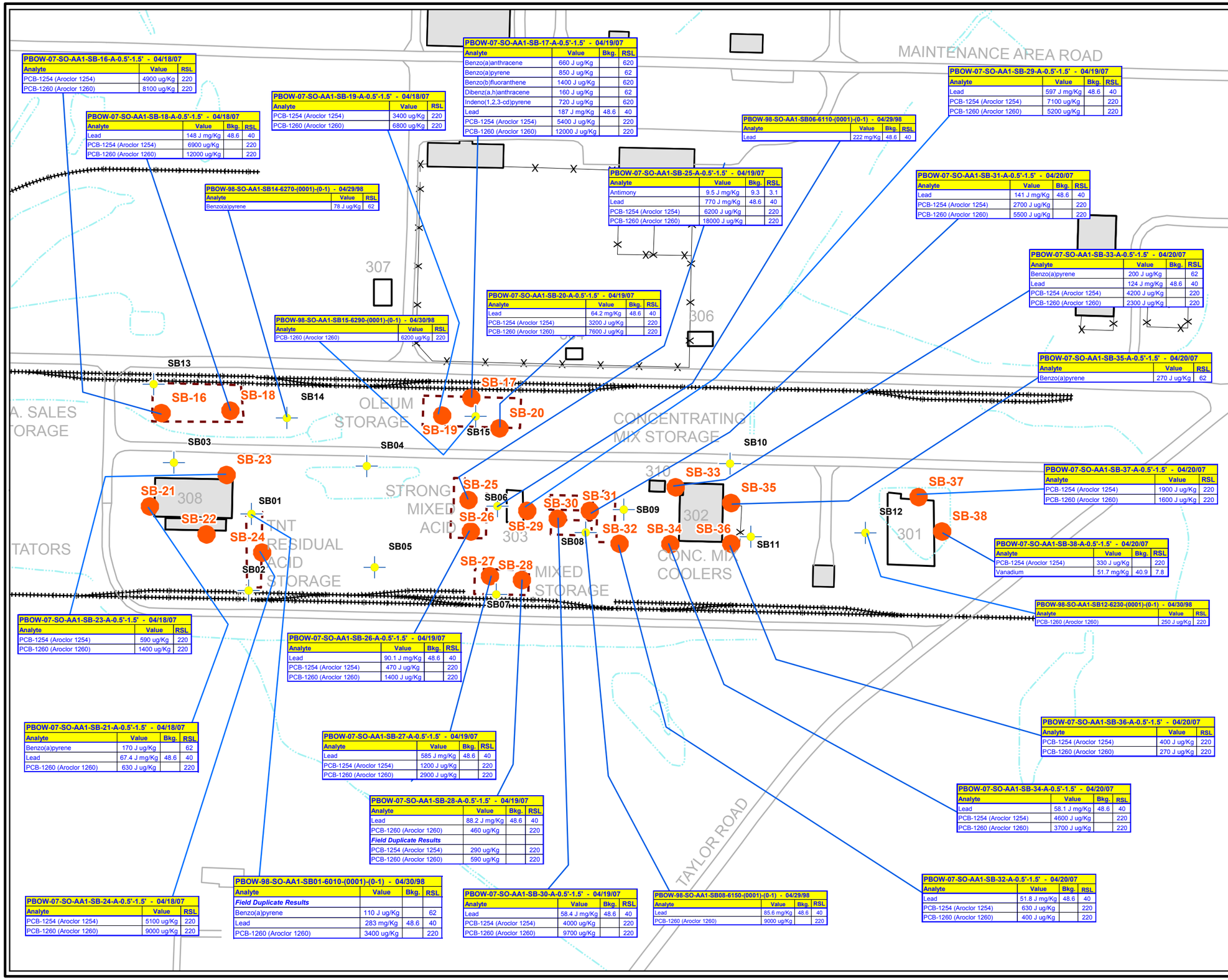

MK-MW19
MNTA-BEDGW-001
MAINTENANCE AREA ROAD
307
306
304
SWSD-12
SWSD-01
SWSD-02
SWSD-03
BEDGW-004
PZ-01
AA1-GW-002
AA1-BEDGW-001
PZ-05
PZ-08
SWSD-04
SB-16
SB-18
OLEUM
STORAGE
SB-17
SB-19
SB-20
CONCENTRATING
MIX STORAGE
SWSD-11
SWSD-14
SWSD-05
PZ-03
PZ-06
SB-23
SWSD-06
SB-21
308
SB-22
SB-24
TNT
RESIDUAL
ACID
STORAGE
STRONG
MIXED
ACID
SB-25
SB-26
SB-29
SB-30
GW-004
SB-31
303
BEDGW-003
SB-32
310
SB-33
SB-35
302
SB-34
SB-36
CONC. MIX
COOLERS
SWSD-13
SB-37
SB-38
301
SWSD-15
PZ-02
GW-005
SWSD-07
SB-27
SB-28
MIXED
STORAGE
PZ-04
PZ-07
GW-003
SWSD-09
SWSD-10
SWSD-08
BEDGW-002
TAYLOR ROAD
Area of Detail
Sandusky
Legend
Surface Soil Locations
Surface Water or Sediment Sampling Locations
Monitoring Wells
Piezometers
Note:
bgs = below ground surface
Bkg. = Background Sample (values are provided in units consistent with the reported sample values)
PRG = Preliminary Remediation Goal (values are provided in units consistent with the reported sample values)
Storage Tank Areas from Engineering Drawings
Creek, Ditch, Conveyance
Buildings
Railway
N
0 50 100 200
Feet
Sources
Data mapped to Ohio State Plane North NAD83, map grid units in feet.
JACOBS
Surface Water/Sediment and Surface Soil Sampling Locations Showing Monitoring Wells — Acid Area 1
Plum Brook Ordnance Works
Sandusky, Ohio
7/24/09 JP X:/GIS/Projects/Plumbrook/Projects /AA1 HHRA/ArcGIS/ AA1_HH_sediment_surface_soil_gw.mxd
Figure 2-1

Figure 3-1
Human Health Conceptual Site Exposure Model
Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio



Source Medium	Primary Release	Secondary Medium	Secondary Release	Tertiary Medium	Tertiary Release	Exposure Medium	Exposure Route	Groundskeeper (Current)	Construction Worker (Current)	Groundskeeper (Future)	Construction Worker (Future)	On-site Resident (Future)	Indoor Worker (Future)	Hunter (Current and Future)
Surface Soil						Soil	Incidental Ingestion	*	*	*	*	*	*	*
							Dermal Contact	*	*	*	*	*	2	*
	Dust Emissions, Volatization					Air	Inhalation	*	*	*	*	*	2	2
	Biouptake	Vegetation	Biouptake	Deer		Venison	Venison Consumption	1	1	1	1	1	1	*
	Erosion, Runoff			Surface Water		Surface Water	Incidental Ingestion	3	2	3	2	2	1	3
							Dermal Contact	3	*	3	*	*	1	3
					Volatization	Air	Inhalation	2	2	2	2	2	1	3
					Partitioning	Sediment	Incidental Ingestion	3	*	3	*	*	1	3
							Dermal Contact	3	*	3	*	*	1	3
Subsurface Soil						Soil	Incidental Ingestion	1	*	1	*	*	1	3
							Dermal Contact	1	*	1	*	*	1	3
	Dust Emissions, Volatization					Air	Inhalation	1	*	1	*	*	1	3
	Volatization	Soil Gas	Entrapment in Building			Indoor Air	Inhalation	1	1	1	1	*	*	1
	Infiltration, Leaching	Groundwater				Groundwater	Incidental Ingestion	1	*	1	*	*	*	1
							Dermal Contact	1	*	1	*	*	*	1
					Volatization	Air	Inhalation	2	2	2	2	*	1	1
			Discharge	Surface Water		Surface Water	Incidental Ingestion	3	2	3	2	2	1	1
							Dermal Contact	3	*	3	*	*	1	1
					Volatization	Air	Inhalation	2	2	2	2	2	1	1

* = Complete exposure route quantified in the risk assessment.
1 = There is no plausible pathway for exposure in this medium.
2 = Although theoretically complete, this pathway in 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.



PBOW-07-SO-AA1-SB-16-A-0.5'-1.5' - 04/18/07

Analyte	Value	RSL
PCB-1254 (Aroclor 1254)	4900 ug/Kg	220
PCB-1260 (Aroclor 1260)	8100 ug/Kg	220

PBOW-07-SO-AA1-SB-18-A-0.5'-1.5' - 04/18/07

Analyte	Value	Bkg.	RSL
Lead	148 J mg/Kg	48.6	40
PCB-1254 (Aroclor 1254)	6900 ug/Kg		220
PCB-1260 (Aroclor 1260)	12000 ug/Kg		220

PBOW-07-SO-AA1-SB-19-A-0.5'-1.5' - 04/18/07

Analyte	Value	RSL
PCB-1254 (Aroclor 1254)	3400 ug/Kg	220
PCB-1260 (Aroclor 1260)	6800 ug/Kg	220

PBOW-98-SO-AA1-SB14-6270-(0001)-(0-1) - 04/29/98

Analyte	Value	RSL
Benzo(a)pyrene	78 J ug/Kg	62

PBOW-98-SO-AA1-SB15-6290-(0001)-(0-1) - 04/30/98

Analyte	Value	RSL
PCB-1260 (Aroclor 1260)	6200 ug/Kg	220

PBOW-07-SO-AA1-SB-17-A-0.5'-1.5' - 04/19/07

Analyte	Value	Bkg.	RSL
Benzo(a)anthracene	660 J ug/Kg		620
Benzo(a)pyrene	850 J ug/Kg		62
Benzo(b)fluoranthene	1400 J ug/Kg		620
Dibenz(a,h)anthracene	160 J ug/Kg		62
Indeno(1,2,3-cd)pyrene	720 J ug/Kg		620
Lead	187 J mg/Kg	48.6	40
PCB-1254 (Aroclor 1254)	5400 J ug/Kg		220
PCB-1260 (Aroclor 1260)	12000 J ug/Kg		220

PBOW-07-SO-AA1-SB-20-A-0.5'-1.5' - 04/19/07

Analyte	Value	Bkg.	RSL
Lead	64.2 mg/Kg	48.6	40
PCB-1254 (Aroclor 1254)	3200 J ug/Kg		220
PCB-1260 (Aroclor 1260)	7600 J ug/Kg		220

PBOW-07-SO-AA1-SB-25-A-0.5'-1.5' - 04/19/07

Analyte	Value	Bkg.	RSL
Antimony	9.5 J mg/Kg	9.3	3.1
Lead	770 J mg/Kg	48.6	40
PCB-1254 (Aroclor 1254)	6200 J ug/Kg		220
PCB-1260 (Aroclor 1260)	18000 J ug/Kg		220

PBOW-98-SO-AA1-SB06-6110-(0001)-(0-1) - 04/29/98

Analyte	Value	Bkg.	RSL
Lead	222 mg/Kg	48.6	40

PBOW-07-SO-AA1-SB-29-A-0.5'-1.5' - 04/19/07

Analyte	Value	Bkg.	RSL
Lead	597 J mg/Kg	48.6	40
PCB-1254 (Aroclor 1254)	7100 ug/Kg		220
PCB-1260 (Aroclor 1260)	5200 ug/Kg		220

PBOW-07-SO-AA1-SB-31-A-0.5'-1.5' - 04/20/07

Analyte	Value	Bkg.	RSL
Lead	141 J mg/Kg	48.6	40
PCB-1254 (Aroclor 1254)	2700 J ug/Kg		220
PCB-1260 (Aroclor 1260)	5500 J ug/Kg		220

PBOW-07-SO-AA1-SB-33-A-0.5'-1.5' - 04/20/07

Analyte	Value	Bkg.	RSL
Benzo(a)pyrene	200 J ug/Kg		62
Lead	124 J mg/Kg	48.6	40
PCB-1254 (Aroclor 1254)	4200 J ug/Kg		220
PCB-1260 (Aroclor 1260)	2300 J ug/Kg		220

PBOW-07-SO-AA1-SB-35-A-0.5'-1.5' - 04/20/07

Analyte	Value	RSL
Benzo(a)pyrene	270 J ug/Kg	62

PBOW-07-SO-AA1-SB-37-A-0.5'-1.5' - 04/20/07

Analyte	Value	RSL
PCB-1254 (Aroclor 1254)	1900 J ug/Kg	220
PCB-1260 (Aroclor 1260)	1600 J ug/Kg	220

PBOW-07-SO-AA1-SB-38-A-0.5'-1.5' - 04/20/07

Analyte	Value	Bkg.	RSL
PCB-1254 (Aroclor 1254)	330 J ug/Kg		220
Vanadium	51.7 mg/Kg	40.9	7.8

PBOW-98-SO-AA1-SB12-6230-(0001)-(0-1) - 04/30/98

Analyte	Value	RSL
PCB-1260 (Aroclor 1260)	250 J ug/Kg	220

PBOW-07-SO-AA1-SB-23-A-0.5'-1.5' - 04/18/07

Analyte	Value	RSL
PCB-1254 (Aroclor 1254)	590 ug/Kg	220
PCB-1260 (Aroclor 1260)	1400 ug/Kg	220

PBOW-07-SO-AA1-SB-26-A-0.5'-1.5' - 04/19/07

Analyte	Value	Bkg.	RSL
Lead	90.1 J mg/Kg	48.6	40
PCB-1254 (Aroclor 1254)	470 J ug/Kg		220
PCB-1260 (Aroclor 1260)	1400 J ug/Kg		220

PBOW-07-SO-AA1-SB-21-A-0.5'-1.5' - 04/18/07

Analyte	Value	Bkg.	RSL
Benzo(a)pyrene	170 J ug/Kg		62
Lead	67.4 J mg/Kg	48.6	40
PCB-1260 (Aroclor 1260)	630 J ug/Kg		220

PBOW-07-SO-AA1-SB-27-A-0.5'-1.5' - 04/19/07

Analyte	Value	Bkg.	RSL
Lead	585 J mg/Kg	48.6	40
PCB-1254 (Aroclor 1254)	1200 J ug/Kg		220
PCB-1260 (Aroclor 1260)	2900 J ug/Kg		220

PBOW-07-SO-AA1-SB-36-A-0.5'-1.5' - 04/20/07

Analyte	Value	RSL
PCB-1254 (Aroclor 1254)	400 J ug/Kg	220
PCB-1260 (Aroclor 1260)	270 J ug/Kg	220

PBOW-07-SO-AA1-SB-28-A-0.5'-1.5' - 04/19/07

Analyte	Value	Bkg.	RSL
Lead	88.2 J mg/Kg	48.6	40
PCB-1260 (Aroclor 1260)	460 ug/Kg		220
Field Duplicate Results			
PCB-1254 (Aroclor 1254)	290 ug/Kg		220
PCB-1260 (Aroclor 1260)	590 ug/Kg		220

PBOW-07-SO-AA1-SB-34-A-0.5'-1.5' - 04/20/07

Analyte	Value	Bkg.	RSL
Lead	58.1 J mg/Kg	48.6	40
PCB-1254 (Aroclor 1254)	4600 J ug/Kg		220
PCB-1260 (Aroclor 1260)	3700 J ug/Kg		220

PBOW-07-SO-AA1-SB-24-A-0.5'-1.5' - 04/18/07

Analyte	Value	RSL
PCB-1254 (Aroclor 1254)	5100 ug/Kg	220
PCB-1260 (Aroclor 1260)	9000 ug/Kg	220

PBOW-98-SO-AA1-SB01-6010-(0001)-(0-1) - 04/30/98

Analyte	Value	Bkg.	RSL
Field Duplicate Results			
Benzo(a)pyrene	110 J ug/Kg		62
Lead	283 mg/Kg	48.6	40
PCB-1260 (Aroclor 1260)	3400 ug/Kg		220

PBOW-07-SO-AA1-SB-30-A-0.5'-1.5' - 04/19/07

Analyte	Value	Bkg.	RSL
Lead	58.4 J mg/Kg	48.6	40
PCB-1254 (Aroclor 1254)	4000 ug/Kg		220
PCB-1260 (Aroclor 1260)	9700 ug/Kg		220

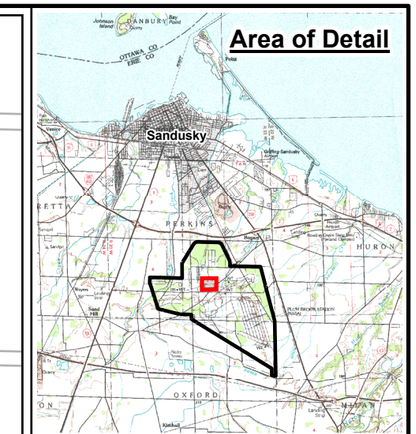
PBOW-98-SO-AA1-SB08-6150-(0001)-(0-1) - 04/29/98

Analyte	Value	Bkg.	RSL
Lead	85.6 mg/Kg	48.6	40
PCB-1260 (Aroclor 1260)	9000 ug/Kg		220

PBOW-07-SO-AA1-SB-32-A-0.5'-1.5' - 04/20/07

Analyte	Value	Bkg.	RSL
Lead	51.8 J mg/Kg	48.6	40
PCB-1254 (Aroclor 1254)	630 J ug/Kg		220
PCB-1260 (Aroclor 1260)	400 J ug/Kg		220

Area of Detail



Legend

1998 SI Soil Borings

Soil Boring

Note:
bgs = below ground surface
Bkg. = Background Sample (values are provided in units consistent with the reported sample values)
RSL = Regional Screening Level (values are provided in units consistent with the reported sample values)

Storage Tank Areas from Engineering Drawings

Creek, Ditch, Conveyance

Buildings

Railway

0 50 100 200 Feet

N

Sources
Data mapped to Ohio State Plane North NAD83, map grid units in feet.

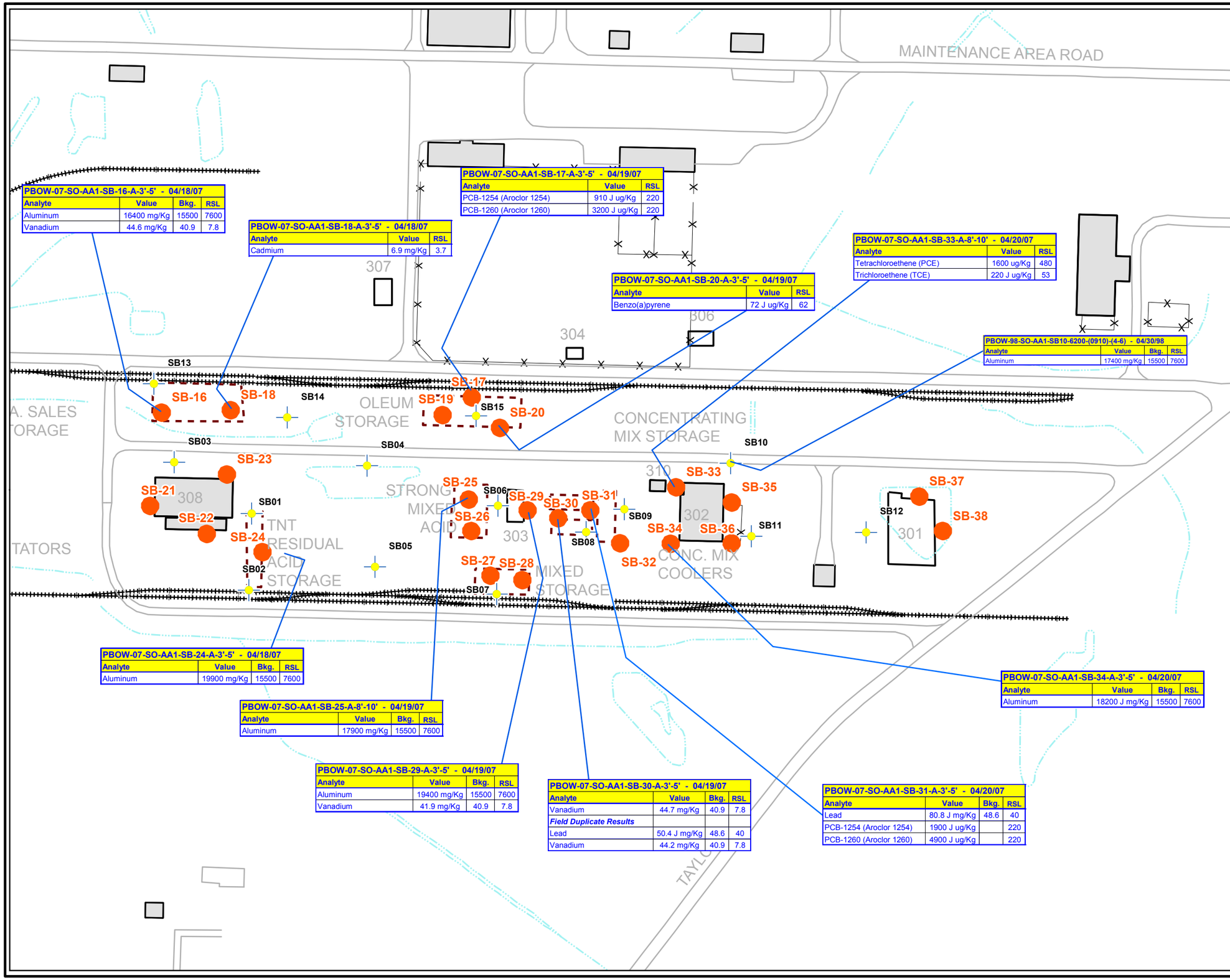
JACOBS™

Distribution of Contaminants Exceeding RSL's in Surface Soil — Acid Area 1

Plum Brook Ordnance Works
Sandusky, Ohio

7/24/09 JP X:/GIS/Projects/Plumbrook/Projects /AA1 HHRA/ArcGIS/AA1_HH_Surface_Soil.mxd

Figure 5-1



PBOW-07-SO-AA1-SB-16-A-3'-5' - 04/18/07

Analyte	Value	Bkg.	RSL
Aluminum	16400 mg/Kg	15500	7600
Vanadium	44.6 mg/Kg	40.9	7.8

PBOW-07-SO-AA1-SB-18-A-3'-5' - 04/18/07

Analyte	Value	RSL
Cadmium	6.9 mg/Kg	3.7

PBOW-07-SO-AA1-SB-17-A-3'-5' - 04/19/07

Analyte	Value	RSL
PCB-1254 (Aroclor 1254)	910 J ug/Kg	220
PCB-1260 (Aroclor 1260)	3200 J ug/Kg	220

PBOW-07-SO-AA1-SB-20-A-3'-5' - 04/19/07

Analyte	Value	RSL
Benzo(a)pyrene	72 J ug/Kg	62

PBOW-07-SO-AA1-SB-33-A-8'-10' - 04/20/07

Analyte	Value	RSL
Tetrachloroethene (PCE)	1600 ug/Kg	480
Trichloroethene (TCE)	220 J ug/Kg	53

PBOW-98-SO-AA1-SB10-6200-(0910)-(4-6) - 04/30/98

Analyte	Value	Bkg.	RSL
Aluminum	17400 mg/Kg	15500	7600

PBOW-07-SO-AA1-SB-24-A-3'-5' - 04/18/07

Analyte	Value	Bkg.	RSL
Aluminum	19900 mg/Kg	15500	7600

PBOW-07-SO-AA1-SB-25-A-8'-10' - 04/19/07

Analyte	Value	Bkg.	RSL
Aluminum	17900 mg/Kg	15500	7600

PBOW-07-SO-AA1-SB-29-A-3'-5' - 04/19/07

Analyte	Value	Bkg.	RSL
Aluminum	19400 mg/Kg	15500	7600
Vanadium	41.9 mg/Kg	40.9	7.8

PBOW-07-SO-AA1-SB-30-A-3'-5' - 04/19/07

Analyte	Value	Bkg.	RSL
Vanadium	44.7 mg/Kg	40.9	7.8
Field Duplicate Results			
Lead	50.4 J mg/Kg	48.6	40
Vanadium	44.2 mg/Kg	40.9	7.8

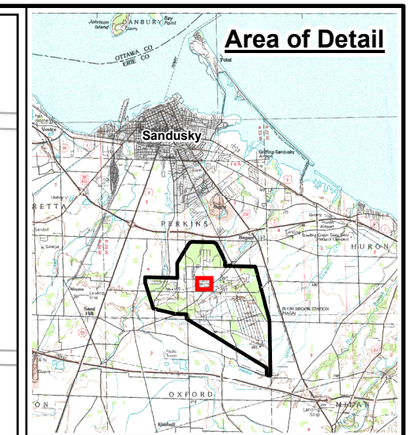
PBOW-07-SO-AA1-SB-31-A-3'-5' - 04/20/07

Analyte	Value	Bkg.	RSL
Lead	80.8 J mg/Kg	48.6	40
PCB-1254 (Aroclor 1254)	1900 J ug/Kg		220
PCB-1260 (Aroclor 1260)	4900 J ug/Kg		220

PBOW-07-SO-AA1-SB-34-A-3'-5' - 04/20/07

Analyte	Value	Bkg.	RSL
Aluminum	18200 J mg/Kg	15500	7600

Area of Detail



Legend

- 1998 SI Soil Borings
- Soil Boring

Note:
bgs = below ground surface
Bkg. = Background Sample (values are provided in units consistent with the reported sample values)
RSL = Regional Screening Level (values are provided in units consistent with the reported sample values)

- Storage Tank Areas from Engineering Drawings
- Creek, Ditch, Conveyance
- Buildings
- Railway

0 50 100 200 Feet

N

Sources
Data mapped to Ohio State Plane North NAD83, map grid units in feet.

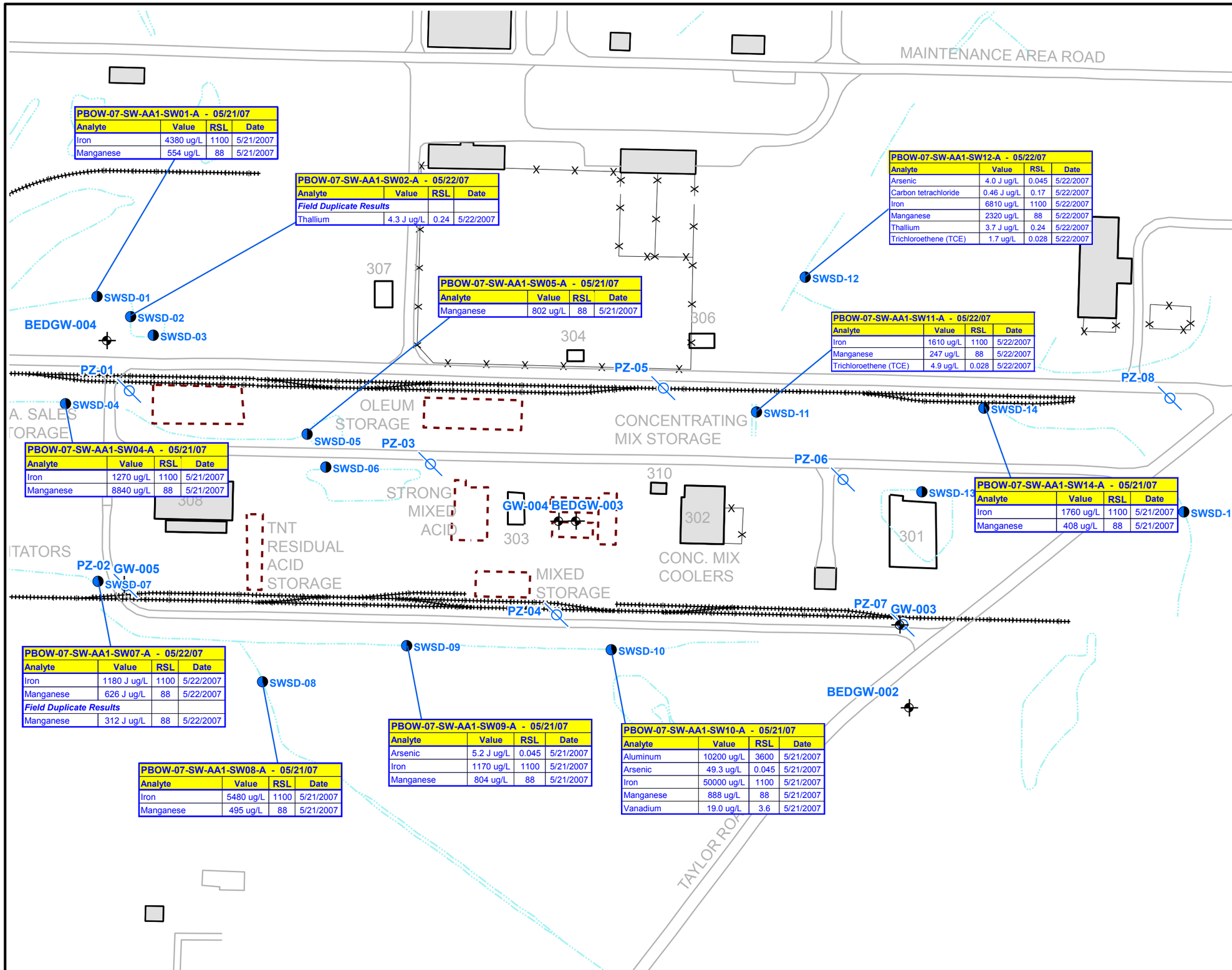
JACOBS™

Distribution of Contaminants Exceeding RSL's in Subsurface Soil — Acid Area 1

Plum Brook Ordnance Works
Sandusky, Ohio

7/24/09 JP X:/GIS/Projects/Plumbrook/Projects /AA1 HHRA/ArcGIS/AA1_HH_SubSurface_Soil.mxd

Figure 5-2



PBOW-07-SW-AA1-SW01-A - 05/21/07			
Analyte	Value	RSL	Date
Iron	4380 ug/L	1100	5/21/2007
Manganese	554 ug/L	88	5/21/2007

PBOW-07-SW-AA1-SW02-A - 05/22/07			
Analyte	Value	RSL	Date
Field Duplicate Results			
Thallium	4.3 J ug/L	0.24	5/22/2007

PBOW-07-SW-AA1-SW05-A - 05/21/07			
Analyte	Value	RSL	Date
Manganese	802 ug/L	88	5/21/2007

PBOW-07-SW-AA1-SW12-A - 05/22/07			
Analyte	Value	RSL	Date
Arsenic	4.0 J ug/L	0.045	5/22/2007
Carbon tetrachloride	0.46 J ug/L	0.17	5/22/2007
Iron	6810 ug/L	1100	5/22/2007
Manganese	2320 ug/L	88	5/22/2007
Thallium	3.7 J ug/L	0.24	5/22/2007
Trichloroethene (TCE)	1.7 ug/L	0.028	5/22/2007

PBOW-07-SW-AA1-SW11-A - 05/22/07			
Analyte	Value	RSL	Date
Iron	1610 ug/L	1100	5/22/2007
Manganese	247 ug/L	88	5/22/2007
Trichloroethene (TCE)	4.9 ug/L	0.028	5/22/2007

PBOW-07-SW-AA1-SW04-A - 05/21/07			
Analyte	Value	RSL	Date
Iron	1270 ug/L	1100	5/21/2007
Manganese	8840 ug/L	88	5/21/2007

PBOW-07-SW-AA1-SW14-A - 05/21/07			
Analyte	Value	RSL	Date
Iron	1760 ug/L	1100	5/21/2007
Manganese	408 ug/L	88	5/21/2007

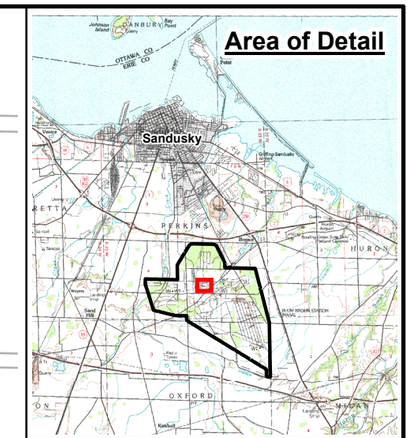
PBOW-07-SW-AA1-SW07-A - 05/22/07			
Analyte	Value	RSL	Date
Iron	1180 J ug/L	1100	5/22/2007
Manganese	626 J ug/L	88	5/22/2007
Field Duplicate Results			
Manganese	312 J ug/L	88	5/22/2007

PBOW-07-SW-AA1-SW08-A - 05/21/07			
Analyte	Value	RSL	Date
Iron	5480 ug/L	1100	5/21/2007
Manganese	495 ug/L	88	5/21/2007

PBOW-07-SW-AA1-SW09-A - 05/21/07			
Analyte	Value	RSL	Date
Arsenic	5.2 J ug/L	0.045	5/21/2007
Iron	1170 ug/L	1100	5/21/2007
Manganese	804 ug/L	88	5/21/2007

PBOW-07-SW-AA1-SW10-A - 05/21/07			
Analyte	Value	RSL	Date
Aluminum	10200 ug/L	3600	5/21/2007
Arsenic	49.3 ug/L	0.045	5/21/2007
Iron	50000 ug/L	1100	5/21/2007
Manganese	888 ug/L	88	5/21/2007
Vanadium	19.0 ug/L	3.6	5/21/2007

Area of Detail



Legend

- Surface Water or Sediment Sampling Locations
- Monitoring Wells
- Piezometers

Note:
bgs = below ground surface
Bkg. = Background Sample (values are provided in units consistent with the reported sample values)
RSL = Regional Screening Level (values are provided in units consistent with the reported sample values)

- Storage Tank Areas from Engineering Drawings
- Creek, Ditch, Conveyance
- Buildings
- Railway

0 50 100 200 Feet

N

Sources
Data mapped to Ohio State Plane North NAD83, map grid units in feet.

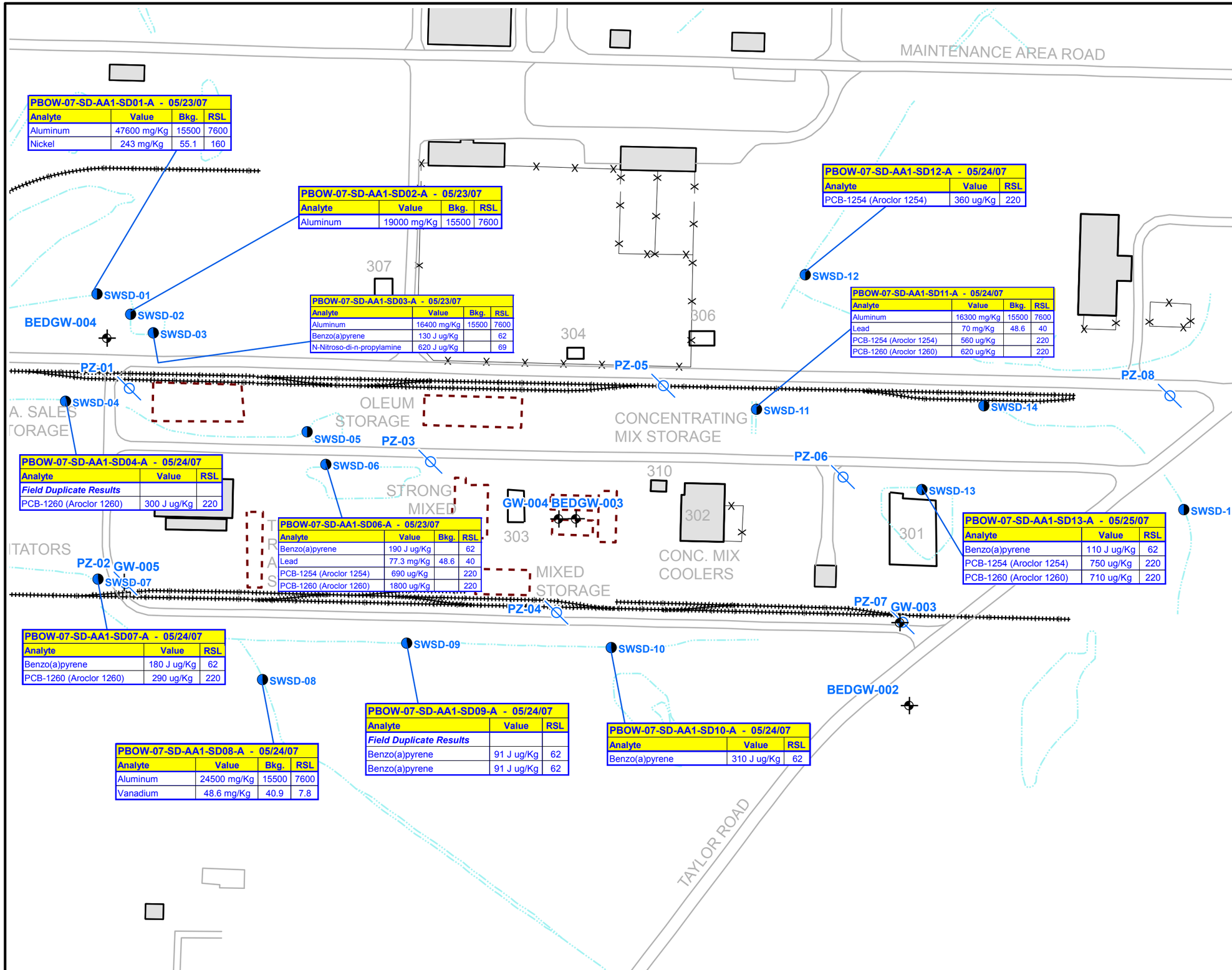
JACOBS™

Distribution of Contaminants Exceeding PRG's in Surface Water — Acid Area 1

Plum Brook Ordnance Works
Sandusky, Ohio

7/24/09 JP X:/GIS/Projects/Plumbrook/Projects /AA1_HHRA/ArcGIS/AA1_HH_Surface_Water.mxd

Figure 5-3



PBOW-07-SD-AA1-SD01-A - 05/23/07			
Analyte	Value	Bkg.	RSL
Aluminum	47600 mg/Kg	15500	7600
Nickel	243 mg/Kg	55.1	160

PBOW-07-SD-AA1-SD02-A - 05/23/07			
Analyte	Value	Bkg.	RSL
Aluminum	19000 mg/Kg	15500	7600

PBOW-07-SD-AA1-SD03-A - 05/23/07			
Analyte	Value	Bkg.	RSL
Aluminum	16400 mg/Kg	15500	7600
Benzo(a)pyrene	130 J ug/Kg		62
N-Nitroso-di-n-propylamine	620 J ug/Kg		69

PBOW-07-SD-AA1-SD04-A - 05/24/07		
Analyte	Value	RSL
Field Duplicate Results		
PCB-1260 (Aroclor 1260)	300 J ug/Kg	220

PBOW-07-SD-AA1-SD06-A - 05/23/07			
Analyte	Value	Bkg.	RSL
Benzo(a)pyrene	190 J ug/Kg		62
Lead	77.3 mg/Kg	48.6	40
PCB-1254 (Aroclor 1254)	690 ug/Kg		220
PCB-1260 (Aroclor 1260)	1800 ug/Kg		220

PBOW-07-SD-AA1-SD07-A - 05/24/07		
Analyte	Value	RSL
Benzo(a)pyrene	180 J ug/Kg	62
PCB-1260 (Aroclor 1260)	290 ug/Kg	220

PBOW-07-SD-AA1-SD08-A - 05/24/07			
Analyte	Value	Bkg.	RSL
Aluminum	24500 mg/Kg	15500	7600
Vanadium	48.6 mg/Kg	40.9	7.8

PBOW-07-SD-AA1-SD09-A - 05/24/07		
Analyte	Value	RSL
Field Duplicate Results		
Benzo(a)pyrene	91 J ug/Kg	62
Benzo(a)pyrene	91 J ug/Kg	62

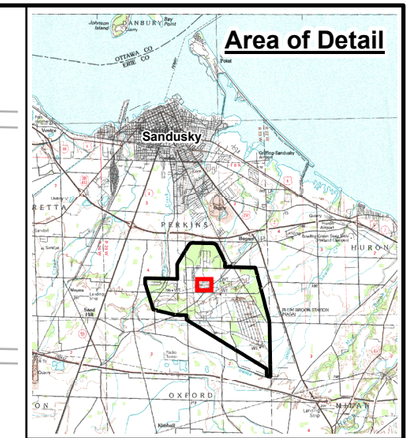
PBOW-07-SD-AA1-SD10-A - 05/24/07		
Analyte	Value	RSL
Benzo(a)pyrene	310 J ug/Kg	62

PBOW-07-SD-AA1-SD11-A - 05/24/07			
Analyte	Value	Bkg.	RSL
Aluminum	16300 mg/Kg	15500	7600
Lead	70 mg/Kg	48.6	40
PCB-1254 (Aroclor 1254)	560 ug/Kg		220
PCB-1260 (Aroclor 1260)	620 ug/Kg		220

PBOW-07-SD-AA1-SD12-A - 05/24/07		
Analyte	Value	RSL
PCB-1254 (Aroclor 1254)	360 ug/Kg	220

PBOW-07-SD-AA1-SD13-A - 05/25/07		
Analyte	Value	RSL
Benzo(a)pyrene	110 J ug/Kg	62
PCB-1254 (Aroclor 1254)	750 ug/Kg	220
PCB-1260 (Aroclor 1260)	710 ug/Kg	220

Area of Detail



Legend

- Sediment Sampling Locations
- Monitoring Wells
- Piezometers

Note:
bgs = below ground surface
Bkg. = Background Sample (values are provided in units consistent with the reported sample values)
RSL = Regional Screening Level (values are provided in units consistent with the reported sample values)

- Storage Tank Areas from Engineering Drawings
- Creek, Ditch, Conveyance
- Buildings
- Railway

0 50 100 200 Feet

N

Sources
Data mapped to Ohio State Plane North NAD83, map grid units in feet.

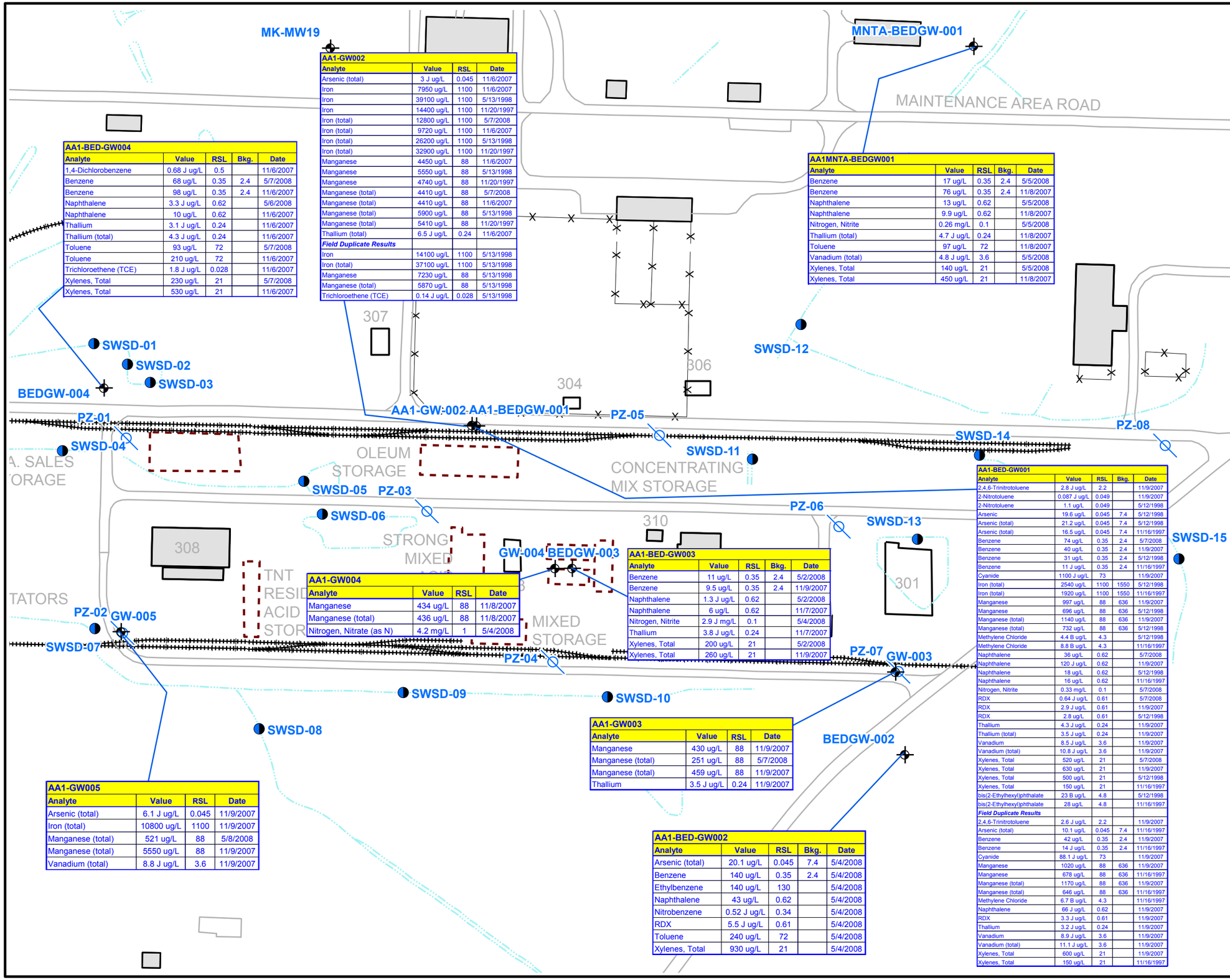
JACOBS™

Distribution of Contaminants Exceeding RSL's in Sediment — Acid Area 1

Plum Brook Ordnance Works
Sandusky, Ohio

7/24/08 JP X:/GIS/Projects/Plumbrook/Projects /AA1_HHRA/ArcGIS/AA1_HH_Sediment.mxd

Figure 5-4



AA1-BED-GW004				
Analyte	Value	RSL	Bkg.	Date
1,4-Dichlorobenzene	0.68 J ug/L	0.5		11/6/2007
Benzene	68 ug/L	0.35	2.4	5/7/2008
Benzene	98 ug/L	0.35	2.4	11/6/2007
Naphthalene	3.3 J ug/L	0.62		5/6/2008
Naphthalene	10 ug/L	0.62		11/6/2007
Thallium	3.1 J ug/L	0.24		11/6/2007
Thallium (total)	4.3 J ug/L	0.24		11/6/2007
Toluene	93 ug/L	72		5/7/2008
Toluene	210 ug/L	72		11/6/2007
Trichloroethene (TCE)	1.8 J ug/L	0.028		11/6/2007
Xylenes, Total	230 ug/L	21		5/7/2008
Xylenes, Total	530 ug/L	21		11/6/2007

AA1-GW002			
Analyte	Value	RSL	Date
Arsenic (total)	3 J ug/L	0.045	11/6/2007
Iron	7950 ug/L	1100	11/6/2007
Iron	39100 ug/L	1100	5/13/1998
Iron	14400 ug/L	1100	11/20/1997
Iron (total)	12800 ug/L	1100	5/7/2008
Iron (total)	9720 ug/L	1100	11/6/2007
Iron (total)	26200 ug/L	1100	5/13/1998
Iron (total)	32900 ug/L	1100	11/20/1997
Manganese	4450 ug/L	88	11/6/2007
Manganese	5550 ug/L	88	5/13/1998
Manganese	4740 ug/L	88	11/20/1997
Manganese (total)	4410 ug/L	88	5/7/2008
Manganese (total)	4410 ug/L	88	11/6/2007
Manganese (total)	5900 ug/L	88	5/13/1998
Manganese (total)	5410 ug/L	88	11/20/1997
Thallium (total)	6.5 J ug/L	0.24	11/6/2007
Field Duplicate Results			
Iron	14100 ug/L	1100	5/13/1998
Iron (total)	37100 ug/L	1100	5/13/1998
Manganese	7230 ug/L	88	5/13/1998
Manganese (total)	5870 ug/L	88	5/13/1998
Trichloroethene (TCE)	0.14 J ug/L	0.028	5/13/1998

AA1MNTA-BEDGW001				
Analyte	Value	RSL	Bkg.	Date
Benzene	17 ug/L	0.35	2.4	5/5/2008
Benzene	76 ug/L	0.35	2.4	11/8/2007
Naphthalene	13 ug/L	0.62		5/5/2008
Naphthalene	9.9 ug/L	0.62		11/8/2007
Nitrogen, Nitrite	0.26 mg/L	0.1		5/5/2008
Thallium (total)	4.7 J ug/L	0.24		11/8/2007
Toluene	97 ug/L	72		11/8/2007
Vanadium (total)	4.8 J ug/L	3.6		5/5/2008
Xylenes, Total	140 ug/L	21		5/5/2008
Xylenes, Total	450 ug/L	21		11/8/2007

AA1-GW004			
Analyte	Value	RSL	Date
Manganese	434 ug/L	88	11/8/2007
Manganese (total)	436 ug/L	88	11/8/2007
Nitrogen, Nitrate (as N)	4.2 mg/L	1	5/4/2008

AA1-BED-GW003				
Analyte	Value	RSL	Bkg.	Date
Benzene	11 ug/L	0.35	2.4	5/2/2008
Benzene	9.5 ug/L	0.35	2.4	11/9/2007
Naphthalene	1.3 J ug/L	0.62		5/2/2008
Naphthalene	6 ug/L	0.62		11/7/2007
Nitrogen, Nitrite	2.9 J mg/L	0.1		5/4/2008
Thallium	3.8 J ug/L	0.24		11/7/2007
Xylenes, Total	200 ug/L	21		5/2/2008
Xylenes, Total	260 ug/L	21		11/9/2007

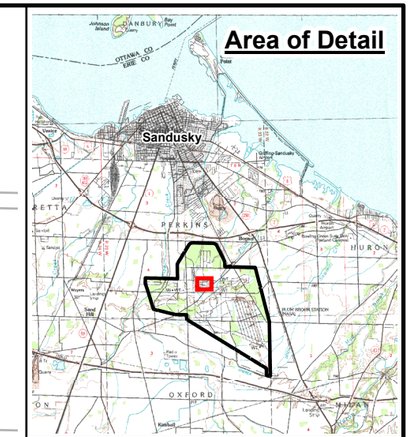
AA1-GW003			
Analyte	Value	RSL	Date
Manganese	430 ug/L	88	11/9/2007
Manganese (total)	251 ug/L	88	5/7/2008
Manganese (total)	459 ug/L	88	11/9/2007
Thallium	3.5 J ug/L	0.24	11/9/2007

AA1-GW005			
Analyte	Value	RSL	Date
Arsenic (total)	6.1 J ug/L	0.045	11/9/2007
Iron (total)	10800 ug/L	1100	11/9/2007
Manganese (total)	521 ug/L	88	5/8/2008
Manganese (total)	5550 ug/L	88	11/9/2007
Vanadium (total)	8.8 J ug/L	3.6	11/9/2007

AA1-BED-GW002				
Analyte	Value	RSL	Bkg.	Date
Arsenic (total)	20.1 ug/L	0.045	7.4	5/4/2008
Benzene	140 ug/L	0.35	2.4	5/4/2008
Ethylbenzene	140 ug/L	130		5/4/2008
Naphthalene	43 ug/L	0.62		5/4/2008
Nitrobenzene	0.52 J ug/L	0.34		5/4/2008
RDX	5.5 J ug/L	0.61		5/4/2008
Toluene	240 ug/L	72		5/4/2008
Xylenes, Total	930 ug/L	21		5/4/2008

AA1-BED-GW001				
Analyte	Value	RSL	Bkg.	Date
2,4,6-Trinitrotoluene	2.8 J ug/L	2.2		11/9/2007
2-Nitrotoluene	0.087 J ug/L	0.049		11/9/2007
2-Nitrotoluene	1.1 ug/L	0.049		5/12/1998
Arsenic	19.6 ug/L	0.045	7.4	5/12/1998
Arsenic (total)	21.2 ug/L	0.045	7.4	5/12/1998
Arsenic (total)	16.5 ug/L	0.045	7.4	11/16/1997
Benzene	74 ug/L	0.35	2.4	5/7/2008
Benzene	40 ug/L	0.35	2.4	11/9/2007
Benzene	31 ug/L	0.35	2.4	5/12/1998
Benzene	11 J ug/L	0.35	2.4	11/16/1997
Cyanide	1100 J ug/L	73		11/9/2007
Iron (total)	2540 ug/L	1100	1550	5/12/1998
Iron (total)	1920 ug/L	1100	1550	11/16/1997
Manganese	997 ug/L	88	636	11/9/2007
Manganese	696 ug/L	88	636	5/12/1998
Manganese (total)	1140 ug/L	88	636	11/9/2007
Manganese (total)	732 ug/L	88	636	5/12/1998
Methylene Chloride	4.4 B ug/L	4.3		5/12/1998
Methylene Chloride	8.8 B ug/L	4.3		11/16/1997
Naphthalene	36 ug/L	0.62		5/7/2008
Naphthalene	120 J ug/L	0.62		11/9/2007
Naphthalene	18 ug/L	0.62		5/12/1998
Naphthalene	16 ug/L	0.62		11/16/1997
Nitrogen, Nitrite	0.33 mg/L	0.1		5/7/2008
RDX	0.64 J ug/L	0.61		5/7/2008
RDX	2.9 J ug/L	0.61		11/9/2007
RDX	2.8 ug/L	0.61		5/12/1998
Thallium	4.3 J ug/L	0.24		11/9/2007
Thallium (total)	3.5 J ug/L	0.24		11/9/2007
Vanadium	8.5 J ug/L	3.6		11/9/2007
Vanadium (total)	10.8 J ug/L	3.6		11/9/2007
Xylenes, Total	520 ug/L	21		5/7/2008
Xylenes, Total	630 ug/L	21		11/9/2007
Xylenes, Total	500 ug/L	21		5/12/1998
Xylenes, Total	150 ug/L	21		11/16/1997
bis(2-Ethylhexyl)phthalate	23 B ug/L	4.8		5/12/1998
bis(2-Ethylhexyl)phthalate	28 ug/L	4.8		11/16/1997
Field Duplicate Results				
2,4,6-Trinitrotoluene	2.6 J ug/L	2.2		11/9/2007
Arsenic (total)	10.1 ug/L	0.045	7.4	11/16/1997
Benzene	42 ug/L	0.35	2.4	11/9/2007
Benzene	14 J ug/L	0.35	2.4	11/16/1997
Cyanide	88.1 J ug/L	73		11/9/2007
Manganese	1020 ug/L	88	636	11/9/2007
Manganese	678 ug/L	88	636	11/16/1997
Manganese (total)	1170 ug/L	88	636	11/9/2007
Manganese (total)	646 ug/L	88	636	11/16/1997
Methylene Chloride	6.7 B ug/L	4.3		11/16/1997
Naphthalene	66 J ug/L	0.62		11/9/2007
RDX	3.3 J ug/L	0.61		11/9/2007
Thallium	3.2 J ug/L	0.24		11/9/2007
Vanadium	8.9 J ug/L	3.6		11/9/2007
Vanadium (total)	11.1 J ug/L	3.6		11/9/2007
Xylenes, Total	600 ug/L	21		11/9/2007
Xylenes, Total	150 ug/L	21		11/16/1997

Area of Detail



Legend

- Surface Water or Sediment Sampling Locations
- Monitoring Wells
- Piezometers

Note:
bgs = below ground surface
Bkg. = Background Sample (values are provided in units consistent with the reported sample values)
RSL = Regional Screening Level (values are provided in units consistent with the reported sample values)

- Storage Tank Areas from Engineering Drawings
- Creek, Ditch, Conveyance
- Buildings
- Railway

0 50 100 200 Feet

N

Sources
Data mapped to Ohio State Plane North NAD83, map grid units in feet.

JACOBS™

Distribution of Contaminants Exceeding RSL's in Groundwater — Acid Area 1

Plum Brook Ordnance Works
Sandusky, Ohio

7/24/09 JP X:/GIS/Projects/Plumbrook/Projects /AA1 HHRA/ArcGIS/AA1_HH_Groundwater2.mxd

Figure 5-5

APPENDICES

APPENDIX A
DERMAL ABSORBED DOSE CALCULATIONS

Cancer Dermal Absorbed Dose Calculations
for Adult Residential Exposures to Inorganics in Acid Area 1

FOR INORGANIC CHEMICALS IN WATER (latest version 04/01)

Worksheet to Calculate Dermal Absorption of Inorganic Chemicals from Aqueous Media

Enter the Following Exposure Conditions: for site specific conditions, change values for A through AT (Given are default values from Table 8-6)

Conc =	1.00E-03	mg/cm3 (default value for purpose of illustration)
SA=	2.00E+04	cm2
t_event =	2.00E-01	hr/event (35 minutes/event)
EV =	1.00E+00	event/day
EF =	3.50E+02	days/yr
ED =	2.40E+01	years
BW =	7.00E+01	kg
AT =	2.56E+04	days

Default conditions for screening purposes:

Compare Dermal to Drinking: Adults showering for 35 minutes/day, compared to drinking 2L water/day

Dermal (mg/day) = DA_event * A * EV
Drinking (mg/day) = Conc * IR * ABSIG

IR: Ingestion rate of drinking water	IR =	2.00E+03	(cm3/day = L/day * 1000 cm3/L)
ABSIG: Absorption fraction in GI tract	Chemical specific		
Condition for screening: "Y" when Dermal is 10% of Drinking			

Compare Dermal to Total dose exposed during adult showering assuming 5 gal/min of water flow rate

Total dose (mg/day) = Q * T_event * EV

Q: Shower flow rate (5-15 gal/min; here using 5 gal/r	Q =	1.14E+06	(cm3/hr = gal/min * 3.785 gal/l * 60 min/hr *1000 cm3/hr)

Refer to Appendix A for equations to evaluate DA_event and DAD

CHEMICAL	Kp (cm/hr)	Source of Kp (exp or default)	Conc (mg/cm3)	DA_event (mg/cm2-event)	DAD (mg/kg-day)	ABSGI (chemical specific)	Screening	Chemicals to be assessed	Derm/ Total Dose
Aluminum (total)	1.0E-03	default	1.16E-02	2.3E-06	2.2E-04	15%	1.33%	N	0.00%
Antimony (total)	1.0E-03	default	3.00E-06	6.0E-10	5.6E-08	15%	1.33%	N	0.00%
Arsenic (total)	1.0E-03	default	2.21E-04	4.4E-08	4.2E-06	95%	0.21%	N	0.00%
Chromium (total)	1.0E-03	experimental	3.17E-05	6.3E-09	6.0E-07	1.3%	15.38%	Y	0.00%
Cyanide	1.0E-03	default	2.90E-04	5.8E-08	5.4E-06	47%	0.43%	N	0.00%
Iron (total)	1.0E-03	default	2.73E-02	5.5E-06	5.1E-04	6%	3.33%	N	0.00%
Manganese (total)	1.0E-03	default	1.02E-03	2.0E-07	1.9E-05	6%	3.33%	N	0.00%

Cancer Dermal Absorbed Dose Calculations
for Adult Residential Exposures to Organics in Acid Area 1

FOR ORGANIC CHEMICALS IN WATER (latest version 04/01)

Worksheet to Calculate Dermal Absorption of Organic Chemicals from Aqueous Media (latest version 04/01)

Enter the Following Exposure Conditions: for site specific conditions, change values in Cells I8-I18
The default exposure conditions used in this spreadsheet assume exposure duration for
carcinogenic effects of chemicals in water through showering

Concentration (mg/L*L/1000 cm3):	Conc =	1E+00 mg/cm3 (default value for purpose of illustration)
Input site specific concentrations in Column marked "Conc"		= 1 mg/L (1 p| = 1 ug/cm3 = 1000 ppb)
Area exposed (cm2):	SA =	20000 cm2
Event time (hr/event):	t_event =	0.20 hr/event (35 minutes/event)
Event frequency (events/day):	EV =	1 event/day
Exposure frequency (days/year):	EF =	350 days/yr
Exposure duration (years):	ED =	24 years
for carcinogenic effects, ED = 30 years (used in this spreadsheet)		
for noncarcinogenic effects, ED = 9 years		
Body weight (kg):	BW =	70.0 kg
Averaging time (days):	AT =	25550 days
for carcinogenic effects, AT=70 years (25,550 days)		
for noncarcinogenic effects, AT=ED (in days)		
Skin thickness (assumed to be 10 um):	lsc =	1.00E-03 cm

Default conditions for screening purposes:

Compare Dermal to Drinking: Adults showering for 35 minutes/day, compared to drinking 2L water/day

Dermal (mg/day) = DA_event * A * EV	IR =	2000 (cm3/day = L/day * 1000 cm3/L)
Drinking (mg/day) = Conc * IR * ABSIG	ABSGI =	1.0 (assumed 100% GI absorption)

IR: Ingestion rate of drinking water
ABSIG: Absorption fraction in GI tract

Refer to Appendix A for equations to evaluate DA_event and DAD

Compare Dermal to Total dose exposed during adult showering assuming 5 gal/min of water flow rate

Total dose (mg/day) = Q * T_event * EV

Q: Shower flow rate (5-15 gal/min; here using 5 gal/min) Q = 1135500.0 (cm3/hr = gal/min * 3.785 gal/l * 60 min/hr *1000 cm3/hr)

(*): outside of the Effective Prediction Domain (EPD) determined by the Flynn's measured Kp data
as evaluated using MLAB (Civilized Software, Bethesda, MD)
95% LCI and UCI are evaluated using STATA

(**): halogenated chemicals.
Note:

	CHEMICAL	CAS No.	MWT	logKow	Kp 95% LCI	Kp (cm/hr) predicted	Kp (cm/hr) measured	Kp 95% UCI	Special Chemicals (*) or (**)	Derm/ Drink	Chem Assess	Derm/ Total Dose	B	tau (hr)	t_star (hr)	FA	Conc (mg/cm3)	Kp used in DA_event	DA_event (mg/cm2-evt)	DAD (mg/kg-day)	log(Ds/lsc)	Dsc/lsc	Dsc
	Acenaphthene	83329	154.2	3.92	5.0E-04	8.6E-02		3.1E-01		94%	Y	1%	0.4	0.78	1.87	1.0	5.35E-04	8.6E-02	5.0E-05	4.7E-03	-3.7E+00	2.14E-04	2.14E-07
	17 Benzene	71432	78.1	2.13	5.9E-04	1.5E-02		3.7E-01		10%	N	0%	0.1	0.29	0.70	1.0	2.46E-03	1.5E-02	2.4E-05	2.3E-03	-3.2E+00	5.71E-04	5.71E-07
*	19 Benzo(a)anthracene	56553	228.3	5.66	1.7E-02	4.7E-01		1.3E+01 *		834%	Y	7%	2.8	2.03	8.53	1.0	2.93E-07	4.7E-01	2.4E-07	2.3E-05	-4.1E+00	8.20E-05	8.20E-08
	35 Carbon disulfide	75150	80.0	2.24	6.9E-04	1.7E-02		4.3E-01		12%	Y	0%	0.1	0.30	0.72	1.0	2.34E-04	1.7E-02	2.7E-06	2.6E-04	-3.3E+00	5.57E-04	5.57E-07
**	45 Chloromethane	74873	50.5	0.91	1.3E-04	3.3E-03		8.3E-02 **		2%	N	0%	0.0	0.20	0.49	1.0	5.40E-05	3.3E-03	9.9E-08	9.3E-06	-3.1E+00	8.16E-04	8.16E-07
	109 Ethylbenzene	100414	106.2	3.15	1.9E-03	4.9E-02		1.2E+00		39%	Y	0%	0.2	0.42	1.01	1.0	1.37E-04	4.9E-02	5.4E-06	5.1E-04	-3.4E+00	3.97E-04	3.97E-07
	143 Naphthalene	91203	128.2	3.30	1.8E-03	4.7E-02		1.2E+00		43%	Y	0%	0.2	0.56	1.34	1.0	8.87E-06	4.7E-02	3.8E-07	3.6E-05	-3.5E+00	2.99E-04	2.99E-07
	193 Toluene	108883	92.1	2.73	1.2E-03	3.1E-02		7.8E-01		23%	Y	0%	0.1	0.35	0.84	1.0	4.03E-04	3.1E-02	9.2E-06	8.6E-04	-3.3E+00	4.77E-04	4.77E-07
	209 Xylenes, total	1330207	106.2	3.15		4.9E-02		1.4E+00		39%	Y	0%	0.2	0.42	1.01	1.0	1.61E-03	4.9E-02	6.3E-05	6.0E-03	-3.4E+00	3.97E-04	3.97E-07

Noncancer Dermal Absorbed Dose Calculations
for Adult Residential Exposures to Inorganics in Acid Area 1

FOR INORGANIC CHEMICALS IN WATER (latest version 04/01)

Worksheet to Calculate Dermal Absorption of Inorganic Chemicals from Aqueous Media

Enter the Following Exposure Conditions: for site specific conditions, change values for A through AT (Given are default values from Table 8-6)

Conc =	1.00E-03	mg/cm3 (default value for purpose of illustration)
SA=	2.00E+04	cm2
t_event =	2.00E-01	hr/event (35 minutes/event)
EV =	1.00E+00	event/day
EF =	3.50E+02	days/yr
ED =	2.40E+01	years
BW =	7.00E+01	kg
AT =	8.76E+03	days

Default conditions for screening purposes:

Compare Dermal to Drinking: Adults showering for 35 minutes/day, compared to drinking 2L water/day

Dermal (mg/day) = DA_event * A * EV
Drinking (mg/day) = Conc * IR * ABSIG

IR: Ingestion rate of drinking water	IR =	2.00E+03	(cm3/day = L/day * 1000 cm3/L)
ABSIG: Absorption fraction in GI tract	Chemical specific		
Condition for screening: "Y" when Dermal is 10% of Drinking			

Compare Dermal to Total dose exposed during adult showering assuming 5 gal/min of water flow rate

Total dose (mg/day) = Q * T_event * EV

Q: Shower flow rate (5-15 gal/min; here using 5 gal/r	Q =	1.14E+06	(cm3/hr = gal/min * 3.785 gal/l * 60 min/hr *1000 cm3/hr)

Refer to Appendix A for equations to evaluate DA_event and DAD

CHEMICAL	Kp (cm/hr)	Source of Kp (exp or default)	Conc (mg/cm3)	DA_event (mg/cm2-event)	DAD (mg/kg-day)	ABSGI (chemical specific)	Screening	Chemicals to be assessed	Derm/ Total Dose
Aluminum (total)	1.0E-03	default	1.16E-02	2.3E-06	6.4E-04	15%	1.33%	N	0.00%
Antimony (Total)	1.0E-03	default	3.00E-06	6.0E-10	1.6E-07	15%	1.33%	N	0.00%
Arsenic (total)	1.0E-03	default	2.21E-04	4.4E-08	1.2E-05	95%	0.21%	N	0.00%
Chromium (total)	1.0E-03	experimental	3.17E-05	6.3E-09	1.7E-06	1.3%	15.38%	Y	0.00%
Cyanide	1.0E-03	default	2.90E-04	5.8E-08	1.6E-05	47%	0.43%	N	0.00%
Iron (total)	1.0E-03	default	2.73E-02	5.5E-06	1.5E-03	6%	3.33%	N	0.00%
Manganese (total)	1.0E-03	default	1.02E-03	2.0E-07	5.6E-05	6%	3.33%	N	0.00%
Thallium (total)	1.0E-03	default	2.30E-06	4.6E-10	1.3E-07	100%	0.20%	N	0.00%
Vanadium (total)	1.0E-03	default	2.24E-05	4.5E-09	1.2E-06	2.6%	7.69%	N	0.00%

Noncancer Dermal Absorbed Dose Calculations
for Adult Residential Exposures to Organics in Acid Area 1

FOR ORGANIC CHEMICALS IN WATER (latest version 04/01)

Worksheet to Calculate Dermal Absorption of Organic Chemicals from Aqueous Media (latest version 04/01)

Enter the Following Exposure Conditions: for site specific conditions, change values in Cells I8-I18
The default exposure conditions used in this spreadsheet assume exposure duration for carcinogenic effects of chemicals in water through showering

Concentration (mg/L*L/1000 cm3):	Conc =	1E-03 mg/cm3 (default value for purpose of illustration)
Input site specific concentrations in Column marked "Conc"		= 1 mg/L (1 pl= 1 ug/cm3 = 1000 ppb)
Area exposed (cm2):	SA =	20000 cm2
Event time (hr/event):	t_event =	0.20 hr/event (35 minutes/event)
Event frequency (events/day):	EV =	1 event/day
Exposure frequency (days/year):	EF =	350 days/yr
Exposure duration (years):	ED =	24 years
for carcinogenic effects, ED = 30 years (used in this spreadsheet)		
for noncarcinogenic effects, ED = 9 years		
Body weight (kg):	BW =	70.0 kg
Averaging time (days):	AT =	8760 days
for carcinogenic effects, AT=70 years (25,550 days)		
for noncarcinogenic effects, AT=ED (in days)		
Skin thickness (assumed to be 10 um):	lsc =	1.00E-03 cm

Default conditions for screening purposes:

Compare Dermal to Drinking: Adults showering for 35 minutes/day, compared to drinking 2L water/day

Dermal (mg/day) = DA_event * A * EV	IR =	2000 (cm3/day = L/day * 1000 cm3/L)
Drinking (mg/day) = Conc * IR * ABSIG	ABSGI =	1.0 (assumed 100% GI absorption)

IR: Ingestion rate of drinking water
ABSIG: Absorption fraction in GI tract

Refer to Appendix A for equations to evaluate DA_event and DAD

Compare Dermal to Total dose exposed during adult showering assuming 5 gal/min of water flow rate

Total dose (mg/day) = Q * T_event * EV

Q: Shower flow rate (5-15 gal/min; here using 5 gal/min) Q = 1135500.0 (cm3/hr = gal/min * 3.785 gal/l * 60 min/hr *1000 cm3/hr)

(*): outside of the Effective Prediction Domain (EPD) determined by the Flynn's measured Kp data
as evaluated using MLAB (Civilized Software, Bethesda, MD)
95% LCI and UCI are evaluated using STATA

(**): halogenated chemicals.
Note:

		CHEMICAL		MWT	logKow	Kp 95% LCI	Kp (cm/hr) predicted	Kp (cm/hr) measured	Kp 95% UCI	Special Chemicals (*) or (**)	Derm/ Drink	Chem Assess	Derm/ Total Dose	B	tau (hr)	t_star (hr)	FA	Conc (mg/cm3)	Kp used in DA_event	DA_event (mg/cm2-evt)	DAD (mg/kg-day)	log(Ds/lsc)	Dsc/lsc	Dsc
		Acenaphthene	#	154.2	3.92	5.0E-04	8.6E-02		3.1E-01		94%	Y	1%	0.4	0.78	1.87	1.0	5.35E-04	8.6E-02	5.0E-05	1.4E-02	-3.7E+00	2.14E-04	2.14E-07
	17	Benzene	#	78.1	2.13	5.9E-04	1.5E-02		3.7E-01		10%	N	0%	0.1	0.29	0.70	1.0	2.46E-03	1.5E-02	2.4E-05	6.7E-03	-3.2E+00	5.71E-04	5.71E-07
*	19	Benzo(a)anthracene	#	228.3	5.66	1.7E-02	4.7E-01		1.3E+01	*	834%	Y	7%	2.8	2.03	8.53	1.0	2.93E-07	4.7E-01	2.4E-07	6.7E-05	-4.1E+00	8.20E-05	8.20E-08
	35	Carbon disulfide	#	80.0	2.24	6.9E-04	1.7E-02		4.3E-01		12%	Y	0%	0.1	0.30	0.72	1.0	2.34E-04	1.7E-02	2.7E-06	7.4E-04	-3.3E+00	5.57E-04	5.57E-07
**	45	Chloromethane	#	50.5	0.91	1.3E-04	3.3E-03		8.3E-02	**	2%	N	0%	0.0	0.20	0.49	1.0	5.40E-05	3.3E-03	9.9E-08	2.7E-05	-3.1E+00	8.16E-04	8.16E-07
	109	Ethylbenzene	#	106.2	3.15	1.9E-03	4.9E-02		1.2E+00		39%	Y	0%	0.2	0.42	1.01	1.0	1.37E-04	4.9E-02	5.4E-06	1.5E-03	-3.4E+00	3.97E-04	3.97E-07
	143	Naphthalene	#	128.2	3.30	1.8E-03	4.7E-02		1.2E+00		43%	Y	0%	0.2	0.56	1.34	1.0	8.87E-06	4.7E-02	3.8E-07	1.0E-04	-3.5E+00	2.99E-04	2.99E-07
	193	Toluene	#	92.1	2.73	1.2E-03	3.1E-02		7.8E-01		23%	Y	0%	0.1	0.35	0.84	1.0	4.03E-04	3.1E-02	9.2E-06	2.5E-03	-3.3E+00	4.77E-04	4.77E-07
	209	Xylenes, total	#	106.2	3.15		4.9E-02		1.4E+00		39%	Y	0%	0.2	0.42	1.01	1.0	1.61E-03	4.9E-02	6.3E-05	1.7E-02	-3.4E+00	3.97E-04	3.97E-07

Cancer Dermal Absorbed Dose Calculations
for Child Residential Exposures to Inorganics in Acid Area 1

FOR INORGANIC CHEMICALS IN WATER (latest version 04/01)

Worksheet to Calculate Dermal Absorption of Inorganic Chemicals from Aqueous Media

Enter the Following Exposure Conditions: for site specific conditions, change values for A through AT (Given are default values from Table 8-6)

Conc =	1.00E-03	mg/cm3 (default value for purpose of illustration)
SA=	6.60E+03	cm2
t_event =	3.33E-01	hr/event (35 minutes/event)
EV =	1.00E+00	event/day
EF =	3.50E+02	days/yr
ED =	6.00E+00	years
BW =	1.50E+01	kg
AT =	2.56E+04	days

Default conditions for screening purposes:

Compare Dermal to Drinking: Adults showering for 35 minutes/day, compared to drinking 2L water/day

Dermal (mg/day) = DA_event * A * EV
Drinking (mg/day) = Conc * IR * ABSIG

IR: Ingestion rate of drinking water IR = 2.00E+03 (cm3/day = L/day * 1000 cm3/L)
ABSIG: Absorption fraction in GI tract Chemical specific
Condition for screening: "Y" when Dermal is 10% of Drinking

Compare Dermal to Total dose exposed during adult showering assuming 5 gal/min of water flow rate

Total dose (mg/day) = Q * T_event * EV

Q: Shower flow rate (5-15 gal/min; here using 5 gal/ Q = 1.14E+06 (cm3/hr = gal/min * 3.785 gal/l * 60 min/hr *1000 cm3/hr)

Refer to Appendix A for equations to evaluate DA_event and DAD

CHEMICAL	Kp (cm/hr)	Source of Kp (exp or default)	Conc (mg/cm3)	DA_event (mg/cm2-event)	DAD (mg/kg-day)	ABSGI (chemical specific)	Screening	Chemicals to be assessed	Derm/ Total Dose
Aluminum (total)	1.0E-03	default	1.16E-02	3.9E-06	1.4E-04	15%	0.73%	N	0.00%
Antimony (Total)	1.0E-03	default	3.00E-06	1.0E-09	3.6E-08	15%	0.73%	N	0.00%
Arsenic (total)	1.0E-03	default	2.21E-04	7.4E-08	2.7E-06	95%	0.12%	N	0.00%
Chromium (total)	1.0E-03	experimental	3.17E-05	1.1E-08	3.8E-07	1.3%	8.45%	N	0.00%
Cyanide	1.0E-03	default	2.90E-04	9.7E-08	3.5E-06	47%	0.23%	N	0.00%
Iron (total)	1.0E-03	default	2.73E-02	9.1E-06	3.3E-04	6%	1.83%	N	0.00%
Manganese (total)	1.0E-03	default	1.02E-03	3.4E-07	1.2E-05	6%	1.83%	N	0.00%
Thallium (total)	1.0E-03	default	2.30E-06	7.7E-10	2.8E-08	100%	0.11%	N	0.00%
Vanadium (total)	1.0E-03	default	2.24E-05	7.5E-09	2.7E-07	2.6%	4.23%	N	0.00%

Cancer Dermal Absorbed Dose Calculations
for Child Residential Exposures to Organics in Acid Area 1

FOR ORGANIC CHEMICALS IN WATER (latest version 04/01)

Worksheet to Calculate Dermal Absorption of Organic Chemicals from Aqueous Media (latest version 04/01)

Enter the Following Exposure Conditions: for site specific conditions, change values in Cells I8-I18
The default exposure conditions used in this spreadsheet assume exposure duration for
carcinogenic effects of chemicals in water through showering

Concentration (mg/L*L/1000 cm3):	Conc =	1E-03 mg/cm3 (default value for purpose of illustration)
Input site specific concentrations in Column marked "Conc"		= 1 mg/L (1 pl= 1 ug/cm3 = 1000 ppb)
Area exposed (cm2):	SA =	6600 cm2
Event time (hr/event):	t_event =	0.33 hr/event (35 minutes/event)
Event frequency (events/day):	EV =	1 event/day
Exposure frequency (days/year):	EF =	350 days/yr
Exposure duration (years):	ED =	6 years
for carcinogenic effects, ED = 30 years (used in this spreadsheet)		
for noncarcinogenic effects, ED = 9 years		
Body weight (kg):	BW =	15 kg
Averaging time (days):	AT =	25550 days
for carcinogenic effects, AT=70 years (25,550 days)		
for noncarcinogenic effects, AT=ED (in days)		
Skin thickness (assumed to be 10 um):	lsc =	1.00E-03 cm

Default conditions for screening purposes:

Compare Dermal to Drinking: Adults showering for 35 minutes/day, compared to drinking 2L water/day

Dermal (mg/day) = DA_event * A * EV	IR =	2000 (cm3/day = L/day * 1000 cm3/L)
Drinking (mg/day) = Conc * IR * ABSIG	ABSGI =	1.0 (assumed 100% GI absorption)

IR: Ingestion rate of drinking water
ABSIG: Absorption fraction in GI tract

Refer to Appendix A for equations to evaluate DA_event and DAD

Compare Dermal to Total dose exposed during adult showering assuming 5 gal/min of water flow rate

Total dose (mg/day) = Q * T_event * EV

Q: Shower flow rate (5-15 gal/min; here using 5 gal/min) Q = 1135500.0 (cm3/hr = gal/min * 3.785 gal/l * 60 min/hr *1000 cm3/hr)

(*): outside of the Effective Prediction Domain (EPD) determined by the Flynn's measured Kp data
as evaluated using MLAB (Civilized Software, Bethesda, MD)
95% LCI and UCI are evaluated using STATA

(**): halogenated chemicals.
Note:

	CHEMICAL	CAS No.	MWT	logKow	Kp 95% LCI	Kp (cm/hr) predicted	Kp (cm/hr) measured	Kp 95% UCI	Special Chemicals (*) or (**)	Derm/ Drink	Chem Assess	Derm/ Total Dose	B	tau (hr)	t_star (hr)	FA	Conc (mg/cm3)	Kp used in DA_event	DA_event (mg/cm2-evt)	DAD (mg/kg-day)	log(Ds/lsc)	Dsc/lsc	Dsc
	Acenaphthene	83329	154.2	3.92		8.6E-02				40%	Y	0%	0.4	0.78	1.87	1.0	5.35E-04	8.6E-02	6.5E-05	2.3E-03	-3.7E+00	2.14E-04	2.14E-07
	17 Benzene	71432	78.1	2.13	5.9E-04	1.5E-02		3.7E-01		4%	N	0%	0.1	0.29	0.70	1.0	2.46E-03	1.5E-02	3.2E-05	1.1E-03	-3.2E+00	5.71E-04	5.71E-07
*	19 Benzo(a)anthracene	56553	228.3	5.66	1.7E-02	4.7E-01		1.3E+01 *		355%	Y	2%	2.8	2.03	8.53	1.0	2.93E-07	4.7E-01	3.2E-07	1.1E-05	-4.1E+00	8.20E-05	8.20E-08
	35 Carbon disulfide	75150	80.0	2.24	6.9E-04	1.7E-02		4.3E-01		5%	N	0%	0.1	0.30	0.72	1.0	2.34E-04	1.7E-02	3.5E-06	1.3E-04	-3.3E+00	5.57E-04	5.57E-07
**	45 Chloromethane	74873	50.5	0.91	1.3E-04	3.3E-03		8.3E-02 **		1%	N	0%	0.0	0.20	0.49	1.0	5.40E-05	3.3E-03	1.3E-07	4.6E-06	-3.1E+00	8.16E-04	8.16E-07
	109 Ethylbenzene	100414	106.2	3.15	1.9E-03	4.9E-02		1.2E+00		17%	Y	0%	0.2	0.42	1.01	1.0	1.37E-04	4.9E-02	7.0E-06	2.5E-04	-3.4E+00	3.97E-04	3.97E-07
	143 Naphthalene	91203	128.2	3.30	1.8E-03	4.7E-02		1.2E+00		18%	Y	0%	0.2	0.56	1.34	1.0	8.87E-06	4.7E-02	4.9E-07	1.8E-05	-3.5E+00	2.99E-04	2.99E-07
	193 Toluene	108883	92.1	2.73	1.2E-03	3.1E-02		7.8E-01		10%	N	0%	0.1	0.35	0.84	1.0	4.03E-04	3.1E-02	1.2E-05	4.3E-04	-3.3E+00	4.77E-04	4.77E-07
	209 Xylenes, total	1330207	106.2	3.15		4.9E-02		1.4E+00		17%	Y	0%	0.2	0.42	1.01	1.0	1.61E-03	4.9E-02	8.2E-05	3.0E-03	-3.4E+00	3.97E-04	3.97E-07

Noncancer Dermal Absorbed Dose Calculations
for Child Residential Exposures to Inorganics in Acid Area 1

FOR INORGANIC CHEMICALS IN WATER (latest version 04/01)

Worksheet to Calculate Dermal Absorption of Inorganic Chemicals from Aqueous Media

Enter the Following Exposure Conditions: for site specific conditions, change values for A through AT (Given are default values from Table 8-6)

Conc =	1.00E-03	mg/cm3 (default value for purpose of illustration)
SA=	6.60E+03	cm2
t_event =	3.33E-01	hr/event (35 minutes/event)
EV =	1.00E+00	event/day
EF =	3.50E+02	days/yr
ED =	6.00E+00	years
BW =	1.50E+01	kg
AT =	2.19E+03	days

Default conditions for screening purposes:

Compare Dermal to Drinking: Adults showering for 35 minutes/day, compared to drinking 2L water/day

Dermal (mg/day) = DA_event * A * EV
Drinking (mg/day) = Conc * IR * ABSIG

IR: Ingestion rate of drinking water IR = 2.00E+03 (cm3/day = L/day * 1000 cm3/L)
ABSIG: Absorption fraction in GI tract Chemical specific
Condition for screening: "Y" when Dermal is 10% of Drinking

Compare Dermal to Total dose exposed during adult showering assuming 5 gal/min of water flow rate

Total dose (mg/day) = Q * T_event * EV

Q: Shower flow rate (5-15 gal/min; here using 5 gal/ Q = 1.14E+06 (cm3/hr = gal/min * 3.785 gal/l * 60 min/hr *1000 cm3/hr)

Refer to Appendix A for equations to evaluate DA_event and DAD

CHEMICAL	Kp (cm/hr)	Source of Kp (exp or default)	Conc (mg/cm3)	DA_event (mg/cm2-event)	DAD (mg/kg-day)	ABSGI (chemical specific)	Screening	Chemicals to be assessed	Derm/ Total Dose
Aluminum (total)	1.0E-03	default	1.16E-02	3.9E-06	1.6E-03	15%	0.73%	N	0.00%
Antimony (Total)	1.0E-03	default	3.00E-06	1.0E-09	4.2E-07	15%	0.73%	N	0.00%
Arsenic (total)	1.0E-03	default	2.21E-04	7.4E-08	3.1E-05	95%	0.12%	N	0.00%
Chromium (total)	1.0E-03	experimental	3.17E-05	1.1E-08	4.5E-06	1.3%	8.45%	N	0.00%
Cyanide	1.0E-03	default	2.90E-04	9.7E-08	4.1E-05	47%	0.23%	N	0.00%
Iron (total)	1.0E-03	default	2.73E-02	9.1E-06	3.8E-03	6%	1.83%	N	0.00%
Manganese (total)	1.0E-03	default	1.02E-03	3.4E-07	1.4E-04	6%	1.83%	N	0.00%
Thallium (total)	1.0E-03	default	2.30E-06	7.7E-10	3.2E-07	100%	0.11%	N	0.00%
Vanadium (total)	1.0E-03	default	2.24E-05	7.5E-09	3.1E-06	2.6%	4.23%	N	0.00%

Noncancer Dermal Absorbed Dose Calculations
for Child Residential Exposures to Organics in Acid Area 1

FOR ORGANIC CHEMICALS IN WATER (latest version 04/01)

Worksheet to Calculate Dermal Absorption of Organic Chemicals from Aqueous Media (latest version 04/01)

Enter the Following Exposure Conditions: for site specific conditions, change values in Cells I8-I18
The default exposure conditions used in this spreadsheet assume exposure duration for
carcinogenic effects of chemicals in water through showering

Concentration (mg/L*L/1000 cm3):	Conc =	1E-03 mg/cm3 (default value for purpose of illustration)
Input site specific concentrations in Column marked "Conc"		= 1 mg/L (1 p| = 1 ug/cm3 = 1000 ppb)
Area exposed (cm2):	SA =	6600 cm2
Event time (hr/event):	t_event =	0.33 hr/event (35 minutes/event)
Event frequency (events/day):	EV =	1 event/day
Exposure frequency (days/year):	EF =	350 days/yr
Exposure duration (years):	ED =	6 years
for carcinogenic effects, ED = 30 years (used in this spreadsheet)		
for noncarcinogenic effects, ED = 9 years		
Body weight (kg):	BW =	15.0 kg
Averaging time (days):	AT =	2190 days
for carcinogenic effects, AT=70 years (25,550 days)		
for noncarcinogenic effects, AT=ED (in days)		
Skin thickness (assumed to be 10 um):	lsc =	1.00E-03 cm

Default conditions for screening purposes:

Compare Dermal to Drinking: Adults showering for 35 minutes/day, compared to drinking 2L water/day

Dermal (mg/day) = DA_event * A * EV	IR =	2000 (cm3/day = L/day * 1000 cm3/L)
Drinking (mg/day) = Conc * IR * ABSIG	ABSGI =	1.0 (assumed 100% GI absorption)

IR: Ingestion rate of drinking water
ABSIG: Absorption fraction in GI tract

Refer to Appendix A for equations to evaluate DA_event and DAD

Compare Dermal to Total dose exposed during adult showering assuming 5 gal/min of water flow rate

Total dose (mg/day) = Q * T_event * EV

Q: Shower flow rate (5-15 gal/min; here using 5 gal/min) Q = 1135500.0 (cm3/hr = gal/min * 3.785 gal/l * 60 min/hr *1000 cm3/hr)

(*): outside of the Effective Prediction Domain (EPD) determined by the Flynn's measured Kp data
as evaluated using MLAB (Civilized Software, Bethesda, MD)
95% LCI and UCI are evaluated using STATA

(**): halogenated chemicals.
Note:

		CHEMICAL	CAS No.	MWT	logKow	Kp 95% LCI	Kp (cm/hr) predicted	Kp (cm/hr) measured	Kp 95% UCI	Special Chemicals (*) or (**)	Derm/ Drink	Chem Assess	Derm/ Total Dose	B	tau (hr)	t_star (hr)	FA	Conc (mg/cm3)	Kp used in DA_event	DA_event (mg/cm2-evt)	DAD (mg/kg-day)	log(Ds/lsc)	Dsc/lsc	Dsc
		Acenaphthene	83329	154.2	3.92	5.0E-04	8.6E-02		3.1E-01		40%	Y	0%	0.4	0.78	1.87	1.0	5.35E-04	8.6E-02	6.5E-05	2.7E-02	-3.7E+00	2.14E-04	2.14E-07
	17	Benzene	71432	78.1	2.13	5.9E-04	1.5E-02		3.7E-01		4%	N	0%	0.1	0.29	0.70	1.0	2.46E-03	1.5E-02	3.2E-05	1.3E-02	-3.2E+00	5.71E-04	5.71E-07
*	19	Benzo(a)anthracene	56553	228.3	5.66	1.7E-02	4.7E-01		1.3E+01	*	355%	Y	2%	2.8	2.03	8.53	1.0	2.93E-07	4.7E-01	3.2E-07	1.3E-04	-4.1E+00	8.20E-05	8.20E-08
	35	Carbon disulfide	75150	80.0	2.24	6.9E-04	1.7E-02		4.3E-01		5%	N	0%	0.1	0.30	0.72	1.0	2.34E-04	1.7E-02	3.5E-06	1.5E-03	-3.3E+00	5.57E-04	5.57E-07
**	45	Chloromethane	74873	50.5	0.91	1.3E-04	3.3E-03		8.3E-02	**	1%	N	0%	0.0	0.20	0.49	1.0	5.40E-05	3.3E-03	1.3E-07	5.4E-05	-3.1E+00	8.16E-04	8.16E-07
	109	Ethylbenzene	100414	106.2	3.15	1.9E-03	4.9E-02		1.2E+00		17%	Y	0%	0.2	0.42	1.01	1.0	1.37E-04	4.9E-02	7.0E-06	2.9E-03	-3.4E+00	3.97E-04	3.97E-07
	143	Naphthalene	91203	128.2	3.30	1.8E-03	4.7E-02		1.2E+00		18%	Y	0%	0.2	0.56	1.34	1.0	8.87E-06	4.7E-02	4.9E-07	2.1E-04	-3.5E+00	2.99E-04	2.99E-07
	193	Toluene	108883	92.1	2.73	1.2E-03	3.1E-02		7.8E-01		10%	N	0%	0.1	0.35	0.84	1.0	4.03E-04	3.1E-02	1.2E-05	5.0E-03	-3.3E+00	4.77E-04	4.77E-07
	209	Xylenes, total	1330207	106.2	3.15		4.9E-02		1.4E+00		17%	Y	0%	0.2	0.42	1.01	1.0	1.61E-03	4.9E-02	8.2E-05	3.5E-02	-3.4E+00	3.97E-04	3.97E-07

Cancer Dermal Absorbed Dose Calculations
for Indoor Worker Exposures to Inorganics in Acid Area 1

FOR INORGANIC CHEMICALS IN WATER (latest version 04/01)

Worksheet to Calculate Dermal Absorption of Inorganic Chemicals from Aqueous Media

Enter the Following Exposure Conditions: for site specific conditions, change values for A through AT (Given are default values from Table 8-6)

Conc =	1.00E-03	mg/cm3 (default value for purpose of illustration)
SA=	3.30E+03	cm2
t_event =	1.00E+00	hr/event (35 minutes/event)
EV =	1.00E+00	event/day
EF =	2.50E+02	days/yr
ED =	2.50E+01	years
BW =	7.00E+01	kg
AT =	2.56E+04	days

Default conditions for screening purposes:

Compare Dermal to Drinking: Adults showering for 35 minutes/day, compared to drinking 2L water/day

Dermal (mg/day) = DA_event * A * EV
Drinking (mg/day) = Conc * IR * ABSIG

IR: Ingestion rate of drinking water IR = 2.00E+03 (cm3/day = L/day * 1000 cm3/L)
ABSIG: Absorption fraction in GI tract Chemical specific
Condition for screening: "Y" when Dermal is 10% of Drinking

Compare Dermal to Total dose exposed during adult showering assuming 5 gal/min of water flow rate

Total dose (mg/day) = Q * T_event * EV

Q: Shower flow rate (5-15 gal/min; here using 5 gal/ Q = 1.14E+06 (cm3/hr = gal/min * 3.785 gal/l * 60 min/hr *1000 cm3/hr)

Refer to Appendix A for equations to evaluate DA_event and DAD

CHEMICAL	Kp (cm/hr)	Source of Kp (exp or default)	Conc (mg/cm3)	DA_event (mg/cm2-event)	DAD (mg/kg-day)	ABSGI (chemical specific)	Screening	Chemicals to be assessed	Derm/ Total Dose
Aluminum (total)	1.0E-03	default	1.16E-02	1.2E-05	1.3E-04	15%	1.10%	N	0.00%
Antimony (Total)	1.0E-03	default	3.00E-06	3.0E-09	3.5E-08	15%	1.10%	N	0.00%
Arsenic (total)	1.0E-03	default	2.21E-04	2.2E-07	2.5E-06	95%	0.17%	N	0.00%
Chromium (total)	1.0E-03	experimental	3.17E-05	3.2E-08	3.7E-07	1.3%	12.69%	Y	0.00%
Cyanide	1.0E-03	default	2.90E-04	2.9E-07	3.3E-06	47%	0.35%	N	0.00%
Iron (total)	1.0E-03	default	2.73E-02	2.7E-05	3.1E-04	6%	2.75%	N	0.00%
Manganese (total)	1.0E-03	default	1.02E-03	1.0E-06	1.2E-05	6%	2.75%	N	0.00%
Thallium (total)	1.0E-03	default	2.30E-06	2.3E-09	2.7E-08	100%	0.17%	N	0.00%
Vanadium (total)	1.0E-03	default	2.24E-05	2.2E-08	2.6E-07	2.6%	6.35%	N	0.00%

Cancer Dermal Absorbed Dose Calculations
for Indoor Worker Exposures to Organics in Acid Area 1

FOR ORGANIC CHEMICALS IN WATER (latest version 04/01)

Worksheet to Calculate Dermal Absorption of Organic Chemicals from Aqueous Media (latest version 04/01)

Enter the Following Exposure Conditions: for site specific conditions, change values in Cells I8-I18
The default exposure conditions used in this spreadsheet assume exposure duration for
carcinogenic effects of chemicals in water through showering

Concentration (mg/L*L/1000 cm3):	Conc =	1E-03 mg/cm3 (default value for purpose of illustration)
Input site specific concentrations in Column marked "Conc"		= 1 mg/L (1 p| = 1 ug/cm3 = 1000 ppb)
Area exposed (cm2):	SA =	3300 cm2
Event time (hr/event):	t_event =	1.00 hr/event (35 minutes/event)
Event frequency (events/day):	EV =	1 event/day
Exposure frequency (days/year):	EF =	250 days/yr
Exposure duration (years):	ED =	25 years
for carcinogenic effects, ED = 30 years (used in this spreadsheet)		
for noncarcinogenic effects, ED = 9 years		
Body weight (kg):	BW =	70.0 kg
Averaging time (days):	AT =	25550 days
for carcinogenic effects, AT=70 years (25,550 days)		
for noncarcinogenic effects, AT=ED (in days)		
Skin thickness (assumed to be 10 um):	lsc =	1.00E-03 cm

Default conditions for screening purposes:

Compare Dermal to Drinking: Adults showering for 35 minutes/day, compared to drinking 2L water/day

Dermal (mg/day) = DA_event * A * EV	IR =	2000 (cm3/day = L/day * 1000 cm3/L)
Drinking (mg/day) = Conc * IR * ABSIG	ABSGI =	1.0 (assumed 100% GI absorption)

IR: Ingestion rate of drinking water
ABSIG: Absorption fraction in GI tract

Refer to Appendix A for equations to evaluate DA_event and DAD

Compare Dermal to Total dose exposed during adult showering assuming 5 gal/min of water flow rate

Total dose (mg/day) = Q * T_event * EV

Q: Shower flow rate (5-15 gal/min; here using 5 gal/min) Q = 1135500.0 (cm3/hr = gal/min * 3.785 gal/l * 60 min/hr *1000 cm3/hr)

(*): outside of the Effective Prediction Domain (EPD) determined by the Flynn's measured Kp data
as evaluated using MLAB (Civilized Software, Bethesda, MD)
95% LCI and UCI are evaluated using STATA

(**): halogenated chemicals.
Note:

		CHEMICAL	CAS No.	MWT	logKow	Kp 95% LCI	Kp (cm/hr) predicted	Kp (cm/hr) measured	Kp 95% UCI	Special Chemicals (*) or (**)	Derm/ Drink	Chem Assess	Derm/ Total Dose	B	tau (hr)	t_star (hr)	FA	Conc (mg/cm3)	Kp used in DA_event	DA_event (mg/cm2-evt)	DAD (mg/kg-day)	log(Ds/lsc)	Dsc/lsc	Dsc
		Acenaphthene	83329	154.2	3.92	5.0E-04	8.6E-02		3.1E-01		35%	Y	0%	0.4	0.78	1.87	1.0	5.35E-04	8.6E-02	1.1E-04	1.3E-03	-3.7E+00	2.14E-04	2.14E-07
	17	Benzene	71432	78.1	2.13	5.9E-04	1.5E-02		3.7E-01		4%	N	0%	0.1	0.29	0.70	1.0	2.46E-03	1.5E-02	5.7E-05	6.6E-04	-3.2E+00	5.71E-04	5.71E-07
*	19	Benzo(a)anthracene	56553	228.3	5.66	1.7E-02	4.7E-01		1.3E+01 *		308%	Y	1%	2.8	2.03	8.53	1.0	2.93E-07	4.7E-01	5.5E-07	6.3E-06	-4.1E+00	8.20E-05	8.20E-08
	35	Carbon disulfide	75150	80.0	2.24	6.9E-04	1.7E-02		4.3E-01		4%	N	0%	0.1	0.30	0.72	1.0	2.34E-04	1.7E-02	6.3E-06	7.3E-05	-3.3E+00	5.57E-04	5.57E-07
**	45	Chloromethane	74873	50.5	0.91	1.3E-04	3.3E-03		8.3E-02 **		1%	N	0%	0.0	0.20	0.49	1.0	5.40E-05	3.3E-03	2.5E-07	2.9E-06	-3.1E+00	8.16E-04	8.16E-07
	109	Ethylbenzene	100414	106.2	3.15	1.9E-03	4.9E-02		1.2E+00		15%	Y	0%	0.2	0.42	1.01	1.0	1.37E-04	4.9E-02	1.2E-05	1.4E-04	-3.4E+00	3.97E-04	3.97E-07
	143	Naphthalene	91203	128.2	3.30	1.8E-03	4.7E-02		1.2E+00		16%	Y	0%	0.2	0.56	1.34	1.0	8.87E-06	4.7E-02	8.5E-07	9.8E-06	-3.5E+00	2.99E-04	2.99E-07
	193	Toluene	108883	92.1	2.73	1.2E-03	3.1E-02		7.8E-01		9%	N	0%	0.1	0.35	0.84	1.0	4.03E-04	3.1E-02	2.1E-05	2.4E-04	-3.3E+00	4.77E-04	4.77E-07
	209	Xylenes, total	1330207	106.2	3.15		4.9E-02		1.4E+00		15%	Y	0%	0.2	0.42	1.01	1.0	1.61E-03	4.9E-02	1.4E-04	1.6E-03	-3.4E+00	3.97E-04	3.97E-07

Noncancer Dermal Absorbed Dose Calculations
for Indoor Worker Exposures to Inorganics in Acid Area 1

FOR INORGANIC CHEMICALS IN WATER (latest version 04/01)

Worksheet to Calculate Dermal Absorption of Inorganic Chemicals from Aqueous Media

Enter the Following Exposure Conditions: for site specific conditions, change values for A through AT (Given are default values from Table 8-6)

Conc =	1.00E-03	mg/cm3 (default value for purpose of illustration)
SA=	3.30E+03	cm2
t_event =	1.00E+00	hr/event (35 minutes/event)
EV =	1.00E+00	event/day
EF =	2.50E+02	days/yr
ED =	2.50E+01	years
BW =	7.00E+01	kg
AT =	9.13E+03	days

Default conditions for screening purposes:

Compare Dermal to Drinking: Adults showering for 35 minutes/day, compared to drinking 2L water/day

Dermal (mg/day) = DA_event * A * EV
Drinking (mg/day) = Conc * IR * ABSIG

IR: Ingestion rate of drinking water IR = 2.00E+03 (cm3/day = L/day * 1000 cm3/L)
ABSIG: Absorption fraction in GI tract Chemical specific
Condition for screening: "Y" when Dermal is 10% of Drinking

Compare Dermal to Total dose exposed during adult showering assuming 5 gal/min of water flow rate

Total dose (mg/day) = Q * T_event * EV

Q: Shower flow rate (5-15 gal/min; here using 5 gal/ Q = 1.14E+06 (cm3/hr = gal/min * 3.785 gal/l * 60 min/hr *1000 cm3/hr)

Refer to Appendix A for equations to evaluate DA_event and DAD

CHEMICAL	Kp (cm/hr)	Source of Kp (exp or default)	Conc (mg/cm3)	DA_event (mg/cm2-event)	DAD (mg/kg-day)	ABSGI (chemical specific)	Screening	Chemicals to be assessed	Derm/ Total Dose
Aluminum (total)	1.0E-03	default	1.16E-02	1.2E-05	3.7E-04	15%	1.10%	N	0.00%
Antimony (Total)	1.0E-03	default	3.00E-06	3.0E-09	9.7E-08	15%	1.10%	N	0.00%
Arsenic (total)	1.0E-03	default	2.21E-04	2.2E-07	7.1E-06	95%	0.17%	N	0.00%
Chromium (total)	1.0E-03	experimental	3.17E-05	3.2E-08	1.0E-06	1.3%	12.69%	Y	0.00%
Cyanide	1.0E-03	default	2.90E-04	2.9E-07	9.4E-06	47%	0.35%	N	0.00%
Iron (total)	1.0E-03	default	2.73E-02	2.7E-05	8.8E-04	6%	2.75%	N	0.00%
Manganese (total)	1.0E-03	default	1.02E-03	1.0E-06	3.3E-05	6%	2.75%	N	0.00%
Thallium (total)	1.0E-03	default	2.30E-06	2.3E-09	7.4E-08	100%	0.17%	N	0.00%
Vanadium (total)	1.0E-03	default	2.24E-05	2.2E-08	7.2E-07	2.6%	6.35%	N	0.00%

Noncancer Dermal Absorbed Dose Calculations
for Indoor Worker Exposures to Organics in Acid Area 1

FOR ORGANIC CHEMICALS IN WATER (latest version 04/01)

Worksheet to Calculate Dermal Absorption of Organic Chemicals from Aqueous Media (latest version 04/01)

Enter the Following Exposure Conditions: for site specific conditions, change values in Cells I8-I18
The default exposure conditions used in this spreadsheet assume exposure duration for
carcinogenic effects of chemicals in water through showering

Concentration (mg/L*L/1000 cm3):	Conc =	1E-03 mg/cm3 (default value for purpose of illustration)
Input site specific concentrations in Column marked "Conc"		= 1 mg/L (1 p| = 1 ug/cm3 = 1000 ppb)
Area exposed (cm2):	SA =	3300 cm2
Event time (hr/event):	t_event =	1.00 hr/event (35 minutes/event)
Event frequency (events/day):	EV =	1 event/day
Exposure frequency (days/year):	EF =	250 days/yr
Exposure duration (years):	ED =	25 years
for carcinogenic effects, ED = 30 years (used in this spreadsheet)		
for noncarcinogenic effects, ED = 9 years		
Body weight (kg):	BW =	70.0 kg
Averaging time (days):	AT =	9125 days
for carcinogenic effects, AT=70 years (25,550 days)		
for noncarcinogenic effects, AT=ED (in days)		
Skin thickness (assumed to be 10 um):	lsc =	1.00E-03 cm

Default conditions for screening purposes:

Compare Dermal to Drinking: Adults showering for 35 minutes/day, compared to drinking 2L water/day

Dermal (mg/day) = DA_event * A * EV	IR =	2000 (cm3/day = L/day * 1000 cm3/L)
Drinking (mg/day) = Conc * IR * ABSIG	ABSGI =	1.0 (assumed 100% GI absorption)

IR: Ingestion rate of drinking water
ABSIG: Absorption fraction in GI tract

Refer to Appendix A for equations to evaluate DA_event and DAD

Compare Dermal to Total dose exposed during adult showering assuming 5 gal/min of water flow rate

Total dose (mg/day) = Q * T_event * EV

Q: Shower flow rate (5-15 gal/min; here using 5 gal/min) Q = 1135500.0 (cm3/hr = gal/min * 3.785 gal/l * 60 min/hr *1000 cm3/hr)

(*): outside of the Effective Prediction Domain (EPD) determined by the Flynn's measured Kp data
as evaluated using MLAB (Civilized Software, Bethesda, MD)
95% LCI and UCI are evaluated using STATA

(**): halogenated chemicals.
Note:

		CHEMICAL	CAS No.	MWT	logKow	Kp 95% LCI	Kp (cm/hr) predicted	Kp (cm/hr) measured	Kp 95% UCI	Special Chemicals (*) or (**)	Derm/ Drink	Chem Assess	Derm/ Total Dose	B	tau (hr)	t_star (hr)	FA	Conc (mg/cm3)	Kp used in DA_event	DA_event (mg/cm2-evt)	DAD (mg/kg-day)	log(Ds/lsc)	Dsc/lsc	Dsc
		Acenaphthene	83329	154.2	3.92	5.0E-04	8.6E-02		3.1E-01		35%	Y	0%	0.4	0.78	1.87	1.0	5.35E-04	8.6E-02	1.1E-04	3.6E-03	-3.7E+00	2.14E-04	2.14E-07
	17	Benzene	71432	78.1	2.13	5.9E-04	1.5E-02		3.7E-01		4%	N	0%	0.1	0.29	0.70	1.0	2.46E-03	1.5E-02	5.7E-05	1.8E-03	-3.2E+00	5.71E-04	5.71E-07
*	19	Benzo(a)anthracene	56553	228.3	5.66	1.7E-02	4.7E-01		1.3E+01 *		308%	Y	1%	2.8	2.03	8.53	1.0	2.93E-07	4.7E-01	5.5E-07	1.8E-05	-4.1E+00	8.20E-05	8.20E-08
	35	Carbon disulfide	75150	80.0	2.24	6.9E-04	1.7E-02		4.3E-01		4%	N	0%	0.1	0.30	0.72	1.0	2.34E-04	1.7E-02	6.3E-06	2.0E-04	-3.3E+00	5.57E-04	5.57E-07
**	45	Chloromethane	74873	50.5	0.91	1.3E-04	3.3E-03		8.3E-02 **		1%	N	0%	0.0	0.20	0.49	1.0	5.40E-05	3.3E-03	2.5E-07	8.0E-06	-3.1E+00	8.16E-04	8.16E-07
	109	Ethylbenzene	100414	106.2	3.15	1.9E-03	4.9E-02		1.2E+00		15%	Y	0%	0.2	0.42	1.01	1.0	1.37E-04	4.9E-02	1.2E-05	3.9E-04	-3.4E+00	3.97E-04	3.97E-07
	143	Naphthalene	91203	128.2	3.30	1.8E-03	4.7E-02		1.2E+00		16%	Y	0%	0.2	0.56	1.34	1.0	8.87E-06	4.7E-02	8.5E-07	2.8E-05	-3.5E+00	2.99E-04	2.99E-07
	193	Toluene	108883	92.1	2.73	1.2E-03	3.1E-02		7.8E-01		9%	N	0%	0.1	0.35	0.84	1.0	4.03E-04	3.1E-02	2.1E-05	6.8E-04	-3.3E+00	4.77E-04	4.77E-07
	209	Xylenes, total	1330207	106.2	3.15		4.9E-02		1.4E+00		15%	Y	0%	0.2	0.42	1.01	1.0	1.61E-03	4.9E-02	1.4E-04	4.6E-03	-3.4E+00	3.97E-04	3.97E-07

APPENDIX B
RISK CALCULATIONS

APPENDIX B
RISK CALCULATIONS

Table B-1. Risks and Hazards from Ingestion of Surface Soil at Acid Area 1 for Groundskeeper Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Soil (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	7.64E+00	3.00E-04	7.48E-06	2.49E-02	2.67E-06	1.50E+00	4.00E-06
Cobalt	8.37E+00	2.00E-02	8.19E-06	4.09E-04	2.92E-06	No toxicity value	NA
Lead	1.92E+02	No toxicity value	1.88E-04	NA	6.71E-05	No toxicity value	NA
PCB-1254 (Aroclor 1254)	2.40E+00	2.00E-05	2.35E-06	1.17E-01	8.39E-07	2.00E+00	1.68E-06
PCB-1260 (Aroclor 1260)	6.53E+00	No toxicity value	6.39E-06	NA	2.28E-06	2.00E+00	4.56E-06
Benzo(a)anthracene	1.25E-01	No toxicity value	1.22E-07	NA	4.37E-08	7.30E-01	3.19E-08
Benzo(a)pyrene	1.11E-01	No toxicity value	1.09E-07	NA	3.88E-08	7.30E+00	2.83E-07
Benzo(b)fluoranthene	2.13E-01	No toxicity value	2.08E-07	NA	7.44E-08	7.30E-01	5.43E-08
Dibenz(a,h)anthracene	1.60E-01	No toxicity value	1.57E-07	NA	5.59E-08	7.30E+00	4.08E-07
Indeno(1,2,3-cd)pyrene	9.85E-02	No toxicity value	9.64E-08	NA	3.44E-08	7.30E-01	2.51E-08
Hazard Index				1.43E-01			
Total Cancer Risk							1.10E-05

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

Table B-2. Risks and Hazards from Dermal contact with Surface Soil at Acid Area 1 for Groundskeeper Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Soil (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	7.64E+00	3.00E-04	2.28E-07	7.60E-04	8.15E-08	1.50E+00	1.22E-07
Cobalt	8.37E+00	2.00E-02	ND	NA	ND	No toxicity value	NA
Lead	1.92E+02	No toxicity value	ND	NA	ND	No toxicity value	NA
PCB-1254 (Aroclor 1254)	2.40E+00	2.00E-05	3.34E-07	1.67E-02	1.19E-07	2.00E+00	2.39E-07
PCB-1260 (Aroclor 1260)	6.53E+00	No toxicity value	9.10E-07	NA	3.25E-07	2.00E+00	6.50E-07
Benzo(a)anthracene	1.25E-01	No toxicity value	1.62E-08	NA	5.78E-09	7.30E-01	4.22E-09
Benzo(a)pyrene	1.11E-01	No toxicity value	1.44E-08	NA	5.13E-09	7.30E+00	3.74E-08
Benzo(b)fluoranthene	2.13E-01	No toxicity value	2.76E-08	NA	9.84E-09	7.30E-01	7.18E-09
Dibenz(a,h)anthracene	1.60E-01	No toxicity value	2.07E-08	NA	7.39E-09	7.30E+00	5.40E-08
Indeno(1,2,3-cd)pyrene	9.85E-02	No toxicity value	1.27E-08	NA	4.55E-09	7.30E-01	3.32E-09
Hazard Index				1.75E-02			
Total Cancer Risk							1.12E-06

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

APPENDIX B
RISK CALCULATIONS

Table B-3. Risks and Hazards from Inhalation of Particulates from Surface Soil at Acid Area 1 for Groundskeeper Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Soil (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	7.64E+00	No toxicity value	3.49E-10	NA	1.25E-10	1.51E+01	1.88E-09
Cobalt	8.37E+00	5.71E-06	3.83E-10	6.70E-05	1.37E-10	9.80E+00	1.34E-09
Lead	1.92E+02	No toxicity value	8.78E-09	NA	3.14E-09	No toxicity value	NA
PCB-1254 (Aroclor 1254)	2.40E+00	2.00E-05	1.10E-10	5.49E-06	3.92E-11	2.00E+00	7.84E-11
PCB-1260 (Aroclor 1260)	6.53E+00	No toxicity value	2.99E-10	NA	1.07E-10	2.00E+00	2.13E-10
Benzo(a)anthracene	1.25E-01	No toxicity value	5.72E-12	NA	2.04E-12	3.10E-01	6.33E-13
Benzo(a)pyrene	1.11E-01	No toxicity value	5.08E-12	NA	1.81E-12	3.10E+00	5.62E-12
Benzo(b)fluoranthene	2.13E-01	No toxicity value	9.74E-12	NA	3.48E-12	3.10E-01	1.08E-12
Dibenz(a,h)anthracene	1.60E-01	No toxicity value	7.32E-12	NA	2.61E-12	3.10E+00	8.10E-12
Indeno(1,2,3-cd)pyrene	9.85E-02	No toxicity value	4.50E-12	NA	1.61E-12	3.10E-01	4.99E-13
Hazard Index				7.25E-05			
Total Cancer Risk							3.52E-09

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

Table B-4. Risks and Hazards from Ingestion of Surface Soil at Acid Area 1 for Adult Hunter Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Soil (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	7.64E+00	3.00E-04	4.19E-07	1.40E-03	1.79E-07	1.50E+00	2.69E-07
Cobalt	8.37E+00	2.00E-02	4.59E-07	2.29E-05	1.97E-07	No toxicity value	NA
Lead	1.92E+02	No toxicity value	1.05E-05	NA	4.51E-06	No toxicity value	NA
PCB-1254 (Aroclor 1254)	2.40E+00	2.00E-05	1.32E-07	6.58E-03	5.64E-08	2.00E+00	1.13E-07
PCB-1260 (Aroclor 1260)	6.53E+00	No toxicity value	3.58E-07	NA	1.53E-07	2.00E+00	3.07E-07
Benzo(a)anthracene	1.25E-01	No toxicity value	6.85E-09	NA	2.94E-09	7.30E-01	2.14E-09
Benzo(a)pyrene	1.11E-01	No toxicity value	6.08E-09	NA	2.61E-09	7.30E+00	1.90E-08
Benzo(b)fluoranthene	2.13E-01	No toxicity value	1.17E-08	NA	5.00E-09	7.30E-01	3.65E-09
Dibenz(a,h)anthracene	1.60E-01	No toxicity value	8.77E-09	NA	3.76E-09	7.30E+00	2.74E-08
Indeno(1,2,3-cd)pyrene	9.85E-02	No toxicity value	5.40E-09	NA	2.31E-09	7.30E-01	1.69E-09
Hazard Index				7.99E-03			
Total Cancer Risk							7.42E-07

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

APPENDIX B
RISK CALCULATIONS

Table B-5. Risks and Hazards from Dermal Contact with Surface Soil at Acid Area 1 for Adult Hunter Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Soil (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	7.64E+00	3.00E-04	1.13E-07	3.77E-04	4.84E-08	1.50E+00	7.27E-08
Cobalt	8.37E+00	2.00E-02	ND	NA	ND	No toxicity value	NA
Lead	1.92E+02	No toxicity value	ND	NA	ND	No toxicity value	NA
PCB-1254 (Aroclor 1254)	2.40E+00	2.00E-05	1.66E-07	8.28E-03	7.10E-08	2.00E+00	1.42E-07
PCB-1260 (Aroclor 1260)	6.53E+00	No toxicity value	4.51E-07	NA	1.93E-07	2.00E+00	3.86E-07
Benzo(a)anthracene	1.25E-01	No toxicity value	8.01E-09	NA	3.43E-09	7.30E-01	2.51E-09
Benzo(a)pyrene	1.11E-01	No toxicity value	7.12E-09	NA	3.05E-09	7.30E+00	2.23E-08
Benzo(b)fluoranthene	2.13E-01	No toxicity value	1.37E-08	NA	5.85E-09	7.30E-01	4.27E-09
Dibenz(a,h)anthracene	1.60E-01	No toxicity value	1.03E-08	NA	4.40E-09	7.30E+00	3.21E-08
Indeno(1,2,3-cd)pyrene	9.85E-02	No toxicity value	6.31E-09	NA	2.71E-09	7.30E-01	1.98E-09
Hazard Index				8.66E-03			
Total Cancer Risk							6.64E-07

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

Table B-6. Risks and Hazards from Ingestion of Venison Harvested from Acid Area 1 for Adult Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Venison (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	2.66E-07	3.00E-04	4.73E-11	1.58E-07	2.03E-11	1.50E+00	3.04E-11
Cobalt	2.33E-03	2.00E-02	4.15E-07	2.07E-05	1.78E-07	No toxicity value	NA
Lead	1.50E-07	No toxicity value	2.68E-11	NA	1.15E-11	No toxicity value	NA
PCB-1254 (Aroclor 1254)	6.67E-06	2.00E-05	1.19E-09	5.94E-05	5.09E-10	2.00E+00	1.02E-09
PCB-1260 (Aroclor 1260)	5.13E-06	No toxicity value	9.14E-10	NA	3.92E-10	2.00E+00	7.83E-10
Benzo(a)anthracene	2.06E-08	No toxicity value	3.66E-12	NA	1.57E-12	7.30E-01	1.15E-12
Benzo(a)pyrene	2.22E-08	No toxicity value	3.95E-12	NA	1.69E-12	7.30E+00	1.24E-11
Benzo(b)fluoranthene	5.27E-08	No toxicity value	9.39E-12	NA	4.02E-12	7.30E-01	2.94E-12
Dibenz(a,h)anthracene	1.54E-07	No toxicity value	2.74E-11	NA	1.17E-11	7.30E+00	8.57E-11
Indeno(1,2,3-cd)pyrene	2.02E-08	No toxicity value	3.59E-12	NA	1.54E-12	7.30E-01	1.12E-12
Hazard Index				8.03E-05			
Total Cancer Risk							1.93E-09

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

APPENDIX B
RISK CALCULATIONS

Table B-7. Risks and Hazards from Ingestion of Venison Harvested from Acid Area 1 for Child Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Venison (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	2.66E-07	3.00E-04	8.50E-11	2.83E-07	7.28E-12	1.50E+00	1.09E-11
Cobalt	2.33E-03	2.00E-02	7.45E-07	3.72E-05	6.38E-08	No toxicity value	NA
Lead	1.50E-07	No toxicity value	4.81E-11	NA	4.12E-12	No toxicity value	NA
PCB-1254 (Aroclor 1254)	6.67E-06	2.00E-05	2.13E-09	1.07E-04	1.83E-10	2.00E+00	3.65E-10
PCB-1260 (Aroclor 1260)	5.13E-06	No toxicity value	1.64E-09	NA	1.41E-10	2.00E+00	2.81E-10
Benzo(a)anthracene	2.06E-08	No toxicity value	6.57E-12	NA	5.64E-13	7.30E-01	4.11E-13
Benzo(a)pyrene	2.22E-08	No toxicity value	7.10E-12	NA	6.08E-13	7.30E+00	4.44E-12
Benzo(b)fluoranthene	5.27E-08	No toxicity value	1.68E-11	NA	1.44E-12	7.30E-01	1.05E-12
Dibenz(a,h)anthracene	1.54E-07	No toxicity value	4.92E-11	NA	4.21E-12	7.30E+00	3.08E-11
Indeno(1,2,3-cd)pyrene	2.02E-08	No toxicity value	6.44E-12	NA	5.52E-13	7.30E-01	4.03E-13
Hazard Index				1.44E-04			
Total Cancer Risk							6.95E-10

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure

Table B-8. Risks and Hazards from Ingestion of Surface Soil at Acid Area 1 for Construction Worker Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Soil (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	7.64E+00	3.00E-04	2.08E-05	6.94E-02	1.49E-07	1.50E+00	2.23E-07
Cobalt	8.37E+00	2.00E-02	2.28E-05	1.14E-03	1.63E-07	No toxicity value	NA
Lead	1.92E+02	No toxicity value	5.23E-04	NA	3.74E-06	No toxicity value	NA
PCB-1254 (Aroclor 1254)	2.40E+00	2.00E-05	6.54E-06	3.27E-01	4.67E-08	2.00E+00	9.34E-08
PCB-1260 (Aroclor 1260)	6.53E+00	No toxicity value	1.78E-05	NA	1.27E-07	2.00E+00	2.54E-07
Benzo(a)anthracene	1.25E-01	No toxicity value	3.41E-07	NA	2.43E-09	7.30E-01	1.78E-09
Benzo(a)pyrene	1.11E-01	No toxicity value	3.02E-07	NA	2.16E-09	7.30E+00	1.58E-08
Benzo(b)fluoranthene	2.13E-01	No toxicity value	5.80E-07	NA	4.14E-09	7.30E-01	3.03E-09
Dibenz(a,h)anthracene	1.60E-01	No toxicity value	4.36E-07	NA	3.11E-09	7.30E+00	2.27E-08
Indeno(1,2,3-cd)pyrene	9.85E-02	No toxicity value	2.68E-07	NA	1.92E-09	7.30E-01	1.40E-09
Hazard Index				3.97E-01			
Total Cancer Risk							6.15E-07

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

APPENDIX B
RISK CALCULATIONS

Table B-9. Risks and Hazards from Dermal Contact with Surface Soil at Acid Area 1 for Construction Worker Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Soil (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	7.64E+00	3.00E-04	1.95E-06	6.49E-03	1.39E-08	1.50E+00	2.09E-08
Cobalt	8.37E+00	2.00E-02	ND	NA	ND	No toxicity value	NA
Lead	1.92E+02	No toxicity value	ND	NA	ND	No toxicity value	NA
PCB-1254 (Aroclor 1254)	2.40E+00	2.00E-05	2.85E-06	1.43E-01	2.04E-08	2.00E+00	4.08E-08
PCB-1260 (Aroclor 1260)	6.53E+00	No toxicity value	7.76E-06	NA	5.55E-08	2.00E+00	1.11E-07
Benzo(a)anthracene	1.25E-01	No toxicity value	1.38E-07	NA	9.86E-10	7.30E-01	7.20E-10
Benzo(a)pyrene	1.11E-01	No toxicity value	1.23E-07	NA	8.75E-10	7.30E+00	6.39E-09
Benzo(b)fluoranthene	2.13E-01	No toxicity value	2.35E-07	NA	1.68E-09	7.30E-01	1.23E-09
Dibenz(a,h)anthracene	1.60E-01	No toxicity value	1.77E-07	NA	1.26E-09	7.30E+00	9.21E-09
Indeno(1,2,3-cd)pyrene	9.85E-02	No toxicity value	1.09E-07	NA	7.77E-10	7.30E-01	5.67E-10
Hazard Index				1.49E-01			
Total Cancer Risk							1.91E-07

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

Table B-10. Risks and Hazards from inhalation of Surface Soil at Acid Area 1 for Construction Worker Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Soil (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	7.64E+00	No toxicity value	3.35E-10	NA	2.40E-12	1.51E+01	3.61E-11
Cobalt	8.37E+00	5.71E-06	3.67E-10	6.43E-05	2.62E-12	9.80E+00	2.57E-11
Lead	1.92E+02	No toxicity value	8.43E-09	NA	6.02E-11	No toxicity value	NA
PCB-1254 (Aroclor 1254)	2.40E+00	2.00E-05	1.05E-10	5.27E-06	7.52E-13	2.00E+00	1.50E-12
PCB-1260 (Aroclor 1260)	6.53E+00	No toxicity value	2.87E-10	NA	2.05E-12	2.00E+00	4.09E-12
Benzo(a)anthracene	1.25E-01	No toxicity value	5.49E-12	NA	3.92E-14	3.10E-01	1.21E-14
Benzo(a)pyrene	1.11E-01	No toxicity value	4.87E-12	NA	3.48E-14	3.10E+00	1.08E-13
Benzo(b)fluoranthene	2.13E-01	No toxicity value	9.35E-12	NA	6.68E-14	3.10E-01	2.07E-14
Dibenz(a,h)anthracene	1.60E-01	No toxicity value	7.02E-12	NA	5.02E-14	3.10E+00	1.56E-13
Indeno(1,2,3-cd)pyrene	9.85E-02	No toxicity value	4.32E-12	NA	3.09E-14	3.10E-01	9.57E-15
Hazard Index				6.96E-05			
Total Cancer Risk							6.77E-11

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

APPENDIX B
RISK CALCULATIONS

Table B-11. Risks and Hazards from Ingestion of Subsurface Soil at Acid Area 1 for Construction Worker Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Soil (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	8.83E+00	3.00E-04	2.41E-05	8.02E-02	1.72E-07	1.50E+00	2.58E-07
Cobalt	1.13E+01	2.00E-02	3.08E-05	1.54E-03	2.20E-07	No toxicity value	NA
PCB-1254 (Aroclor 1254)	1.11E+00	2.00E-05	3.02E-06	1.51E-01	2.16E-08	2.00E+00	4.32E-08
PCB-1260 (Aroclor 1260)	3.01E+00	No toxicity value	8.20E-06	NA	5.86E-08	2.00E+00	1.17E-07
Benzo(a)pyrene	7.20E-02	No toxicity value	1.96E-07	NA	1.40E-09	7.30E+00	1.02E-08
Tetrachloroethene (PCE)	1.60E+00	1.00E-02	4.36E-06	4.36E-04	3.11E-08	5.40E-01	1.68E-08
Hazard Index				2.33E-01			
Total Cancer Risk							4.45E-07

kg = kilogram
mg = milligram

RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

Table B-12. Risks and Hazards from Dermal contact with Subsurface Soil at Acid Area 1 for Construction Worker Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Soil (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	8.83E+00	3.00E-04	2.25E-06	7.50E-03	1.61E-08	1.50E+00	2.41E-08
Cobalt	1.13E+01	2.00E-02	ND	NA	ND	No toxicity value	NA
PCB-1254 (Aroclor 1254)	1.11E+00	2.00E-05	1.32E-06	6.60E-02	9.43E-09	2.00E+00	1.89E-08
PCB-1260 (Aroclor 1260)	3.01E+00	No toxicity value	3.58E-06	NA	2.56E-08	2.00E+00	5.11E-08
Benzo(a)pyrene	7.20E-02	No toxicity value	7.95E-08	NA	5.68E-10	7.30E+00	4.14E-09
Tetrachloroethene (PCE)	1.60E+00	1.00E-02	ND	NA	ND	5.40E-01	NA
Hazard Index				7.35E-02			
Total Cancer Risk							9.82E-08

kg = kilogram
mg = milligram

RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

Table B-13. Risks and Hazards from Dermal Contact with Surface Water at Acid Area 1 for Construction Worker Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Water (mg/L) RME	Reference Dose 1/(mg/kg-day)	Dermal Absorbed Dose RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Dermal Absorbed Dose RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	1.58E-02	3.00E-04	1.91E-06	6.37E-03	1.37E-08	1.50E+00	2.05E-08
Cobalt	8.46E-03	2.00E-02	1.02E-06	5.12E-05	7.33E-09	No toxicity value	NA
Iron	1.89E+01	7.00E-01	2.29E-03	3.27E-03	1.64E-05	No toxicity value	NA
Manganese	3.38E+00	4.67E-02	NA	NA	NA	No toxicity value	NA
Thallium	3.87E-03	7.00E-05	4.68E-07	6.69E-03	3.35E-09	No toxicity value	NA
1,1-Dichloroethane	2.97E-03	2.00E-01	2.84E-06	1.42E-05	2.03E-08	No toxicity value	NA
Carbon tetrachloride	4.60E-04	7.00E-04	1.22E-06	1.75E-03	8.76E-09	1.30E-01	1.14E-09
Trichloroethene (TCE)	2.62E-03	3.00E-04	4.64E-06	1.55E-02	3.32E-08	4.00E-01	1.33E-08
Hazard Index				3.36E-02			
Total Cancer Risk							3.50E-08

RME = reasonable maximum exposure
RfD = reference dose
Sf = slope factor

Table B-14. Risks and Hazards from Ingestion of Sediment at Acid Area 1 for Construction Worker Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Sediment (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	9.66E+00	3.00E-04	1.32E-05	4.39E-02	9.40E-08	1.50E+00	1.41E-07
Cobalt	2.30E+01	2.00E-02	3.13E-05	1.57E-03	2.24E-07	No toxicity value	NA
PCB-1254 (Aroclor 1254)	4.88E-01	2.00E-05	6.65E-07	3.32E-02	4.75E-09	2.00E+00	9.50E-09
PCB-1260 (Aroclor 1260)	8.07E-01	No toxicity value	1.10E-06	NA	7.85E-09	2.00E+00	1.57E-08
Benzo(a)anthracene	1.94E-01	No toxicity value	2.64E-07	NA	1.89E-09	7.30E-01	1.38E-09
Benzo(a)pyrene	1.52E-01	No toxicity value	2.07E-07	NA	1.48E-09	7.30E+00	1.08E-08
Benzo(b)fluoranthene	2.42E-01	No toxicity value	3.30E-07	NA	2.35E-09	7.30E-01	1.72E-09
Indeno(1,2,3-cd)pyrene	2.76E-01	No toxicity value	3.76E-07	NA	2.69E-09	7.30E-01	1.96E-09
N-Nitroso-di-n-propylamine	6.20E-01	No toxicity value	8.44E-07	NA	6.03E-09	7.00E+00	4.22E-08
Hazard Index				7.87E-02			
Total Cancer Risk							2.24E-07

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

APPENDIX B
RISK CALCULATIONS

Table B-15. Risks and Hazards from Dermal Contact with Sediment at Acid Area 1 for Construction Worker Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Sediment (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	9.66E+00	3.00E-04	1.01E-06	3.38E-03	7.23E-09	1.50E+00	1.08E-08
Cobalt	2.30E+01	2.00E-02	ND	NA	ND	No toxicity value	NA
PCB-1254 (Aroclor 1254)	4.88E-01	2.00E-05	2.39E-07	1.19E-02	1.71E-09	2.00E+00	3.41E-09
PCB-1260 (Aroclor 1260)	8.07E-01	No toxicity value	3.95E-07	NA	2.82E-09	2.00E+00	5.64E-09
Benzo(a)anthracene	1.94E-01	No toxicity value	8.81E-08	NA	6.29E-10	7.30E-01	4.60E-10
Benzo(a)pyrene	1.52E-01	No toxicity value	6.90E-08	NA	4.93E-10	7.30E+00	3.60E-09
Benzo(b)fluoranthene	2.42E-01	No toxicity value	1.10E-07	NA	7.85E-10	7.30E-01	5.73E-10
Indeno(1,2,3-cd)pyrene	2.76E-01	No toxicity value	1.25E-07	NA	8.96E-10	7.30E-01	6.54E-10
N-Nitroso-di-n-propylamine	6.20E-01	No toxicity value	ND	NA	ND	7.00E+00	NA
Hazard Index				1.53E-02			
Total Cancer Risk							2.52E-08

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

Table B-16. Risks and Hazards from Ingestion of Bedrock Groundwater at Acid Area 1 for Indoor Worker Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Groundwater (mg/L) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
2,4,6-Trinitrotoluene	1.53E-03	5.00E-04	1.50E-05	2.99E-02	5.35E-06	3.00E-02	1.60E-07
2-Methylnaphthalene	1.06E-01	2.00E-02	1.04E-03	5.19E-02	3.70E-04	No toxicity value	NA
2-Nitrotoluene	9.55E-04	1.00E-02	9.34E-06	9.34E-04	3.34E-06	2.30E-01	7.68E-07
Arsenic (total)	1.24E-02	3.00E-04	1.21E-04	4.03E-01	4.32E-05	1.50E+00	6.47E-05
Cyanide	7.73E-01	2.00E-02	7.56E-03	3.78E-01	2.70E-03	No toxicity value	NA
Manganese (total)	6.85E-01	4.67E-02	6.70E-03	1.44E-01	2.39E-03	No toxicity value	NA
Thallium (total)	4.04E-03	7.00E-05	3.95E-05	5.65E-01	1.41E-05	No toxicity value	NA
Benzene	7.57E-02	4.00E-03	7.41E-04	1.85E-01	2.65E-04	5.50E-02	1.45E-05
bis(2-Ethylhexyl)phthalate	1.30E-02	2.00E-02	1.27E-04	6.36E-03	4.54E-05	1.40E-02	6.36E-07
Ethylbenzene	7.03E-02	1.00E-01	6.88E-04	6.88E-03	2.46E-04	No toxicity value	NA
Methylene Chloride	3.68E-03	6.00E-02	3.60E-05	6.00E-04	1.29E-05	7.50E-03	9.64E-08
Naphthalene	4.42E-02	2.00E-02	4.32E-04	2.16E-02	1.54E-04	No toxicity value	NA
RDX	2.24E-03	3.00E-03	2.19E-05	7.31E-03	7.83E-06	1.10E-01	8.61E-07
Trichloroethene (TCE)	1.80E-03	3.00E-04	1.76E-05	5.87E-02	6.29E-06	4.00E-01	2.52E-06
Xylenes, Total	5.44E-01	2.00E-01	5.32E-03	2.66E-02	1.90E-03	No toxicity value	NA
Hazard Index				1.89E+00			
Total Cancer Risk							8.43E-05

RME = reasonable maximum exposure
Sf = slope factor
RfD = reference dose

APPENDIX B
RISK CALCULATIONS

Table B-17. Risks and Hazards from Dermal Contact with Bedrock Groundwater at Acid Area 1 for Indoor Worker Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Groundwater (mg/L) RME	Reference Dose 1/(mg/kg-day)	Dermal Absorbed Dose RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Dermal Absorbed Dose RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
2,4,6-Trinitrotoluene	1.53E-03	5.00E-04	5.03E-07	1.01E-03	1.80E-07	3.00E-02	5.39E-09
2-Methylnaphthalene	1.06E-01	2.00E-02	4.35E-06	2.18E-04	2.69E-04	No toxicity value	NA
2-Nitrotoluene	9.55E-04	1.00E-02	7.63E-07	7.63E-05	2.72E-07	2.30E-01	6.27E-08
Arsenic (total)	1.24E-02	3.00E-04	3.99E-07	1.33E-03	1.42E-07	1.50E+00	2.14E-07
Cyanide	7.73E-01	2.00E-02	2.50E-05	1.25E-03	8.91E-06	No toxicity value	NA
Manganese (total)	6.85E-01	4.67E-02	2.21E-05	4.74E-04	7.90E-06	No toxicity value	NA
Thallium (total)	4.04E-03	7.00E-05	1.30E-07	1.86E-03	4.66E-08	No toxicity value	NA
Benzene	7.57E-02	4.00E-03	5.69E-05	1.42E-02	2.03E-05	5.50E-02	1.12E-06
bis(2-Ethylhexyl)phthalate	1.30E-02	2.00E-02	9.44E-05	4.72E-03	3.37E-05	1.40E-02	4.72E-07
Ethylbenzene	7.03E-02	1.00E-01	2.00E-04	2.00E-03	7.15E-05	No toxicity value	NA
Methylene Chloride	3.68E-03	6.00E-02	6.87E-07	1.15E-05	2.45E-07	7.50E-03	1.84E-09
Naphthalene	4.42E-02	2.00E-02	1.37E-04	6.87E-03	4.91E-05	No toxicity value	NA
RDX	2.24E-03	3.00E-03	1.59E-05	5.31E-03	5.69E-06	1.10E-01	6.26E-07
Trichloroethene (TCE)	1.80E-03	3.00E-04	5.11E-06	1.70E-02	1.83E-06	4.00E-01	7.30E-07
Xylenes, Total	5.44E-01	2.00E-01	1.55E-03	7.74E-03	5.53E-04	No toxicity value	NA
Hazard Index				6.41E-02			
Total Cancer Risk							3.23E-06

RME = reasonable maximum exposure
RfD = reference dose
Sf = slope factor

Table B-18. Risks and Hazards from Ingestion of Surface Soil at Acid Area 1 for Indoor Worker Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Soil (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	7.64E+00	3.00E-04	3.74E-06	1.25E-02	1.33E-06	1.50E+00	2.00E-06
Cobalt	8.37E+00	2.00E-02	4.09E-06	2.05E-04	1.46E-06	No toxicity value	NA
Lead	1.92E+02	No toxicity value	9.39E-05	NA	3.35E-05	No toxicity value	NA
PCB-1254 (Aroclor 1254)	2.40E+00	2.00E-05	1.17E-06	5.87E-02	4.19E-07	2.00E+00	8.39E-07
PCB-1260 (Aroclor 1260)	6.53E+00	No toxicity value	3.19E-06	NA	1.14E-06	2.00E+00	2.28E-06
Benzo(a)anthracene	1.25E-01	No toxicity value	6.12E-08	NA	2.18E-08	7.30E-01	1.59E-08
Benzo(a)pyrene	1.11E-01	No toxicity value	5.43E-08	NA	1.94E-08	7.30E+00	1.42E-07
Benzo(b)fluoranthene	2.13E-01	No toxicity value	1.04E-07	NA	3.72E-08	7.30E-01	2.72E-08
Dibenz(a,h)anthracene	1.60E-01	No toxicity value	7.83E-08	NA	2.80E-08	7.30E+00	2.04E-07
Indeno(1,2,3-cd)pyrene	9.85E-02	No toxicity value	4.82E-08	NA	1.72E-08	7.30E-01	1.26E-08
Hazard Index				7.14E-02			
Total Cancer Risk							5.52E-06

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

APPENDIX B
RISK CALCULATIONS

Table B-19. Risks and Hazards from Ingestion of Bedrock Groundwater at Acid Area 1 for Adult Residential Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Groundwater (mg/L) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
2,4,6-Trinitrotoluene	1.53E-03	5.00E-04	4.19E-05	8.38E-02	1.44E-05	3.00E-02	4.31E-07
2-Methylnaphthalene	1.06E-01	2.00E-02	2.90E-03	1.45E-01	9.96E-04	No toxicity value	NA
2-Nitrotoluene	9.55E-04	1.00E-02	2.62E-05	2.62E-03	8.97E-06	2.30E-01	2.06E-06
Arsenic (total)	1.24E-02	3.00E-04	3.38E-04	1.13E+00	1.16E-04	1.50E+00	1.74E-04
Cyanide	7.73E-01	2.00E-02	2.12E-02	1.06E+00	7.26E-03	No toxicity value	NA
Manganese (total)	6.85E-01	4.67E-02	1.88E-02	4.02E-01	6.43E-03	No toxicity value	NA
Thallium (total)	4.04E-03	7.00E-05	1.11E-04	1.58E+00	3.79E-05	No toxicity value	NA
Benzene	7.57E-02	4.00E-03	2.07E-03	5.18E-01	7.11E-04	5.50E-02	3.91E-05
bis(2-Ethylhexyl)phthalate	1.30E-02	2.00E-02	3.56E-04	1.78E-02	1.22E-04	1.40E-02	1.71E-06
Ethylbenzene	7.03E-02	1.00E-01	1.93E-03	1.93E-02	6.60E-04	No toxicity value	NA
Methylene Chloride	3.68E-03	6.00E-02	1.01E-04	1.68E-03	3.46E-05	7.50E-03	2.59E-07
Naphthalene	4.42E-02	2.00E-02	1.21E-03	6.05E-02	4.15E-04	No toxicity value	NA
RDX	2.24E-03	3.00E-03	6.14E-05	2.05E-02	2.10E-05	1.10E-01	2.31E-06
Trichloroethene (TCE)	1.80E-03	3.00E-04	4.93E-05	1.64E-01	1.69E-05	4.00E-01	6.76E-06
Xylenes, Total	5.44E-01	2.00E-01	1.49E-02	7.45E-02	5.11E-03	No toxicity value	NA
Hazard Index				5.28E+00			
Total Cancer Risk							2.27E-04

RME = reasonable maximum exposure
Sf = slope factor
RfD = reference dose

Table B-20. Risks and Hazards from Dermal Contact with Bedrock Groundwater at Acid Area 1 for Adult Residential Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Groundwater (mg/L) RME	Reference Dose 1/(mg/kg-day)	Dermal Absorbed Dose RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Dermal Absorbed Dose RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
2,4,6-Trinitrotoluene	1.53E-03	5.00E-04	1.91E-06	3.82E-03	6.55E-07	3.00E-02	1.96E-08
2-Methylnaphthalene	1.06E-01	2.00E-02	2.86E-03	1.43E-01	9.81E-04	No toxicity value	NA
2-Nitrotoluene	9.55E-04	1.00E-02	2.89E-06	2.89E-04	9.92E-07	2.30E-01	2.28E-07
Arsenic (total)	1.24E-02	3.00E-04	6.77E-07	2.26E-03	2.32E-07	1.50E+00	3.48E-07
Cyanide	7.73E-01	2.00E-02	4.24E-05	2.12E-03	1.45E-05	No toxicity value	NA
Manganese (total)	6.85E-01	4.67E-02	3.75E-05	8.04E-04	1.29E-05	No toxicity value	NA
Thallium (total)	4.04E-03	7.00E-05	2.21E-07	3.16E-03	7.59E-08	No toxicity value	NA
Benzene	7.57E-02	4.00E-03	2.06E-04	5.15E-02	7.06E-05	5.50E-02	3.88E-06
bis(2-Ethylhexyl)phthalate	1.30E-02	2.00E-02	3.58E-04	1.79E-02	1.23E-04	1.40E-02	1.72E-06
Ethylbenzene	7.03E-02	1.00E-01	7.60E-04	7.60E-03	2.60E-04	No toxicity value	NA
Methylene Chloride	3.68E-03	6.00E-02	2.49E-06	4.15E-05	8.54E-07	7.50E-03	6.41E-09
Naphthalene	4.42E-02	2.00E-02	5.21E-04	2.61E-02	1.79E-04	No toxicity value	NA
RDX	2.24E-03	3.00E-03	6.04E-05	2.01E-02	2.07E-05	1.10E-01	2.28E-06
Trichloroethene (TCE)	1.80E-03	3.00E-04	1.94E-05	6.47E-02	6.65E-06	4.00E-01	2.66E-06
Xylenes, Total	5.44E-01	2.00E-01	5.88E-03	2.94E-02	2.02E-03	No toxicity value	NA
Hazard Index				3.73E-01			
Total Cancer Risk							1.11E-05

RME = reasonable maximum exposure
RfD = reference dose
Sf = slope factor

APPENDIX B
RISK CALCULATIONS

Table B-21. Risks and Hazards from Inhalation of Volatiles from Bedrock Groundwater at Acid Area 1 for Adult Residential Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Groundwater (mg/L) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Benzene	7.57E-02	8.57E-03	4.32E-04	5.04E-02	1.48E-04	2.70E-02	4.00E-06
bis(2-Ethylhexyl)phthalate	1.30E-02	2.00E-02	7.42E-05	3.71E-03	2.54E-05	1.40E-02	3.56E-07
Ethylbenzene	7.03E-02	2.90E-01	4.01E-04	1.38E-03	1.38E-04	No toxicity value	NA
Methylene Chloride	3.68E-03	8.57E-01	2.10E-05	2.45E-05	7.20E-06	1.65E-03	1.18E-08
Naphthalene	4.42E-02	8.57E-04	2.52E-04	2.94E-01	8.65E-05	No toxicity value	NA
RDX	2.24E-03	3.00E-03	1.28E-05	4.26E-03	4.38E-06	1.10E-01	4.82E-07
Trichloroethene (TCE)	1.80E-03	1.14E-02	1.03E-05	9.01E-04	3.52E-06	4.00E-01	1.41E-06
Xylenes, Total	5.44E-01	2.86E-02	3.10E-03	1.09E-01	1.06E-03	No toxicity value	NA
Hazard Index				4.64E-01			
Total Cancer Risk							6.26E-06

RME = reasonable maximum exposure
Sf = slope factor
RfD = reference dose

Table B-22. Risks and Hazards from Ingestion of Surface Soil at Acid Area 1 for Adult Residential Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Soil (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	7.64E+00	3.00E-04	9.42E-06	3.14E-02	3.23E-06	1.50E+00	4.84E-06
Cobalt	8.37E+00	2.00E-02	1.03E-05	5.16E-04	3.54E-06	No toxicity value	NA
Lead	1.92E+02	No toxicity value	2.37E-04	NA	8.12E-05	No toxicity value	NA
PCB-1254 (Aroclor 1254)	2.40E+00	2.00E-05	2.96E-06	1.48E-01	1.01E-06	2.00E+00	2.03E-06
PCB-1260 (Aroclor 1260)	6.53E+00	No toxicity value	8.05E-06	NA	2.76E-06	2.00E+00	5.52E-06
Benzo(a)anthracene	1.25E-01	No toxicity value	1.54E-07	NA	5.28E-08	7.30E-01	3.86E-08
Benzo(a)pyrene	1.11E-01	No toxicity value	1.37E-07	NA	4.69E-08	7.30E+00	3.43E-07
Benzo(b)fluoranthene	2.13E-01	No toxicity value	2.63E-07	NA	9.00E-08	7.30E-01	6.57E-08
Dibenz(a,h)anthracene	1.60E-01	No toxicity value	1.97E-07	NA	6.76E-08	7.30E+00	4.94E-07
Indeno(1,2,3-cd)pyrene	9.85E-02	No toxicity value	1.21E-07	NA	4.16E-08	7.30E-01	3.04E-08
Hazard Index				1.80E-01			
Total Cancer Risk							1.34E-05

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

APPENDIX B
RISK CALCULATIONS

Table B-23. Risks and Hazards from Dermal Contact with Surface Soil at Acid Area 1 for Adult Residential Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Soil (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	7.64E+00	3.00E-04	2.57E-06	8.57E-03	8.82E-07	1.50E+00	1.32E-06
Cobalt	8.37E+00	2.00E-02	ND	NA	ND	No toxicity value	NA
Lead	1.92E+02	No toxicity value	ND	NA	ND	No toxicity value	NA
PCB-1254 (Aroclor 1254)	2.40E+00	2.00E-05	3.77E-06	1.88E-01	1.29E-06	2.00E+00	2.58E-06
PCB-1260 (Aroclor 1260)	6.53E+00	No toxicity value	1.03E-05	NA	3.52E-06	2.00E+00	7.03E-06
Benzo(a)anthracene	1.25E-01	No toxicity value	1.82E-07	NA	6.25E-08	7.30E-01	4.56E-08
Benzo(a)pyrene	1.11E-01	No toxicity value	1.62E-07	NA	5.55E-08	7.30E+00	4.05E-07
Benzo(b)fluoranthene	2.13E-01	No toxicity value	3.11E-07	NA	1.07E-07	7.30E-01	7.78E-08
Dibenz(a,h)anthracene	1.60E-01	No toxicity value	2.33E-07	NA	8.00E-08	7.30E+00	5.84E-07
Indeno(1,2,3-cd)pyrene	9.85E-02	No toxicity value	1.44E-07	NA	4.93E-08	7.30E-01	3.60E-08
Hazard Index				1.97E-01			
Total Cancer Risk							1.21E-05

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

Table B-24. Risks and Hazards from Inhalation of Particulates from Surface Soil at Acid Area 1 for Adult Residential Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Soil (mg/L) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	7.64E+00	No toxicity value	4.40E-10	NA	1.51E-10	1.51E+01	2.27E-09
Cobalt	8.37E+00	5.71E-06	4.82E-10	8.44E-05	1.65E-10	9.80E+00	1.62E-09
Lead	1.92E+02	No toxicity value	1.11E-08	NA	3.79E-09	No toxicity value	NA
PCB-1254 (Aroclor 1254)	2.40E+00	2.00E-05	1.38E-10	6.91E-06	4.74E-11	2.00E+00	9.48E-11
PCB-1260 (Aroclor 1260)	6.53E+00	No toxicity value	3.76E-10	NA	1.29E-10	2.00E+00	2.58E-10
Benzo(a)anthracene	1.25E-01	No toxicity value	7.20E-12	NA	2.47E-12	3.10E-01	7.65E-13
Benzo(a)pyrene	1.11E-01	No toxicity value	6.39E-12	NA	2.19E-12	3.10E+00	6.80E-12
Benzo(b)fluoranthene	2.13E-01	No toxicity value	1.23E-11	NA	4.21E-12	3.10E-01	1.30E-12
Dibenz(a,h)anthracene	1.60E-01	No toxicity value	9.22E-12	NA	3.16E-12	3.10E+00	9.80E-12
Indeno(1,2,3-cd)pyrene	9.85E-02	No toxicity value	5.67E-12	NA	1.95E-12	3.10E-01	6.03E-13
Hazard Index				9.13E-05			
Total Cancer Risk							4.26E-09

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

APPENDIX B
RISK CALCULATIONS

Table B-25. Risks and Hazards from Ingestion of Subsurface Soil at Acid Area 1 for Adult Residential Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Soil (mg/L) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	8.83E+00	3.00E-04	1.09E-05	3.63E-02	3.73E-06	1.50E+00	5.60E-06
Cobalt	1.13E+01	2.00E-02	1.39E-05	6.97E-04	4.78E-06	No toxicity value	NA
PCB-1254 (Aroclor 1254)	1.11E+00	2.00E-05	1.37E-06	6.84E-02	4.69E-07	2.00E+00	9.38E-07
PCB-1260 (Aroclor 1260)	3.01E+00	No toxicity value	3.71E-06	NA	1.27E-06	2.00E+00	2.54E-06
Benzo(a)pyrene	7.20E-02	No toxicity value	8.88E-08	NA	3.04E-08	7.30E+00	2.22E-07
Tetrachloroethene (PCE)	1.60E+00	1.00E-02	1.97E-06	1.97E-04	6.76E-07	5.40E-01	3.65E-07
Hazard Index				1.06E-01			
Total Cancer Risk							9.67E-06

kg = kilogram
mg = milligram

RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

Table B-26. Risks and Hazards from Dermal Contact with Subsurface Soil at Acid Area 1 for Adult Residential Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Soil (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	8.83E+00	3.00E-04	2.97E-06	9.91E-03	1.02E-06	1.50E+00	1.53E-06
Cobalt	1.13E+01	2.00E-02	ND	NA	ND	No toxicity value	NA
PCB-1254 (Aroclor 1254)	1.11E+00	2.00E-05	1.74E-06	8.72E-02	5.98E-07	2.00E+00	1.20E-06
PCB-1260 (Aroclor 1260)	3.01E+00	No toxicity value	4.73E-06	NA	1.62E-06	2.00E+00	3.24E-06
Benzo(a)pyrene	7.20E-02	No toxicity value	1.05E-07	NA	3.60E-08	7.30E+00	2.63E-07
Tetrachloroethene (PCE)	1.60E+00	1.00E-02	ND	NA	ND	5.40E-01	NA
Hazard Index				9.71E-02			
Total Cancer Risk							6.23E-06

kg = kilogram
mg = milligram

RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

APPENDIX B
RISK CALCULATIONS

Table B-27. Risks and Hazards from Dermal Contact with Surface Water at Acid Area 1 for Adult Residential Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Water (mg/L) RME	Reference Dose 1/(mg/kg-day)	Dermal Absorbed Dose RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Dermal Absorbed Dose RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	1.58E-02	3.00E-04	5.26E-07	1.75E-03	1.80E-07	1.50E+00	2.70E-07
Cobalt	8.46E-03	2.00E-02	5.63E-07	2.82E-05	9.65E-08	No toxicity value	NA
Iron	1.89E+01	7.00E-01	6.29E-04	8.98E-04	2.16E-04	No toxicity value	NA
Manganese	3.38E+00	4.67E-02	1.12E-04	2.41E-03	3.86E-05	No toxicity value	NA
Thallium	3.87E-03	7.00E-05	1.29E-07	1.84E-03	4.42E-08	No toxicity value	NA
1,1-Dichloroethane	2.97E-03	2.00E-01	8.24E-07	4.12E-06	2.83E-07	No toxicity value	NA
Carbon tetrachloride	4.60E-04	7.00E-04	3.71E-07	5.30E-04	1.27E-07	1.30E-01	1.65E-08
Trichloroethene (TCE)	2.62E-03	3.00E-04	1.38E-06	4.59E-03	4.73E-07	4.00E-01	1.89E-07
Hazard Index				1.21E-02			
Total Cancer Risk							4.76E-07

RME - Reasonable Maximum Exposure
RfD - Reference Dose
Sf-Slope factor

Table B-28. Risks and Hazards from Ingestion of Sediment at Acid Area 1 for Adult Residential Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Sediment (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	9.66E+00	3.00E-04	1.32E-06	4.41E-03	4.54E-07	1.50E+00	6.81E-07
Cobalt	2.30E+01	2.00E-02	3.15E-06	1.58E-04	1.08E-06	No toxicity value	NA
PCB-1254 (Aroclor 1254)	4.88E-01	2.00E-05	6.68E-08	3.34E-03	2.29E-08	2.00E+00	4.58E-08
PCB-1260 (Aroclor 1260)	8.07E-01	No toxicity value	1.11E-07	NA	3.79E-08	2.00E+00	7.58E-08
Benzo(a)anthracene	1.94E-01	No toxicity value	2.66E-08	NA	9.11E-09	7.30E-01	6.65E-09
Benzo(a)pyrene	1.52E-01	No toxicity value	2.08E-08	NA	7.14E-09	7.30E+00	5.21E-08
Benzo(b)fluoranthene	2.42E-01	No toxicity value	3.32E-08	NA	1.14E-08	7.30E-01	8.30E-09
Indeno(1,2,3-cd)pyrene	2.76E-01	No toxicity value	3.78E-08	NA	1.30E-08	7.30E-01	9.46E-09
N-Nitroso-di-n-propylamine	6.20E-01	No toxicity value	8.49E-08	NA	2.91E-08	7.00E+00	2.04E-07
Hazard Index				7.91E-03			
Total Cancer Risk							1.08E-06

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

APPENDIX B
RISK CALCULATIONS

Table B-29. Risks and Hazards from Dermal Contact with Sediment at Acid Area 1 for Adult Residential Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Sediment (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	9.66E+00	3.00E-04	3.61E-07	1.20E-03	1.24E-07	1.50E+00	1.86E-07
Cobalt	2.30E+01	2.00E-02	ND	NA	ND	No toxicity value	NA
PCB-1254 (Aroclor 1254)	4.88E-01	2.00E-05	8.52E-08	4.26E-03	2.92E-08	2.00E+00	5.84E-08
PCB-1260 (Aroclor 1260)	8.07E-01	No toxicity value	1.41E-07	NA	4.83E-08	2.00E+00	9.66E-08
Benzo(a)anthracene	1.94E-01	No toxicity value	3.14E-08	NA	1.08E-08	7.30E-01	7.87E-09
Benzo(a)pyrene	1.52E-01	No toxicity value	2.46E-08	NA	8.45E-09	7.30E+00	6.17E-08
Benzo(b)fluoranthene	2.42E-01	No toxicity value	3.92E-08	NA	1.34E-08	7.30E-01	9.82E-09
Indeno(1,2,3-cd)pyrene	2.76E-01	No toxicity value	4.47E-08	NA	1.53E-08	7.30E-01	1.12E-08
N-Nitroso-di-n-propylamine	6.20E-01	No toxicity value	ND	NA	ND	7.00E+00	NA
Hazard Index				5.46E-03			
Total Cancer Risk							4.31E-07

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

Table B-30. Risks and Hazards from Ingestion of Bedrock Groundwater at Acid Area 1 for Child Residential Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Groundwater (mg/L) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
2,4,6-Trinitrotoluene	1.53E-03	5.00E-04	9.78E-05	1.96E-01	8.38E-06	3.00E-02	2.52E-07
2-Methylnaphthalene	1.06E-01	2.00E-02	6.78E-03	3.39E-01	5.81E-04	No toxicity value	NA
2-Nitrotoluene	9.55E-04	1.00E-02	6.11E-05	6.11E-03	5.23E-06	2.30E-01	1.20E-06
Arsenic (total)	1.24E-02	3.00E-04	7.89E-04	2.63E+00	6.77E-05	1.50E+00	1.02E-04
Cyanide	7.73E-01	2.00E-02	4.94E-02	2.47E+00	4.24E-03	No toxicity value	NA
Manganese (total)	6.85E-01	4.67E-02	4.38E-02	9.38E-01	3.75E-03	No toxicity value	NA
Thallium (total)	4.04E-03	7.00E-05	2.58E-04	3.69E+00	2.21E-05	No toxicity value	NA
Benzene	7.57E-02	4.00E-03	4.84E-03	1.21E+00	4.15E-04	5.50E-02	2.28E-05
bis(2-Ethylhexyl)phthalate	1.30E-02	2.00E-02	8.31E-04	4.16E-02	7.12E-05	1.40E-02	9.97E-07
Ethylbenzene	7.03E-02	1.00E-01	4.49E-03	4.49E-02	3.85E-04	No toxicity value	NA
Methylene Chloride	3.68E-03	6.00E-02	2.35E-04	3.92E-03	2.02E-05	7.50E-03	1.51E-07
Naphthalene	4.42E-02	2.00E-02	2.83E-03	1.41E-01	2.42E-04	No toxicity value	NA
RDX	2.24E-03	3.00E-03	1.43E-04	4.77E-02	1.23E-05	1.10E-01	1.35E-06
Trichloroethene (TCE)	1.80E-03	3.00E-04	1.15E-04	3.84E-01	9.86E-06	4.00E-01	3.95E-06
Xylenes, Total	5.44E-01	2.00E-01	3.48E-02	1.74E-01	2.98E-03	No toxicity value	NA
Hazard Index				1.23E+01			
Total Cancer Risk							1.32E-04

RME = reasonable maximum exposure
Sf = slope factor
RfD = reference dose

Table B-31. Risks and Hazards from Dermal Contact with Bedrock Groundwater at Acid Area 1 for Child Residential Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Groundwater (mg/L) RME	Reference Dose 1/(mg/kg-day)	Dermal Absorbed Dose RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Dermal Absorbed Dose RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
2,4,6-Trinitrotoluene	1.53E-03	5.00E-04	3.79E-06	7.59E-03	3.25E-07	3.00E-02	9.76E-09
2-Methylnaphthalene	1.06E-01	2.00E-02	5.68E-03	2.84E-01	4.87E-04	No toxicity value	NA
2-Nitrotoluene	9.55E-04	1.00E-02	5.75E-06	5.75E-04	4.93E-07	2.30E-01	1.13E-07
Arsenic (total)	1.24E-02	3.00E-04	1.74E-06	5.78E-03	1.49E-07	1.50E+00	2.23E-07
Cyanide	7.73E-01	2.00E-02	1.09E-04	5.43E-03	9.31E-06	No toxicity value	NA
Manganese (total)	6.85E-01	4.67E-02	9.62E-05	2.06E-03	8.25E-06	No toxicity value	NA
Thallium (total)	4.04E-03	7.00E-05	5.68E-07	8.11E-03	4.87E-08	No toxicity value	NA
Benzene	7.57E-02	4.00E-03	4.09E-04	1.02E-01	3.51E-05	5.50E-02	1.93E-06
bis(2-Ethylhexyl)phthalate	1.30E-02	2.00E-02	7.12E-04	3.56E-02	6.10E-05	1.40E-02	8.54E-07
Ethylbenzene	7.03E-02	1.00E-01	1.51E-03	1.51E-02	1.29E-04	No toxicity value	NA
Methylene Chloride	3.68E-03	6.00E-02	4.95E-06	8.25E-05	4.24E-07	7.50E-03	3.18E-09
Naphthalene	4.42E-02	2.00E-02	1.04E-03	5.18E-02	8.88E-05	No toxicity value	NA
RDX	2.24E-03	3.00E-03	1.20E-04	4.00E-02	1.03E-05	1.10E-01	1.13E-06
Trichloroethene (TCE)	1.80E-03	3.00E-04	3.85E-05	1.28E-01	3.30E-06	4.00E-01	1.32E-06
Xylenes, Total	5.44E-01	2.00E-01	1.17E-02	5.84E-02	1.00E-03	No toxicity value	NA
Hazard Index				7.45E-01			
Total Cancer Risk							5.59E-06

RME = reasonable maximum exposure
RfD = reference dose
Sf = slope factor

Table B-32. Risks and Hazards from Inhalation of Volatiles from Bedrock Groundwater at Acid Area 1 for Child Residential Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Groundwater (mg/L) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Benzene	7.57E-02	8.57E-03	1.01E-03	1.17E-01	8.63E-05	2.70E-02	2.33E-06
bis(2-Ethylhexyl)phthalate	1.30E-02	2.00E-02	1.73E-04	8.64E-03	1.48E-05	1.40E-02	2.07E-07
Ethylbenzene	7.03E-02	2.90E-01	9.35E-04	3.22E-03	8.01E-05	No toxicity value	NA
Methylene Chloride	3.68E-03	8.57E-01	4.89E-05	5.71E-05	4.19E-06	1.65E-03	6.90E-09
Naphthalene	4.42E-02	8.57E-04	5.88E-04	6.86E-01	5.04E-05	No toxicity value	NA
RDX	2.24E-03	3.00E-03	2.98E-05	9.93E-03	2.55E-06	1.10E-01	2.81E-07
Trichloroethene (TCE)	1.80E-03	1.14E-02	2.39E-05	2.10E-03	2.05E-06	4.00E-01	8.21E-07
Xylenes, Total	5.44E-01	2.86E-02	7.23E-03	2.53E-01	6.20E-04	No toxicity value	NA
Hazard Index				1.08E+00			
Total Cancer Risk							3.65E-06

RME = reasonable maximum exposure
Sf = slope factor
RfD = reference dose

APPENDIX B
RISK CALCULATIONS

Table B-33. Risks and Hazards from Ingestion of Surface Soil at Acid Area 1 for Child Residential Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Soil (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	7.64E+00	3.00E-04	8.79E-05	2.93E-01	7.54E-06	1.50E+00	1.13E-05
Cobalt	8.37E+00	2.00E-02	9.63E-05	4.82E-03	8.26E-06	No toxicity value	NA
Lead	1.92E+02	No toxicity value	2.21E-03	NA	1.89E-04	No toxicity value	NA
PCB-1254 (Aroclor 1254)	2.40E+00	2.00E-05	2.76E-05	1.38E+00	2.37E-06	2.00E+00	4.73E-06
PCB-1260 (Aroclor 1260)	6.53E+00	No toxicity value	7.51E-05	NA	6.44E-06	2.00E+00	1.29E-05
Benzo(a)anthracene	1.25E-01	No toxicity value	1.44E-06	NA	1.23E-07	7.30E-01	9.00E-08
Benzo(a)pyrene	1.11E-01	No toxicity value	1.28E-06	NA	1.09E-07	7.30E+00	7.99E-07
Benzo(b)fluoranthene	2.13E-01	No toxicity value	2.45E-06	NA	2.10E-07	7.30E-01	1.53E-07
Dibenz(a,h)anthracene	1.60E-01	No toxicity value	1.84E-06	NA	1.58E-07	7.30E+00	1.15E-06
Indeno(1,2,3-cd)pyrene	9.85E-02	No toxicity value	1.13E-06	NA	9.72E-08	7.30E-01	7.09E-08
Hazard Index				1.68E+00			
Total Cancer Risk							3.12E-05

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

Table B-34. Risks and Hazards from Dermal Contact with Surface Soil at Acid Area 1 for Child Residential Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Soil (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	7.64E+00	3.00E-04	4.62E-06	1.54E-02	3.96E-07	1.50E+00	5.93E-07
Cobalt	8.37E+00	2.00E-02	ND	NA	ND	No toxicity value	NA
Lead	1.92E+02	No toxicity value	ND	NA	ND	No toxicity value	NA
PCB-1254 (Aroclor 1254)	2.40E+00	2.00E-05	6.77E-06	3.38E-01	5.80E-07	2.00E+00	1.16E-06
PCB-1260 (Aroclor 1260)	6.53E+00	No toxicity value	1.84E-05	NA	1.58E-06	2.00E+00	3.16E-06
Benzo(a)anthracene	1.25E-01	No toxicity value	3.27E-07	NA	2.80E-08	7.30E-01	2.05E-08
Benzo(a)pyrene	1.11E-01	No toxicity value	2.91E-07	NA	2.49E-08	7.30E+00	1.82E-07
Benzo(b)fluoranthene	2.13E-01	No toxicity value	5.58E-07	NA	4.78E-08	7.30E-01	3.49E-08
Dibenz(a,h)anthracene	1.60E-01	No toxicity value	4.19E-07	NA	3.59E-08	7.30E+00	2.62E-07
Indeno(1,2,3-cd)pyrene	9.85E-02	No toxicity value	2.58E-07	NA	2.21E-08	7.30E-01	1.61E-08
Hazard Index				3.54E-01			
Total Cancer Risk							5.42E-06

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

Table B-35. Risks and Hazards from Inhalation of Particulates from Surface Soil at Acid Area 1 for Child Residential Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Soil (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	7.64E+00	No toxicity value	1.03E-09	NA	8.80E-11	1.51E+01	1.32E-09
Cobalt	8.37E+00	5.71E-06	1.13E-09	1.97E-04	9.64E-11	9.80E+00	9.45E-10
Lead	1.92E+02	No toxicity value	2.58E-08	NA	2.21E-09	No toxicity value	NA
PCB-1254 (Aroclor 1254)	2.40E+00	2.00E-05	3.23E-10	1.61E-05	2.77E-11	2.00E+00	5.53E-11
PCB-1260 (Aroclor 1260)	6.53E+00	No toxicity value	8.78E-10	NA	7.52E-11	2.00E+00	1.50E-10
Benzo(a)anthracene	1.25E-01	No toxicity value	1.68E-11	NA	1.44E-12	3.10E-01	4.46E-13
Benzo(a)pyrene	1.11E-01	No toxicity value	1.49E-11	NA	1.28E-12	3.10E+00	3.96E-12
Benzo(b)fluoranthene	2.13E-01	No toxicity value	2.86E-11	NA	2.45E-12	3.10E-01	7.61E-13
Dibenz(a,h)anthracene	1.60E-01	No toxicity value	2.15E-11	NA	1.84E-12	3.10E+00	5.72E-12
Indeno(1,2,3-cd)pyrene	9.85E-02	No toxicity value	1.32E-11	NA	1.13E-12	3.10E-01	3.52E-13
Hazard Index				2.13E-04			
Total Cancer Risk							2.49E-09

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

Table B-36. Risks and Hazards from Ingestion of Subsurface Soil at Acid Area 1 for Child Residential Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Soil (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	8.83E+00	3.00E-04	1.02E-04	3.39E-01	8.71E-06	1.50E+00	1.31E-05
Cobalt	1.13E+01	2.00E-02	1.30E-04	6.50E-03	1.11E-05	No toxicity value	NA
PCB-1254 (Aroclor 1254)	1.11E+00	2.00E-05	1.28E-05	6.39E-01	1.09E-06	2.00E+00	2.19E-06
PCB-1260 (Aroclor 1260)	3.01E+00	No toxicity value	3.46E-05	NA	2.97E-06	2.00E+00	5.94E-06
Benzo(a)pyrene	7.20E-02	No toxicity value	8.28E-07	NA	7.10E-08	7.30E+00	5.18E-07
Tetrachloroethene (PCE)	1.60E+00	1.00E-02	1.84E-05	1.84E-03	1.58E-06	5.40E-01	8.52E-07
Hazard Index				9.86E-01			
Total Cancer Risk							2.26E-05

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

APPENDIX B
RISK CALCULATIONS

Table B-37. Risks and Hazards from Dermal Contact with Subsurface Soil at Acid Area 1 for Child Residential Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Soil (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	8.83E+00	3.00E-04	5.33E-06	1.78E-02	4.57E-07	1.50E+00	6.86E-07
Cobalt	1.13E+01	2.00E-02	ND	NA	ND	No toxicity value	NA
PCB-1254 (Aroclor 1254)	1.11E+00	2.00E-05	3.13E-06	1.56E-01	2.68E-07	2.00E+00	5.36E-07
PCB-1260 (Aroclor 1260)	3.01E+00	No toxicity value	8.49E-06	NA	7.27E-07	2.00E+00	1.45E-06
Benzo(a)pyrene	7.20E-02	No toxicity value	1.88E-07	NA	1.62E-08	7.30E+00	1.18E-07
Tetrachloroethene (PCE)	1.60E+00	1.00E-02	ND	NA	ND	5.40E-01	NA
Hazard Index				1.74E-01			
Total Cancer Risk							2.79E-06

kg = kilogram
mg = milligram

RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

Table B-38. Risks and Hazards from Dermal Contact with Surface Water at Acid Area 1 for Child Residential Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Water (mg/L) RME	Reference Dose 1/(mg/kg-day)	Dermal Absorbed Dose RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Dermal Absorbed Dose RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	1.58E-02	3.00E-04	9.45E-07	3.15E-03	8.10E-08	1.50E+00	1.22E-07
Cobalt	8.46E-03	2.00E-02	5.06E-07	2.53E-05	4.34E-08	No toxicity value	NA
Iron	1.89E+01	7.00E-01	1.13E-03	1.62E-03	9.69E-05	No toxicity value	NA
Manganese	3.38E+00	4.67E-02	NA	NA	NA	No toxicity value	NA
Thallium	3.87E-03	7.00E-05	2.32E-07	3.31E-03	1.98E-08	No toxicity value	NA
1,1-Dichloroethane	2.97E-03	2.00E-01	1.48E-06	7.41E-06	1.27E-07	No toxicity value	NA
Carbon tetrachloride	4.60E-04	7.00E-04	6.67E-07	9.53E-04	5.72E-08	1.30E-01	7.43E-09
Trichloroethene (TCE)	2.62E-03	3.00E-04	2.48E-06	8.26E-03	2.12E-07	4.00E-01	8.50E-08
Hazard Index				1.73E-02			
Total Cancer Risk							2.14E-07

RME - Reasonable Maximum Exposure
RfD - Reference Dose
Sf-Slope factor

Table B-39. Risks and Hazards from Ingestion of Sediment at Acid Area 1 for Child Residential Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Fish (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	9.66E+00	3.00E-04	1.24E-05	4.12E-02	1.06E-06	1.50E+00	1.59E-06
Cobalt	2.30E+01	2.00E-02	2.94E-05	1.47E-03	2.52E-06	No toxicity value	NA
PCB-1254 (Aroclor 1254)	4.88E-01	2.00E-05	6.24E-07	3.12E-02	5.35E-08	2.00E+00	1.07E-07
PCB-1260 (Aroclor 1260)	8.07E-01	No toxicity value	1.03E-06	NA	8.84E-08	2.00E+00	1.77E-07
Benzo(a)anthracene	1.94E-01	No toxicity value	2.48E-07	NA	2.13E-08	7.30E-01	1.55E-08
Benzo(a)pyrene	1.52E-01	No toxicity value	1.94E-07	NA	1.67E-08	7.30E+00	1.22E-07
Benzo(b)fluoranthene	2.42E-01	No toxicity value	3.09E-07	NA	2.65E-08	7.30E-01	1.94E-08
Indeno(1,2,3-cd)pyrene	2.76E-01	No toxicity value	3.53E-07	NA	3.02E-08	7.30E-01	2.21E-08
N-Nitroso-di-n-propylamine	6.20E-01	No toxicity value	7.93E-07	NA	6.79E-08	7.00E+00	4.76E-07
Hazard Index				7.38E-02			
Total Cancer Risk							2.53E-06

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

Table B-40. Risks and Hazards from Dermal Contact with Sediment at Acid Area 1 for Child Residential Receptors at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Fish (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Arsenic	9.66E+00	3.00E-04	6.48E-07	2.16E-03	5.56E-08	1.50E+00	8.34E-08
Cobalt	2.30E+01	2.00E-02	ND	NA	ND	No toxicity value	NA
PCB-1254 (Aroclor 1254)	4.88E-01	2.00E-05	1.53E-07	7.64E-03	1.31E-08	2.00E+00	2.62E-08
PCB-1260 (Aroclor 1260)	8.07E-01	No toxicity value	2.53E-07	NA	2.17E-08	2.00E+00	4.33E-08
Benzo(a)anthracene	1.94E-01	No toxicity value	5.64E-08	NA	4.84E-09	7.30E-01	3.53E-09
Benzo(a)pyrene	1.52E-01	No toxicity value	4.42E-08	NA	3.79E-09	7.30E+00	2.77E-08
Benzo(b)fluoranthene	2.42E-01	No toxicity value	7.04E-08	NA	6.03E-09	7.30E-01	4.40E-09
Indeno(1,2,3-cd)pyrene	2.76E-01	No toxicity value	8.03E-08	NA	6.88E-09	7.30E-01	5.02E-09
N-Nitroso-di-n-propylamine	6.20E-01	No toxicity value	ND	NA	ND	7.00E+00	NA
Hazard Index				9.80E-03			
Total Cancer Risk							1.94E-07

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

APPENDIX B
RISK CALCULATIONS

Table L.126. Risks and Hazards from inhalation of volatile organic compounds from subsurface soil for construction worker exposures at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Soil (mg/L) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Tetrachloroethene (PCE)	1.60E+00	1.14E-01	7.02E-11	6.16E-10	5.02E-13	2.07E-02	1.04E-14
Hazard Index				6.16E-10			
Total Cancer Risk							1.04E-14

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

Table L.132. Risks and Hazards from inhalation of volatile organic compounds from subsurface soil for adult resident at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Soil (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Tetrachloroethene (PCE)	1.60E+00	1.14E-01	3.00E-01	2.63E+00	1.03E-01	2.07E-02	2.13E-03
Hazard Index				2.63E+00			
Total Cancer Risk							2.13E-03

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

Table L.138. Risks and Hazards from inhalation of volatile organic compounds from subsurface soil for a child resident at Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Exposure Point Concentration in Surface Soil (mg/kg) RME	Reference Dose 1/(mg/kg-day)	Intake Values (mg/kg-day) RME	Noncarcinogenic Effects: Hazard Quotient (Intake/RfD) RME	Intake Values (mg/kg-day) RME	Cancer Slope Factor (mg/kg-day)-1	Carcinogenic Effects: Excess Lifetime Cancer Risk (Intake x sf) RME
Tetrachloroethene (PCE)	1.60E+00	1.14E-01	3.00E-01	2.63E+00	1.03E-01	2.07E-02	2.13E-03
Hazard Index				2.98E+00			
Total Cancer Risk							2.13E-03

kg = kilogram
mg = milligram
RfD = reference dose
RME = reasonable maximum exposure
SF = slope factor

APPENDIX C

TOXICOLOGICAL PROFILES FOR CHEMICALS OF CONCERN

APPENDIX C

TOXICOLOGICAL PROFILES FOR THE CHEMICALS OF CONCERN

INTRODUCTION

Toxicological profiles are presented for each chemical of concern. The doubly 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, or, in the case of multiple isomers or members of a chemical class, in the introductory text or the table that provides the physical properties.

Toxicological profiles contain brief descriptions of the nature of the potential 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).

When sufficient data are available, the EPA Integrated Risk Information System (IRIS) presents the EPA's verified chronic toxicity values for noncancer effects, and for cancer risk (EPA, 2001). The toxicity values for noncancer effects include a reference dose (RfD) expressed in milligrams per kilogram per day (mg/kg-day) for chronic oral exposure, and a reference concentration (RfC), in milligrams per cubic meter (mg/m^3), for chronic 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. 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 body weight of 70 kg to yield an inhalation RfD expressed as mg/kg-day.

RfDs and RfCs 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 respond 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).

For cancer effects, IRIS presents a verified EPA cancer weight-of-evidence group classification that reflects qualitatively the likelihood that the chemical is carcinogenic to humans. IRIS also presents 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 and 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 ~ig/m3 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 µg/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 .

Toxicity values are not estimated for acute toxicity and acute exposure is not evaluated in the risk assessment. 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 (LD50) 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.

The toxicity profiles also provide documentation for physical 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 meter/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), and solubility in water (S) in milligrams per liter (mg/L) . In addition, organic chemicals are designated as volatile organic compounds (VOC) or semivolatile organic compounds (SVOC) based on their propensity to volatilize from environmental media. Chemicals designated as VOCs generally have a MW less than 200 g/mole and H greater than 1 E-5 atm-m^3/mole (EPA, 1991).

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, 1996) if the data are available. VP, S and H values are limited to those provided for normal ambient temperatures (0 to 30°C), but the temperatures reported in the original sources are not presented in the toxicity profile, nor is any attempt made to extrapolate K, VP or S to any default temperature.

When values for H were not located, they were calculated as follows, provided the requisite information was available (EPA, 1998):

$$H = \frac{VP \cdot MW}{S} \qquad \text{Eq. 1}$$

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 Da were not located, they were calculated as follows (EPA, 1998):

$$D_s = \frac{1.9}{MW^{2/3}} \qquad \text{Eq. 2}$$

where:

D_a = diffusivity in air (cm2/s, calculated)
MW = molecular weight (g/mole).

When values for DW were not located, they were calculated as follows (EPA, 1998):

$$D_w = \frac{22E-5}{MW^{2/3}} \qquad \text{Eq. 3}$$

where:

D_W = diffusivity in water (cm'/s, calculated)
MW = molecular weight (g/mole).

When values for Koc were not located, they were calculated as follows for phthalates and polyaromatic aromatic hydrocarbons (PAH) provided log K.,, was available (EPA, 1998):

$$\log K_{oc} = 0.97 \log K_{ow} - 0.094 \qquad \text{Eq. 4}$$

where:

K_{oc} = soil/organic carbon partition coefficient (unitless, calculated)
K_{ow} = octanol/water partition coefficient (unitless).

K_{oc}, for other organic chemicals was calculated as follows provided $\log K_{ow}$ was available (EPA, 1998):

$$\log K_{oc} = 0.18 \log K_{ow} + 0.151 \qquad \text{Eq. 5}$$

where:

K_{oc} = soil/organic carbon partition coefficient (unitless, calculated)
K_{ow} = octanol/water partition coefficient (unitless).

The toxicity profiles also present the predominant sources of release to the environment as well as a qualitative description of the fate of the chemical in air, surface water and sediment, and soil. No attempt is made to present quantitative data because environmental fate is usually highly dependent on climatic conditions and the characteristics of the medium to which the chemical is released, 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 many inorganic chemicals and those organic chemicals that are highly lipophilic and persist in the environment. 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. 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. Some of the SVOCs, however, are highly lipophilic. They may persist or yield

metabolites that are significant toxicants in their own right. For example, the organochlorine pesticide DDT is metabolized by mammals to DDE, which is similar in carcinogenic potency to the parent compound. Biotransfer factors are generally estimated for SVOCs that have log K_{ow} values greater than 3.

The biotransfer factors of interest are soil-to-plant biotransfer factors (B_p) and cattle ingestion-to-beef factors (B_b). 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 B_{pr}; soil-to-plant factors for the vegetative parts of plants are designated B_{pv}.

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}:

$$\log B_p = 1.588 - 0.578 \log K_{ow} \qquad \text{Eq. 6}$$

where:

B_p = 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 (B_{pr}) and the vegetative parts of plants (B_{pv}).

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.W:

$$\log B_p = 7.6 + \log K_{ow} \qquad \text{Eq. 7}$$

where:

B_b = cattle ingestion-to-beef biotransfer factor (days/kg, calculated)
K_{ow} = octanol/water partition coefficient (unitless).

This risk assessment followed EPA's *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part E - Supplemental Guidance for Dermal Risk Assessment)* (EPA 2004a). Therefore, oral RfDs and slope factors were used without modification. Additionally, only those constituents identified in the guidance as having sufficient data for dermal uptake from soil were evaluated for soil and sediment. Dermal absorbed doses for surface water and sediment were calculated using the spreadsheet model developed by EPA that accompanies the guidance.

References for Introduction

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.

Devillers, J., S . Bintein and D. Domine, 1996, "Comparison of BCF Models Based on Log P,"Chemosphere, 33(6): 1047-1065.

Hart, R.W. and L.T. Frame, 1996, "Toxicological Defense Mechanisms and How They May Affect the Nature of Dose-Response Relationships," Biological Effects of Low Level Exposure (BELLE) Newsletter, 5(1): 1-16.

Lyman, W. J., W. F. Reehl and D. H. Rosenblatt, 1990, Handbook of Chemical Property Estimation Methods, Environmental Behavior of Organic Compounds, American Chemical Society, Washington, DC.

Travis, C.C. and A.D. Arms, 1988, "Bioconcentration of Organics in Beef, Milk and Vegetation," Environmental Science and Technology, 22(3): 271-274.

U.S. Environmental Protection Agency (EPA), 1991, Risk Assessment Guidancefor Superfund: Volume I-Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), Interim, Office of Emergency and Remedial Response, Washington, DC, OSWER Publication 9285 .7-01B.

U.S. Environmental Protection Agency (EPA), 1992, Dermal Exposure Assessment: Principles and Applications, Interim Report, Office of Research and Development, Washington, DC, EPA/600/8-91/01 1 B, January.

U.S. 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), 1996, Soil Screening Guidance: Users Guide, Office of Solid Waste and Emergency Response, Washington, DC, Publication 9355.4-23, April.

U.S. Environmental Protection Agency (EPA), 2001, Integrated Risk Information System (IRIS), National Center for Environmental Assessment, Cincinnati, OH, on line.

INORGANIC CHEMICALS

ARSENIC (7440-38-2)

Arsenic is a natural metalloid that occurs in both inorganic and organic forms (ATSDR, 1998). Inorganic arsenic is more toxic than organic forms. Major uses in the U.S. include its incorporation into wood preservatives and other agricultural chemicals. Relevant physical properties are compiled below:

MW (g/mole)	log K_{ow} (unitless)	H (atm-m3/mole)	Kd (L/kg)	Da (cm2/s)	Dw (cm2/s)	VP (atm)	S (mg/L)
74.92 (element)	NA	NA	2.9e+1[a]	NA	NA	Note 1[b]	Note 2[b]

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 U.S . Environmental Protection Agency (EPA), 1996, Soil Screening Guidance: Users Guide, Office of Solid Waste and Emergency Response, Washington, DC, Publication 9355 .4-23, April.

b Agency for Toxic Substances and Disease Registry, (ATSDR), 1998, Update Toxicological Profile for Arsenic, U.S. Public Health Service, Atlanta, Georgia, April.

The major source of arsenic release to the environment is from copper, zinc and lead smelting operations (HSDB, 2001). Releases also occur from several other industries that use arsenic. Most (approximately 80 percent) anthropogenic releases are initially to soil (ATSDR, 1998).

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, 1998). 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 transformations and exist in several soluble forms. 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 mobility.

Biotransfer factors for arsenic are compiled below:

BCF (L/kg)	Bpr (unitless)	BPV (Unitless)	Bb (days/kg)
20[a]	6.0E-3[b]	4.0E-2[b]	2.0E-3[b]

a U .S. Environmental Protection Agency (EPA), 1998, Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities, Volume Two, Peer Review Draft, Office of Solid Waste and Emergency Response, Washington, DC, EPA530-D-98-001 B, July.

b Baes, C.F., R.D. Sharp, A.L . Sjoreen, R.W. Shor, 1984,AReview and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture, Health and Safety Division, Oak Ridge National Laboratory, ORNL-5786, September.

Data regarding the dermal uptake of arsenic were not located. The default ABS of 0 .01 for metals (OEPA, 1998) is used herein.

Inorganic arsenic may be an essential nutrient, exerting beneficial effects on growth, health and feed conversion efficiency (Underwood, 1977). A lethal dose of arsenic trioxide in humans is 70-180 mg (=50-140 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 hyperpigmentation and keratosis, as revealed by studies of several hundred Chinese exposed to naturally occurring arsenic in well water (EPA, 2001). Similar effects were observed in persons exposed to high levels of arsenic in water in Utah and the northern part of Mexico. EPA (2001) verified an RfD of 3E-4 mg/kg-day for chronic oral exposure, based on a NOAEL of 8E-4 mg/kg-day for hyperpigmentation 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. Confidence in the RfD is medium. EPA (2001) 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.

Occupational (predominantly inhalation) exposure is also associated with neurological deficits, anemia, and vascular effects (Ishinishi et al., 1986), but concomitant exposure to other chemicals cannot be ruled out. The data are not sufficient for estimation of an inhalation RfC. 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, 2001). Oral exposure to high levels in well water is associated with increased risk of skin cancer. 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. EPA (2001) 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 (2001) noted that the uncertainties associated with the oral unit risk are considerably less than those for most carcinogens, so that the unit risk might be reduced an order of magnitude. An inhalation URF of 4E-3 per pg/m3, 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.

References for Arsenic

Agency for Toxic Substances and Disease Registry, (ATSDR), 1998, Update Toxicological Profile for Arsenic, Draft for Public Comment, U.S. Public Health Service, Atlanta, Georgia, August.

Goyer, R.A., 1991, "Toxic Effects of Metals," in Casarett and DoullIs Toxicology, The Basic Science of Poisons, Fourth Edition, Amdur, M.O., J. Doull and C.D. Klaassen, Eds., Pergamon Press, New York, pp. 623-680.

Ishinishi, N., K. Tsuchiya, M. Vahter and B.A. Fowler, 1986, "Arsenic," In: Friberg, L., G.F. Nordberg and V.B. Vouk, Eds., Handbook on the Toxicology of Metals, Volume 11, Second Edition, New York: Elsevier Science Publishers B.V., pp. 43-83.

Ohio Environmental Protection Agency (OEPA), 1998, U.S. NASA Plum Brook, Erie County, Ohio LD#: 322-0552, Risk Assessment Work Plans, letter from R.E. Nabors, Site Coordinator, to L.S. Ingram, Department of the Army, June 22.

Underwood, E.J., 1977, Trace Elements in Human and Animal Nutrition, Fourth Edition, New York: Academic Press, pp. 424-429.

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

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 /011 B, January.

U.S. Environmental Protection Agency (EPA), 1993, "Oral and Dermal Absorption Factors for Multiple Chemicals (FEMP O.U. #4/Fernald, OH)," Memorandum from Joan Dollarhide, ECAO, to Pat Van Leeuwen, Region V, dated July 21.

U.S. Environmental Protection Agency (EPA), 2001, Integrated Risk Information System (IRIS), On-line, Environmental Criteria and Assessment Office, Cincinnati, OH.

LEAD (7439-92-1)

Lead is a naturally occurring metal used in the manufacture of batteries, ammunition, and other metal products (ATSDR, 1997). Relevant physical properties are compiled below:

MW (g/mole)	log K_{ow} (unitless)	H (atm-m3/mole)	Kd (L/kg)	Da (cm2/s)	Dw (cm2/s)	VP (atm)	S (mg/L)
207.2 (element)	NA	NA	ND	NA	NA	ND	9.9E-3[a]

NA = not applicable, ND = do data

a Value for lead chloride as a typical lead salt (Agency for Toxic Substances and Disease Registry, [ATSDR], 1997, Update Toxicological Profile for Lead, Draft for Public Comment, U.S . Public Health Service, Atlanta, Georgia, August.)

Lead may enter the environment during mining, ore processing, smelting, refining, use, recycling or disposal (ATSDR, 1997; HSDB, 2001). Emission from automobile exhaust was at one time the largest source of atmospheric lead. Natural sources are minor compared with anthropogenic sources. Generally the form of lead that enters the atmosphere is not known. However, metallic lead may be released from smelting and refining plants. Lead in air exists attached to small particles that may travel great distances before removal by wet or dry deposition. Lead deposited on or released to soil generally remains in the top 2 to 5 cm where it remains relatively immobile, although a small percentage may be present in soluble forms that are subject to leaching. Acid conditions increase the potential for leaching. Lead released to surface water tends to form salts that are only sparingly soluble. Deposition in bed sediment is the primary removal mechanism, although biomethylation may mobilize lead and return it to the water column. Soil and sediment act as sinks for anthropogenic releases of lead.

Lead in fish is localized in the mucus on the epidermis, the dermis, and scales so that the edible portions generally do not pose a hazard to human health (HSDB, 2001). Therefore, the BCF listed below probably overstates the danger to humans. Lead does not biomagnify through the aquatic or terrestrial food chains (ATSDR, 1997). Biotransfer factors for lead are compiled below:

BCF (L/kg)	Bpr (unitless)	BPV (Unitless)	Bb (days/kg)
49[a]	9.0E-3[b]	4.5E-2[b]	3.0E-4[b]

a U.S. Environmental Protection Agency (EPA), 1986, Superfund Public Health Evaluation Manual, Office of Emergency and Remedial Response, Washington, DC, OSWER Directive 9285-4-1, EPA/540/1-86/060, PB87-183125, October .

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 .

The noncancer toxicity of lead to humans has been well characterized through decades of medical observation and scientific research (EPA, 2001). The principal effects of acute oral exposure are gastrointestinal colic with diffuse paroxysmal abdominal pain (probably due to vagal irritation), anemia, and, in severe cases, acute encephalopathy, particularly in children (Tsuchiya, 1986). The primary effects of long-term exposure are neurological and hematological. Limited occupational data indicate that long-term exposure to lead may induce kidney damage. The principal target organs of lead toxicity are the nervous system and the erythrocyte. Some of the effects on the blood, particularly changes in levels of certain blood enzymes, and subtle neurobehavioral changes in children, appear to occur at levels so low as to be considered non-threshold effects. In part for this reason the EPA (1990, 2001) considered inappropriate the derivation of an RfD for chronic oral exposure.

The Integrated Exposure, Uptake Biokinetic Model (IEUBK) Version 0.99D (EPA, 1994a) is generally used to evaluate lead in children, the most sensitive receptor under a residential

exposure scenario. The IEUBK model integrates lead uptake from inhalation, drinking water, diet, soil and dust ingestion, and ingestion of incidental sources such as chips of lead-based paint, and estimates blood lead concentrations over the first seven years of a child's life. Generally, it is considered that childhood blood lead levels below 10 µg/dL reflect minimal likelihood of adverse effects from exposure to lead. Since it is plausible that children could be present under most residential site-use scenarios, it is appropriate to use the IEUBK to establish target levels for lead in soil for residential use. EPA (1994b) used the IEUBK to estimate a lead concentration of 400 mg/kg in bare soil to which children might be regularly exposed as the level below which further evaluation and exposure-reduction action is not necessary.

The IEUBK, however, does not address lead concentrations in media to which adults may be exposed in a non-residential site-use scenario. EPA (1996) adopted a model similar to the IEUBK to estimate blood lead concentrations in adult women in an occupational exposure scenario. The pregnant woman is assumed to be the member of the adult population most sensitive to exposure to lead because of the potential for developmental effects on the fetus. The EPA (1996) adult blood lead model estimates a lead concentration in soil of approximately 750 mg/kg (EPA, 2001) as the level below which the 95' percentile fetal blood lead concentration would not exceed 10 µg/dL.

EPA (2001) classified lead in cancer weight-of-evidence Group B2 (probable human carcinogen), based on inadequate evidence in humans and sufficient animal evidence. The human data consist of several epidemiologic occupational studies that yield confusing results. All the studies lacked quantitative exposure date and failed to control for smoking and concomitant exposure to other possibly carcinogenic metals. Rat and mouse bioassays showed statistically significant increases in renal tumors following dietary and subcutaneous exposure to several soluble lead salts. Various lead compounds were observed to induce chromosomal alterations in vivo and in vitro, sister chromatid exchange in exposed workers and cell transformation in Syrian hamster embryo cells, to enhance simian adenovirus induction, and to alter molecular processes that regulate gene expression. EPA (2001) declined to estimate risk for oral exposure to lead because many factors (e.g., age, general health, nutritional status, existing body burden and duration of exposure) influence the bioavailability of ingested lead, introducing a great deal of uncertainty into any estimate of risk.

References for Lead

Agency for Toxic Substances and Disease Registry, (ATSDR), 1997, Update Toxicological Profile for Lead, Draft for Public Comment, U.S. Public Health Service, Atlanta, GA, August.

Hazardous Substance Data Bank (HSDB), 2001, National Library of Medicine, on line.

Ohio Environmental Protection Agency (OEPA), 1998, U.S. NASA Plum Brook, Erie County, Ohio LD#: 322-0552, Risk Assessment Work Plans, letter from R.E. Nabors, Site Coordinator, to L.S. Ingram, Department of the Army, June 22.

Tsuchiya, K., 1986, "Lead," In: Friberg, L., G.F. Nordberg and V.B. Vouk, Eds., Handbook on the Toxicology of Metals, Volume 11, Second Edition, New York: Elsevier Science Publishers B.V. pp. 298-353.

U.S. Environmental Protection Agency (EPA), 1990, Technical Support Document for Lead, Prepared by the Chemical Hazard Assessment Division, Syracuse Research Corporation, under contract to the Environmental Criteria and Assessment Office, Cincinnati, OH.

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 /011 B, January.

U.S. Environmental Protection Agency (EPA), 1993, "Oral and Dermal Absorption Factors for Multiple Chemicals (FEMP O.U. #4/Femald, OH)," Memorandum from Joan Dollarhide, ECAO, to Pat Van Leeuwen, Region V, dated July 21.

U.S. Environmental Protection Agency (EPA), 1994a, Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children, Office of Emergency and Remedial Response, Publ. No. 9285-7-15-1, EPA/540/R-93/081, NTIS No. PB93-963510.

U.S. Environmental Protection Agency (EPA), 1994b, "Guidance on Residential Lead-Based Paint, Lead-Contaminated Dust, and Lead-Contaminated Soil," Memorandum from L.R. Goldman to regional directors, 14 July.

U.S. Environmental Protection Agency (EPA), 1996, Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil, Technical Review Workgroup for Lead, December.

U.S. Environmental Protection Agency (EPA), 2004, Region 9 Preliminary Remediation Goals (PRGs) 2004 Update, online, 1 November.

U.S. Environmental Protection Agency (EPA), 2001, Integrated Risk Information System (IRIS), On-line, Environmental Criteria and Assessment Office, Cincinnati, OH.

MANGANESE (7439-96-5)

Manganese is a naturally occurring metal used in the manufacture of steel, and in other metallurgical processes, batteries, and various manganese-containing chemicals including matches, glass and porcelain, fireworks, varnishes, ceramics and fungicides (ATSDR, 1997; Keen and Leach, 1988). Relevant physical properties are compiled below:

MW (g/mole)	log K_{ow} (unitless)	H (atm-m3/mole)	Kd (L/kg)	Da (cm2/s)	Dw (cm2/s)	VP (atm)	S (mg/L)
54.94 (element)	NA	NA	ND	NA	NA	ND	Note 1[a]

NA = not applicable, ND = do data

Note 1: Metallic manganese decomposes in the presence of water. Manganous chloride as a typical manganese salt: 7.23E+5.

a Agency for Toxic Substances and Disease Registry, (ATSDR), 1997, Update Toxicological Profle for Manganese, Draft for Public Comment, U.S. Public Health Service, Atlanta, Georgia, September.

Anthropogenic sources of atmospheric manganese include metal processing, disposal of manganese-containing materials, resuspension of manganese-containing soil dust, fly ash emissions from incinerators, and the combustion of gasoline containing manganese anti-knock ingredients (ATSDR, 1997; HSDB, 2001). Manganese may be released to water by discharge from industrial facilities or in leachate from landfills and soil. Landfill disposal of manganese-containing wastes is the predominant source of manganese release to soil.

Manganese exists in the air bound to particles; dry deposition is the primary removal mechanism, although wet deposition may also be significant (ATSDR, 1997). Manganese in fly ash exists as chlorides and oxides that are relatively soluble and mobile in the environment.

Manganese in water exists as any number of sparingly soluble salts that attach to suspended sediment (ATSDR, 1977). Sedimentation is the primary removal process. Soluble forms also exist, depending on pH of the water, and may be released from sediment. The extent of absorption to constituents of soil is highly variable. Low concentrations may occur in an irreversibly "fixed" form to clay, but higher concentrations often manifest considerable mobility.

Biotransfer factors for manganese are compiled below:

BCF (L/kg)	Bpr (unitless)	BPV (Unitless)	Bb (days/kg)
See Below	5.0E-2[a]	2.5E-1[a]	4.0E-4[a]

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.

Manganese in aquatic systems tends to bioaccumulate more strongly in plants and lower trophic levels, and less strongly in edible fish. ATSDR (1997) reports BCFs of 10,000 to 20, 000 L/kg for marine and freshwater plants, 2500 to 6300 L/kg for phytoplankton, 300 to 5500 L/kg for marine algae, 800 to 830 L/kg for intertidal mussels, and 100 to 600 L/kg reported for fin fish. The midpoint of the BCF range for intertidal mussels of 815 L/kg is used herein for shellfish. The midpoint of the BCF range for fin fish of 350 L/kg is used herein for fin fish.

Keen and Leach (1988) and ATSDR (1997) reviewed the empirical data and reported that approximately three to five percent of dietary manganese is absorbed, regardless of the amount present in the diet. EPA (2001) selected five percent as a rough approximation of the extent of GI absorption. This value (0.05) is selected as the GAF for manganese.

The ABS of 0.01 is an OEPA (1998) default for metals for which empirical data are lacking.

Manganese is nutritionally required in humans for normal growth and health (EPA, 2001). Humans exposed to approximately 0.8 mg manganese/kg-day in drinking water (28 mg/L) exhibited lethargy, increased muscle tonus, tremor and mental disturbances. The elderly appeared to be more sensitive than children. Oral treatment of laboratory rodents induces biochemical changes in the brain, but rodents do not exhibit the neurological signs exhibited by humans. Occupational exposures to high concentrations in air induce a generally typical spectrum of neurological effects, and increased incidence of pneumonia (ACGIH, 1991).

EPA (2001) derived an oral RfD for manganese of 1.4E-1 mg/kg-day from a NOAEL of I .4E-1 mg/kg-day for neurologic effects from human dietary studies and an uncertainty factor of 1. Confidence in the RfD is medium. The oral RfD of 1 .4E-1 mg/kg-day will be used for dietary items other than drinking water. EPA (2001) recommends that a modifying factor of 3 should be used to adjust the RfD for use when oral exposure involves drinking water and non-dietary ingestion. The oral RfD resulting from application of the modifying factor, 4 .7E-2 mg/kg-day, will be used for drinking water and incidental ingestion of non-dietary items, and will serve as the basis for developing the dermal RfD. The CNS is the target organ for chronic oral exposure to manganese. EPA (2001) presents a verified chronic inhalation RfC of 5E-5 mg/m3 (equivalent to an inhalation RfD of 1 .4E-5 mg/kg-day) based on a LOAEL for neurological effects in occupationally exposed humans and an uncertainty factor of 1000. Confidence in the RfC is medium. The CNS is the target organ for inhalation exposure to manganese.

EPA (2001) classified manganese in cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans). Quantitative cancer risk estimates are not derived for Group D chemicals.

References for Manganese

Agency for Toxic Substances and Disease Registry, (ATSDR), 1992, Toxicological Profile for Acetone, Draft for Public Comment, U.S. Public Health Service, Atlanta, Georgia.

American Conference of Governmental Industrial Hygienists (ACGIH), 1991, Documentation of the Threshold Limit Values and Biological Exposure Indices, Sixth Edition, ACGIH, Cincinnati, OH, pp. 10-11.

Hazardous Substance Data Bank (HSDB), 2001, National Library of Medicine, on line.

Ohio Environmental Protection Agency (OEPA), 1998, U.S. NASA Plum Brook, Erie County, Ohio LD#: 322-0552, Risk Assessment Work Plans, letter from R.E. Nabors, Site Coordinator, to L.S. Ingram, Department of the Army, June 22.

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), 2001, Integrated Risk Information System (IRIS), National Center for Environmental Assessment, Cincinnati, OH, on line.

Benzene (71-43-2)

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, 1995). 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 a component of gasoline. Relevant physical properties are compiled below:

MW (g/mole)	log K_{ow} (unitless)	H (atm-m3/mole)	Kd (L/kg)	Da (cm2/s)	Dw (cm2/s)	VP (atm)	S (mg/L)
78.1	2.13[a]	5.56E-3[b]	1.77[b]	8.8E-2[b]	9.8E-6[b]	1.25E-1[c]	1.75E+3[b]

a U.S . Environmental Protection Agency (EPA), 1992, Dermal Exposure Assessment: Principles and Applications, Interim Report, Office of Research and Development, Washington, DC, EPA/600/8-91/01113, January.

b U.S . Environmental Protection Agency (EPA), 1996, Soil Screening Guidance: Users Guide, Office of Solid Waste and Emergency Response, Washington, DC, Publication 9355 .4-23, April. c U. S. Environmental Protection Agency (EPA), 1994, Technical Background Document for Soil Screening Guidance, Review Draft, Office of Solid Waste and Emergency Response, Washington, DC, Publication No. 9355.4-17, EPA540/R-94/106, PB95-963532, November.

Benzene will enter the atmosphere primarily from fugitive emissions and exhaust connected with its use in gasoline (ATSDR, 1995; HSDB, 2001). Other important sources are emissions associated with its production and use as a solvent, as an industrial intermediate in the production of 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.

Benzene released to the atmosphere will exist almost exclusively in the vapor phase (ATSDR, 1995; HSDB, 2001). 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 which contain nitrogen oxides or sulfur dioxide is accelerated with the half-life being reported as 4-6 hours. Products ofphotooxidation 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, 1995; HSDB, 2001). Benzene may be subject to biodegradation under aerobic conditions. Microbial transformation proceeds through formation of cis-dihydrodiols to catechols, which lead to fission 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, 1995; HSDB, 12001). Benzene released to surface water will be subject to rapid volatilization. It is not expected to sorb to sediment or to hydrolyze significantly. It may be subject to biodegradation, but this is unlikely to be a significant fate process in sediment.

Benzene is not expected to participate significantly in food-chain pathways (HSDB, 2001); therefore, biotransfer factors are not provided.

The OEPA (1998) default ABS of 0.1 for organic chemicals is adopted for this 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, 1995). Oral dosing in animals induces hematopoietic and immune effects. EPA (1996) derived a provisional RfD for chronic oral exposure of 3E-3 mg/kg-day, based on a LOAEL of

8 mg/kg-day in a 28-day drinking water study in mice. The LOAEL was associated with minor hematologic effects (erythrocytopenia, leucopenia, lymphocytopenia), all associated with decreased cell counts, and increased response in several tests of immunologic activity. Depressed immunologic activity was observed at higher dose levels. An uncertainty factor of 3000 was applied to derive the provisional RfD from the LOAEL. Confidence in the RfD is medium. The hematopoietic mechanism and the immune system are the target organs for chronic oral exposure to benzene.

A provisional chronic inhalation RfC of 6E-3 mg/m^3 for benzene was based on a LOAEL of 32 mg/m^3 for depressed hematopoiesis in a study in which mice were exposed intermittently for up to 178 days (EPA, 1994). The exposure concentration was adjusted to an equivalent human continuous exposure concentration of 5.7 mg/m^3. Application of an uncertainty factor of 1000 to the LOAEL of 5 .7 mg/m^3 yields the RfC of 6E-3. The RfC is equivalent to an RfD of 1.7E-3 mg/kg-day. Confidence in the inhalation RfC is low. The hematopoietic mechanism and the immune system are the target organs for chronic inhalation exposure to benzene.

Benzene is classified as an EPA cancer weight-of-evidence Group A chemical (known human carcinogen) based on epidemiologic studies and case studies that provide clear evidence of a causal association between exposure to benzene and acute nonlymphocytic leukemia, and that also provide supportive evidence for chronic nonlymphocytic leukemia and chronic lymphocytic leukemia (EPA, 2001). Other neoplastic conditions that are associated with an increased risk in humans are 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 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, 2001). 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 (2001) 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 4g/m3, is conservatively selected for this evaluation. The URF of 7.8E-6 per ~Lg/m3 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, 2001). 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. EPA (2001) assumed that GI absorption is 100 percent and that respiratory tract uptake is 50 percent. 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 selected as the oral SF for this evaluation.

References for Benzene

Agency for Toxic Substances and Disease Registry, (ATSDR), 1995, Update Toxicological Profile for Benzene, Draft for Public Comment, U.S. Public Health Service, Atlanta, Georgia, August.

Hazardous Substance Data Bank (HSDB), 2001, National Library of Medicine, on line.

Jones, T.D. and BA Owen, 1989, Health Risks from Mixtures of Radionuclides and Chemicals in Drinking Water, Oak Ridge National Laboratory, Oak Ridge, TN, ORNL-6533.

Ohio Environmental Protection Agency (OEPA), 1998, U.S. NASA Plum Brook, Erie County, Ohio LD#: 322-0552, Risk Assessment Work Plans, letter from R.E. Nabors, Site Coordinator, to L.S. Ingram, Department of the Army, June 22.

U.S. Environmental Protection Agency (EPA), 1992, Dermal Exposure Assessment: Principles and Applications, Interim Report, Office of Research and Development, Washington, DC, EPA/600/8-91/01 1 B, January.

U.S. Environmental Protection Agency (EPA), 1994, Risk Assessment Issue Paper for: Derivation of a Provisional Chronic Inhalation RfC for Benzene (CASRN 71-43-2), National Center for Environmental Assessment, Cincinnati, OH, March 23.

U.S. Environmental Protection Agency (EPA), 1996, Risk Assessment Issue Paper for: Derivation of a Provisional Oral RfD for Benzene (CASRN 71-43-2), National Center for Environmental Assessment, Cincinnati, OH, July 2.

U.S. Environmental Protection Agency (EPA), 2001, Integrated Risk Information System (IRIS), National Center for Environmental Assessment, Cincinnati, OH, on line.

NITROTOLUENES

The nitrotoluenes consist of three isomers: o-nitrotoluene (2-nitrotoluene), m-nitrotoluene (3-nitrotoluene) and p-nitrotoluene (4-nitrotoluene) (Lewis, 1997). All behave in the environment as VOCs. The nitrotoluenes, especially the o- and p-isomers, are used as intermediates in the synthesis of other organic chemicals, particularly toluidine, tolidine, fuchsine and other synthetic dyes, explosives, petrochemicals, pesticides, pharmaceuticals, rubber and agricultural chemicals, dyes and pigments (HSDB, 2001). Relevant physical properties are compiled below:

MW (g/mole)	log K_{ow} (unitless)	H (atm-m^3/mole)	Kd (L/kg)	Da (cm2/s)	Dw (cm2/s)	VP (atm)	S (mg/L)
o-nitrotoluene (88-72-2)							
137.13	2.3[a]	5.56E-5[a]	2.44[a]	7.14E-2[b]	8.0E-6[c]	1.32E-4[c]	6.52E+2[a]
m-nitrotoluene (99-08-1)							
137.13	2.45[a]	7.5E-5[a]	2.16[a]	7.14E-2[b]	8.0E-6[c]	2.72E-4[c]	4.98E+2[c]
p-nitrotoluene (99-99-0							
137.13	2.37[a]	5.0E-5[a]	2.49[a]	7.14E-2[b]	8.1E-6[c]	1.22E-4[c]	4.22E+2[c]

a Hazardous Substance Data Bank (HSDB), 2001, National Library of Medicine, on line.
b Calculated as described in Introduction to the Toxicity Profiles.
c Montgomery, J .H., 1996, Groundwater Chemicals Desk Reference, Second Edition, Lewis Publishers, New York, pp. 790-795 .

The major sources of release of nitrotoluenes to the environment appear to be production and use facilities and plants which produce these compounds as by-products (HSDB, 2001). These include manufacturers of dinitrotoluene, trinitrotoluene, intermediates for rubber and agricultural chemicals, and various azo and sulfur dye intermediates. Nitrotoluenes may also enter the environment from the disposal of waste products which contain these compounds.

Nitrotoluenes released to soil are expected to be resistant to oxidation and chemical hydrolysis (HSDB, 2001). The nitrotoluenes are reported to biodegrade under anaerobic conditions to form toluidine; one study under aerobic conditions in a mixed culture of soil microorganisms resulted in persistence exceeding 64 days. The nitrotoluenes are expected to be moderately to highly mobile in soil and volatilize slowly from dry soil surfaces.

Nitrotoluenes released to water are expected to be susceptible to photolysis, volatilization and aerobic biodegradation, provided suitable acclimation has been achieved (HSDB, 2001). Oxidation, chemical hydrolysis, adsorption to suspended solids and sediments and bioaccumulation in aquatic organisms are not expected to be significant fate processes. Insufficient data were available to indicate the significance of anaerobic biodegradation as a possible removal mechanism. Nitrotoluenes released to the atmosphere are expected to exist entirely in the vapor phase (HSDB, 2001). The dominant removal mechanism is expected to be reaction with photochemically generated hydroxyl radicals (estimated half-life 8 hours) and direct photolysis. Photoproducts include 2-methyl-6-nitrophenol and 2-methyl-4-nitrophenol (o-isomer), 3-methyl- 4-nitrophenol, 3-methyl-2-nitrophenol and 3-methyl-6-nitrophenol (m-isomer) and 2-methyl-6- nitrophenol (p-isomer).

The nitrotoluenes are not expected to bioconcentrate or bioaccumulate significantly (HSDB, 2001); therefore, biotransfer factors are not estimated.

Data regarding the dermal uptake of the nitrotoluenes from soil were not located in the available literature; the OEPA (1998) default ABS of 0.1 for organic chemicals is selected for this evaluation.

Data regarding the acute toxicity of oral exposure to the nitrotoluenes were not located. A 13-week dietary study with the three nitrotoluene isomers in rats and mice indicated that effects were most notable with o-nitrotoluene (ACGIH, 1991). Effects included biochemical evidence

of altered liver function, and splenic and renal lesions. EPA (1997) derived a provisional RfD of 1 E-2 mg/kg-day for chronic oral exposure to all three nitrotoluene isomers from data for o-nitrotoluene. In the key study, rats were treated by gavage for 6 months. The LOAEL was 200 mg/kg-day associated with lesions in the spleen. An uncertainty factor of 10,000 was applied to the LOAEL. The derivation of the provisional RfD is unclear, because dividing the LOAEL of 200 mg/kg-day by an uncertainty factor of 10,000 would be expected to yield an RfD of 2E-2 mg/kg-day, not l E-2 mg/kg-day as reported by EPA (1997). The liver, spleen and kidney are considered to be the target organs for chronic oral exposure to the nitrotoluenes.

Data regarding the toxicity of inhalation exposure to the nitrotoluenes were not located in the available literature. The data are inadequate for developing an inhalation RfC.

Data regarding the potential carcinogenicity of the nitrotoluenes were not located in the available literature. The nitrotoluenes are not assigned to a cancer weight-of-evidence group and URFs and SFs are not available.

References for Nitrotoluenes

Agency for Toxic Substances and Disease Registry, (ATSDR), 1990, Toxicological Profile for Nitrobenzene, U.S. Department of Health and Human Services, Atlanta, GA.

Agency for Toxic Substances and Disease Registry, (ATSDR), 1997, Update Toxicological Profile for 2,4-Dinitrotoluene and 2,6-Dinitrotoluene, Draft for Public Comment, U.S. Department of Health and Human Services, Atlanta, GA, September.

American Conference of Governmental Industrial Hygienists (ACGIH), 1991, Documentation of the Threshold Limit Values and Biological Exposure Indices, Sixth Edition, ACGIH, Cincinnati, OH, pp. 1131-1133.

Hazardous Substance Data Bank (HSDB), 2001, National Library of Medicine, on line.

Lewis, R.J., Sr., 1997, Hawley's Condensed Chemical Dictionary, Thirteenth Edition, John Wiley & Sons, Inc., New York, pp. 800-801.

Ohio Environmental Protection Agency (OEPA), 1998, U.S. NASA Plum Brook, Erie County, Ohio LD#: 322-0552, Risk Assessment Work Plans, letter from R.E. Nabors, Site Coordinator, to L.S. Ingram, Department of the Army, June 22.

Environmental Protection Agency (EPA), 1992a, Health Advisory for 2,4- and 2,6-Dinitrotoluene (DNT), Health and Ecological Criteria Division, Office of Water, Washington, DC.

U.S. Environmental Protection Agency (EPA), 1992b, Dermal Exposure Assessment: Principles and Applications, Interim Report, Office of Research and Development, Washington, DC, EPA/600/8-91/01 1 B, January.

U.S. Environmental Protection Agency (EPA), 1997, Health Effects Assessment Summary Tables, FY1997 Update, Office of Solid Waste and Emergency Response, Washington, DC, 9200.6-303(97-1), EPA 540/R-97-036, PB97-921199.

POLYAROMATIC HYDROCARBONS (PAHs)

The PAHs COCs are benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. All are SVOCs. PAHs are the products of incomplete combustion of fossil fuels or other organic matter, hence include both natural and anthropogenic sources (ATSDR, 1993a). Relevant physical properties are compiled below:

MW (g/mole)	log K_{ow} (unitless)	H (atm-m^3/mole)	Kd (L/kg)	Da (cm2/s)	Dw (cm2/s)	VP (atm)	S (mg/L)
benzo(a)anthracene (56-55-3)							
228.29	5.66[a]	1.6E-6[a]	5.30[a]	5.10E-2[d]	9.0E-6[d]	2.9E-11[c]	I[a]
Benzo(a)pyrene (50-32-8)							
252.3	6.16[e]	4.9E-7[a]	6.74[a]	4.30E-2[d]	9.0E-6[d]	7.4E-12[a]	3.8E+3[a]
Benzo(b)fluoranthene (99-99-0)							
252.3	6.12[e]	1.22-5[a]	5.74[a]	2.26E-2[d]	5.56E-6[d]	1.3E-9[a]	I[a]
Benzo(k)fluoranthene (207-08-9)							
252.3	6.06[a]	3.87-5[a]	5.74[a]	2.26E-2[d]	5.56E-6[d]	6.6E-10[a]	I[a]
Dibenz(a,h)anthracene (53-70-3)							
278.35	6.84[e]	7.3-8[a]	6.52[a]	2.02E-2[d]	5.18E-6[d]	8.2E-12[a]	5E-7[a]
Indeno(1,2,3-cd)pyrene (193-39-5)							
276.3	6.58[e]	6.95-8[a]	6.20[a]	1.90E-2[d]	5.66E-6[d]	1.3E-12[a]	6.23E-2[a]

a Agency for Toxic Substances and Disease Registry (ATSDR), 1993a, Update Toxicological Profile for Polycyclic Aromatic Hydrocarbons (PAHs), Draft for Public Comment, U.S. Department of Health and Human Services, Atlanta, Georgia, October.

b Montgomery, J.H ., 1996, Groundwater Chemicals Desk Reference, Second Edition, Lewis Publishers, New York.

c Calculated as described in Introduction to the Toxicity Profiles. 'U.S. Environmental Protection Agency (EPA), 1996,

d Soil Screening Guidance: Users Guide, Office of Solid Waste and Emergency Response, Washington, DC, Publication 9355 .4-23, April.

e U.S. Environmental Protection Agency (EPA), 1992, Dermal Exposure Assessment: Principles and Applications, Interim Report, Office of Research and Development, Washington, DC, EPA/600/8-91/01113, January.

f U .S. Environmental Protection Agency (EPA), 1994, Technical Background Document for Soil Screening Guidance, Review Draft, Office of Solid Waste and Emergency Response, Washington, DC, Publication No . 9355 .4-17, EPA540/R-94/106, PB95-963532, November. 9

g Agency for Toxic Substances and Disease Registry, (ATSDR), 1993b, Update Toxicological Profile for Naphthalene, Draft for Public Comment, U.S. Public Health Service, Atlanta, Georgia, October.

The PAHs are ubiquitous products of incomplete combustion; natural sources include volcanoes and forest fires (ATSDR, 1993a, b; HSDB, 2001). 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. 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. Naphthalene is released during its manufacture and processes that involve its use (e.g., vaporization from moth balls).

PAHs exist in the atmosphere as bothgases and particulates, the proportion depending on the vapor pressure of the individual chemical (ATSDR, 1993a, b; HSDB, 2001). They may travel short or long distances before removal from the air. Wet and dry deposition accounts for removal of the particulates. Vapor forms are subject to chemical oxidation processes in the air.

The predominant sources of PAHs in surface water are deposition from the atmosphere, industrial and sewage effluent and oil spills (ATSDR, 1993x, b). Runoff and erosion can also contribute PAHs to surface water bodies. Depending on solubility and vapor pressure, volatilization is a significant fate process for some of the PAHs in surface water. Adsorption to sediment is another significant removal process. Low molecular weight PAHs (acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, phenanthrene) are subject to chemical degradation and biodegradation. Naphthalene is relatively water soluble and may remain largely in solution. PAHs in sediment may biodegrade or accumulate in living organisms.

Deposition from the atmosphere is the principal source of PAHs in soil (ATSDR, 1993a, 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 propensity for the PAHs to participate in food-chain pathways is chemical specific, depending largely on the tendency for biodegradation or biotransformation (ATSDR, 1993a, b; HSDB, 2001). Biotransfer factors for the PAHs are compiled below:

BCF (L/kg)	B_{pr}[a,b] (unitless)	B_{pv}[a,b] (unitless)	B_b (days/kg)
benzo(a)anthracene (56-55-3)			
350[e]	2.07E-2	2.07E-2	1.15E-2
Benzo(a)pyrene (50-32-8)			
480[c]	1.07E-2	1.07E-2	3.63E-2
Benzo(b)fluoranthene (99-99-0)			
2800[f]	1.12E-2	1.12-2	3.31E-2
Benzo(k)fluoranthene (207-08-9)			
17,100[a]	6.78E-3	6.78E-3	2.88E-2
Dibenz(a,h)anthracene (53-70-3)			
10[e]	5.33E-2	5.33E-2	2.24E-3
Indeno(1,2,3-cd)pyrene (193-39-5)			
12,800[a]	6.09E-3	6.09E-3	9.55E-2

a Calculated as described in Introduction to the Toxicity Profiles.
b The methodology for estimating biotransfer of organic chemicals to plants does not differentiate vegetative and reproductive portions .
c Empirical data in Bluegill Sunfish (Lepomis macrochirus) from Hazardous Substance Data Bank (HSDB), 2001, National Library of Medicine, on line.
d Estimated value from Hazardous Substance Data Bank (HSDB), 2001, National Library of Medicine, on line.
e Empirical data in golden ide fish (Leuciscus idus melanotus) from Hazardous Substance Data Bank (HSDB), 2001, National Library of Medicine, on line .
f Empirical data in clams from Hazardous Substance Data Bank (HSDB), 2001, National Library of Medicine, on line.
g Empirical data in guppies (Poecilia reticulata), from Hazardous Substance Data Bank (HSDB), 2001, National Library of Medicine, on line.
h Empirical data in fathead minnows, from Hazardous Substance Data Bank (HSDB), 2001, National Library of Medicine, on line .

The BCF for indeno(1,2,3-cd)pyrene may be overestimated because the PAHs are generally readily metabolized by vertebrates, reducing the potential for bioconcentration (ATSDR, 1993a; HSDB, 2001). The BCF for benzo(b)fluoranthene is probably overestimated for fin fish because fin fish biotransform and eliminate PAHs much more readily than invertebrates.

Toxicokinetic studies of several PAHs summarized by ATSDR (1993a) provide limited quantitative information regarding the extent of GI absorption. Qualitatively, these studies indicate that absorption is incomplete. A study of benzo(a)pyrene in rats suggested that GI absorption ranges from 38 to 58 percent. The GAF of 0.5 (Jones and Owen, 1989), near the midpoint of the range from the rat study, is selected for benzo(a)pyrene and the other PAHs for which quantitative data are not available. GI absorption of dibenzo(a,h)anthracene is described as high; a GAF of 0 .8 is assumed for this compound.

Empirical data with pure compound dissolved or suspended in vehicles suggest that dermal uptake of benzo(a)pyrene is extensive (ATSDR, 1993x), but data regarding absorption from soil were not located. Lacking suitable empirical data for dermal uptake from soil, the OEPA (1998) Region IV default ABS of 0.1 for organic chemicals is chosen for the PAHs.

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. No Group D PAHs were retained as COCs.

Cancer SFs and URFs are available for the Group B2 compounds but noncancer RfDs or RfCs are not. Therefore, evaluation and RGO development for these compounds are 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.

Recent data, however, support this assumption. De Jong et al. (1999) 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. Forestomach lesions were found in the 30 and 90 mg/kg group. 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 an adjusted NOAEL of 2.1 mg/kg-day. 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 benzo(a)pyrene is essentially limited to one study and several toxicological endpoints (e.g., developmental, reproductive, neurological) were not investigated .

Benzo(a)pyrene is the most extensively studied member of the class, inducing tumors in tissues at the point of contact of virtually 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, 1993a) . 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, 1993a).

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, 2001). 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.

EPA (2001) 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 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.

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 .1 E+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 SFs for the other Group B2 PAHs presented above.

References for PAHs

Agency for Toxic Substances and Disease Registry, (ATSDR), 1993a, Update Toxicological Profile for Polycyclic Aromatic Hydrocarbons (PAHs), Draft for Public Comment, U.S. Public Health Service, Atlanta, Georgia, October.

De Jong, W.H., E.D. Kroes, J.G. Vos and H. Van Loveren, 1999, "Detection of Immunotoxicity of Benzo[a]pyrene in a Subacute Toxicity Study after Oral Exposure in Rats," Toxicological Sciences 50: 214-220.

Hazardous Substance Data Bank (HSDB), 2001, National Library of Medicine, on line.

Jones, TD. and BA Owen, 1989, Health Risks from Mixtures of Radionuclides and Chemicals in Drinking Water, Oak Ridge National Laboratory, Oak Ridge, TN, ORNL-6533.

U.S. Environmental Protection Agency (EPA), 1986, "Guidelines for Carcinogen Risk Assessment," Federal Register 51(185): 33992-34003.

Krewski, D., T. Thorslund and J. Withey, 1989, "Carcinogenic Risk Assessment of Complex Mixtures," Toxicology and Industrial Health, 5: 851-867.

Lewtas, J., 1988, "Genotoxicity of Complex Mixtures: Strategies for the Identification and Comparative Assessment of Airborne Mutagens and Carcinogens from Combustion Sources," Fundamental and Applied Toxicology, 10: 571-589.

Ohio Environmental Protection Agency (OEPA), 1998, U.S. NASA Plum Brook, Erie County, Ohio LD#: 322-0552, Risk Assessment Work Plans, letter from R.E. Nabors, Site Coordinator, to L.S. Ingram, Department of the Army, June 22.

U.S. Environmental Protection Agency (EPA), 1986, "Guidelines for Carcinogen Risk Assessment," Federal Register, 51(185): 33992-3400. U.S. Environmental Protection Agency (EPA), 1990, "National Oil and Hazardous Substances Pollution Contingency Plan," Federal Register 55(46): 8666-8865.

U.S. Environmental Protection Agency (EPA), 1992, Dermal Exposure Assessment: Principles and Applications, Interim Report, Office of Research and Development, Washington, DC, EPA/600/8-91/01 1 B, January.

U.S. Environmental Protection Agency (EPA), 1993b, Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons, Office of Health and Environmental Assessment, Cincinnati, OH, EPA/600/R-93/089.

U.S. Environmental Protection Agency (EPA), 1994, Risk Assessment Issue Paper: Status of Inhalation Cancer Unit Risk for Benzo(a)Pyrene (CAS No. 50-32-8), National Center for Environmental Assessment, Cincinnati, OH, November 18.

U.S. Environmental Protection Agency (EPA), 1997, Health Effects Assessment Summary Tables, FY 1997 Update, Office of Solid Waste and Emergency Response, Washington, DC, 9200.6-303(97-1), EPA 540/R-97-036, PB97-921199.

U.S. Environmental Protection Agency (EPA), 2001, Integrated Risk Information System (IRIS), National Center for Environmental Assessment, Cincinnati, OH, on line.

POLYCHLORINATED BIPHENYLS (PCBs)

The PCBs are a class of SVOCs including 209 possible individual congeners, each consisting of a biphenyl structure and 1 to 10 chlorine atoms (ATSDR, 1995). The PCBs manufactured and used in the U.S. are called Aroclors. The Aroclors are mixtures of several PCB congeners and related compounds. 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 frequently involves "fingerprinting" the mixture, and reporting the result as the Aroclor(s) that most closely reflect the fingerprint(s) (ATSDR, 1995). Recently, however, more attention has been paid to analyzing and reporting individual congeners, because of the possibility that certain congeners may be dioxin-like in their mechanism of toxicity. The Aroclors most commonly identified in environmental media include Aroclor-1016, -1221, -1232, -1242, -1248, -1254, -1260, -1262, and -1268. Relevant physical properties are compiled below:

MW (g/mole)	log K_{ow} (unitless)	H (atm-m^3/mole)	Kd (L/kg)	Da (cm2/s)	Dw (cm2/s)	VP (atm)	S (mg/L)
Aroclor-1254 (11097-69-1)							
328[a,b]	6.5[b]	2.0E-3[b]	5.00[c]	3.99E-2[d]	5.6E-6[c]	1.01E-7[b]	3.5E-2[b]
Aroclor-1260 (11096-82-5)							
375.7[a,b]	6.8[b]	4.6E-3[b]	6.42[c]	3.65E-2[d]	5.3E-6[c]	5.33E-8[a]	4.1E-2[b]

a Average molecular mass for the proportions of individual congeners in the commercial product.
b Agency for Toxic Substances and Disease Registry (ATSDR), 1995, Update Toxicological Profile for Polychorinted Biphenyls, Draft for Public Comment, U.S . Department of Health and Human Services, Atlanta, Georgia, August.
c Montgomery, J.H., 1996, Groundwater Chemicals Desk Reference, Second Edition, Lewis Publishers, New York.
d Calculated as described in Introduction to the Toxicity Profiles.

Former PCB releases occurred as a result of their manufacture, use, disposal, and leakage from damaged PCB-containing equipment (ATSDR, 1995) . 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, 2001). 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, 1995; HSDB, 2001). 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-adsorption-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, 1995). PCBs sorb tightly to constituents of soil with adsorption generally increasing with the degree of chlorination. Although the lesser chlorinated biphenyls may exhibit low mobility in soil, PCBs will generally 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 PCBs. In general, the persistence of PCBs increases with an increase in the degree of chlorination (HSDB, 2001). Mono-, di- and trichlorinated biphenyls (Aroclors-1221 and -1232) biodegrade relatively rapidly, tetrachlorinated biphenyls (Aroclors-1016 and -1242) biodegrad slowly, and higher chlorinated biphenyls (Aroclors-1248, 1-254 and -1260) are resistant to biodegradation. The position of chlorination in the isomeric classes also determines the extent of biodegradation. Although biodegradation of higher 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, 1995). 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:

BCF (L/kg)	B_{pr}[a,b] (unitless)	B_{pv}[a,b] (unitless)	B_b[a] (days/kg)
Aroclor-1254 (11097-69-1)			
See below	6.78E-3	6.78E-3	7.94E-2
Aroclor-1260 (11096-82-5)			
See below	4.55E-3	4.55E-3	1.58E-1

a Calculated as described in Introduction to the Toxicity Profiles.
b The methodology for estimating biotransfer oforganic chemicals to plants does not differentiate vegetative and reproductive portions .

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, 1995). Mink appear to be unusually sensitive. Death appears to be due to respiratory depression and dehydration from diarrhea

The best known incident involving oral exposure by humans 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 leads to liver damage, signs of chloracne, immunological effects, and neurological impairment, particularly of the young. 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 (EPA, 2001). 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.

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, 1995). Concurrent exposure to PCB contaminants, such as PCDFs, 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 arc available.

EPA (2001) 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 (2001) established a tiered approach for estimating the cancer potency of exposure to the PCBs. For the high risk tier, A SF of 2.0E+0 per mg/kg-day is verified as an upper-bound for exposure to PCBs via ingestion in the food chain, ingestion of soil or sediment, inhalation of dust or aerosol, or dermal contact with soil or sediment if an absorption factor is applied. In addition, the SF of 2.0E+0 per mg/kg-day is used for any congeners considered to be persistent or acting in a dioxin-like manner, and for any early life exposures. The high risk tier SF for central tendency (CT) analyses is 1.0E+0 per mg/kg-day. EPA (2001) verified an upperbound SF of 4.0E-1 per mg/kg-day for the low risk tier, which includes ingestion of watersoluble congeners, inhalation of evaporated congeners, and dermal exposure if no absorption factor is applied. A SF of 3E-1 per mg/kg-day is recommended for the low risk CT evaluation. The SF of 2.0E+0 per mg/kg-day is used for all exposure scenarios and exposure routes in this evaluation because analytical data that demonstrate the absence of dioxin-like or persistent congeners are not available, and the exposure of children or youths is plausible.

References for PCBs

Agency for Toxic Substances and Disease Registry, (ATSDR), 1995, Update Toxicological Profile for Polychlorinated Biphenyls, Draft for Public Comment, U.S. Public Health Service, Atlanta, Georgia, August.

Gaffey, W.R., 1983, "The epidemiology of PCBs," In: PCBs: Human and Environmental Hazards, F.M. D'itri and M.A. Kamrin, Eds., Boston: Butterworth Publishers.

Hazardous Substance Data Bank (HSDB), 2001, National Library of Medicine, on line.

U.S. Environmental Protection Agency (EPA), 1992, Dermal Exposure Assessment: Principles and Applications, Interim Report, Office of Research and Development, Washington, DC, EPA/600/8-91/01 1B, January

U.S. Environmental Protection Agency (EPA), 1995, Great Lakes Water Quality Initiative, Technical Support Document for the Procedure to Determine Bioaccumulation Factors, EPA.820.8.95 .CC5, P1395-187290.

U.S. Environmental Protection Agency (EPA), 2001, Integrated Risk Information System (IRIS), National Center for Environmental Assessment, Cincinnati, OH, on line.

XYLENES, TOTAL

The xylenes (1330-20-7), also known as dimethylbenzenes, are synthetic VOCs derived from coal tar, coal gas, and petroleum distillation (ATSDR, 1993; HSDB, 2001). 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, 1993; HSDB, 2001). They are components of aviation gasoline, asphalt and naphtha, and automobile exhaust. Technical xylene consists of approximately 44 percent m-xylene (1,3-dimethylbenzene [108-38-3]), 20 percent o-xylene (1,2- dimethylbenzene [95-47-6]), 20 percent p-xylene (1,4-dimethylbenzene [106-42-3]), and 15 percent ethylbenzene. Laboratory analyses of environmental media often report values for total xylenes (1330-20-7), mixed xylenes or m- and p- xylene. The xylene isomers have similar physical property values and are toxicologically similar; therefore, the relevant physical properties for m-xylene, presented below, may be applied to the mixed xylenes, total xylene or any of the three isomers:

MW (g/mole)	log K_{ow} (unitless)	H (atm-m^3/mole)	Kd (L/kg)	Da (cm2/s)	Dw (cm2/s)	VP (atm)	S (mg/L)
106.2	3.20[a]	7.34E-3[b]	2.61[b]	7.00E-2[b]	7.8E-6[b]	1.06E-2[c]	1.61E+2[b]

a 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 /011 B, January. '

b U.S. Environmental Protection Agency (EPA), 1996, Soil Screening Guidance: Users Guide, Office of Solid Waste and Emergency Response, Washington, DC, Publication 9355 .4-23, April.

c U.S. Environmental Protection Agency (EPA), 1994, Technical Background Document for Soil Screening Guidance, Review Draft, Office of Solid Waste and Emergency Response, Washington, DC, Publication No. 9355 .4-17, EPA540/R-94/106, PB95-963532, November.

Naturally occurring sources of xylenes are petroleum, forest fires and volatiles from plants (ATSDR, 1993; HSDB, 2001). The production and use of xylenes in petroleum products and as chemical solvents and intermediates may result in their release to the environment through various waste streams. Outgassing from landfills and automobile exhaust are other significant sources. Spills, leaking underground storage tanks, 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, 1993; HSDB, 2001). 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, 1993). 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., values have been reported in soil samples with differing pH and organic carbon content (HSDB, 2001), 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, 1993). 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, 2001).

Xylenes are not expected to participate significantly in food-chain pathways (ATSDR, 1993; HSDB, 2001); therefore, biotransfer factors are not provided.

Oral LD50 values for xylenes include 3.5 to 8 .6 g/kg in rats and 1 .6 to 5 .6 g/kg in mice (HSDB, 2001), 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 CNS signs and increased mortality without histopathological alterations in the internal organs (EPA, 2001). EPA (2001) presents a verified chronic oral RfD for total xylenes of 2E+0 mg/kg-day based on a NOAEL for hyperactivity and decreased body weight and increased mortality in male rats in chronic gavage studies with mixed xylenes. An uncertainty factor of 100 was used. Confidence in the chronic oral RfD is medium. EPA (1997) presents provisional RfDs for o-xylene and m-xylene of 2E+0 mg/kg-day based on the same study. The CNS is considered the target organ for prolonged oral exposure to the xylenes. The oral RfD of 2E+0 mg/kg-day is applied to total or mixed xylenes, and to each of the 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. The data are not sufficient for derivation of an inhalation RfC. The CNS is the principal target organ for inhalation exposure to the xylenes.

Xylene is classified as a cancer weight-of-evidence Group D compound (not classifiable as to carcinogenicity to humans) (EPA, 2001). There are no reported human cancer data, and gavage studies in rat and mice of both sexes did not result in significant increases in tumor incidence.

References for Xvlenes, Total

American Conference of Governmental Industrial Hygienists (ACGIH), 1991, Documentation of the Threshold Limit Values and Biological Exposure Indices, Sixth Edition, Cincinnati, OH, pp. 1732-1740.

Agency for Toxic Substances and Disease Registry, (ATSDR), 1993, Toxicological Profile for Xylenes, Draft for Public Comment, U.S. Department of Health and Human Services, Atlanta, GA.

Hazardous Substance Data Bank (HSDB), 2001, National Library of Medicine, on line.

Jones, TD. and BA Owen, 1989, Health Risks from Mixtures of Radionuclides and Chemicals in Drinking Water, Oak Ridge National Laboratory, Oak Ridge, TN, ORNL-6533.

Ohio Environmental Protection Agency (OEPA), 1998, U.S. NASA Plum Brook, Erie County, Ohio LD#: 322-0552, Risk Assessment Work Plans, letter from R.E. Nabors, Site Coordinator, to L.S. Ingram, Department of the Army, June 22.

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 /011 B, January.

U.S. Environmental Protection Agency (EPA), 1997, Health Effects Assessment Summary Tables, FY1997 Update, Office of Solid Waste and Emergency Response, 9200.6-303 (97-1), EPA-540-R-97-036, NTIS No. PB97-921199.

U.S. Environmental Protection Agency (EPA), 2001, Integrated Risk Information System (IRIS), National Center for Environmental Assessment, Cincinnati, OH, on line.

APPENDIX D

ProUCL CALCULATIONS FOR EXPOSURE-POINT CONCENTRATIONS

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	G:\DATAMGMT\Projects\PlumBrook\Stats_2009_AcidArea1\stats_SO_Eco\ProUCLStats\ProUCL_Input.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Acid Area I Soil Chemicals of Potential Ecological Concern

Beryllium

General Statistics

Number of Valid Data	61	Number of Detected Data	42
Number of Distinct Detected Data	36	Number of Non-Detect Data	19
		Percent Non-Detects	31.15%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.23	Minimum Detected	-1.47
Maximum Detected	1.1	Maximum Detected	0.0953
Mean of Detected	0.585	Mean of Detected	-0.604
SD of Detected	0.214	SD of Detected	0.385
Minimum Non-Detect	0.25	Minimum Non-Detect	-1.386
Maximum Non-Detect	0.64	Maximum Non-Detect	-0.446

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	46
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	15
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	75.41%

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.924	Shapiro Wilk Test Statistic	0.93
5% Shapiro Wilk Critical Value	0.942	5% Shapiro Wilk Critical Value	0.942
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	0.495	Mean	-0.802
SD	0.224	SD	0.449
95% DL/2 (t) UCL	0.543	95% H-Stat (DL/2) UCL	0.632
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	0.442	Mean in Log Scale	-0.697
SD	0.29	SD in Log Scale	0.365
95% MLE (t) UCL	0.504	Mean in Original Scale	0.532
95% MLE (Tiku) UCL	0.568	SD in Original Scale	0.199
		95% Percentile Bootstrap UCL	0.574
		95% BCA Bootstrap UCL	0.578

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	6.924
Theta Star	0.0845
nu star	581.6
A-D Test Statistic	0.197
5% A-D Critical Value	0.75
K-S Test Statistic	0.75
5% K-S Critical Value	0.137

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	0.23
Maximum	1.1
Mean	0.582
Median	0.589
SD	0.187
k star	8.939
Theta star	0.0651
Nu star	1091
AppChi2	1015
95% Gamma Approximate UCL	0.625
95% Adjusted Gamma UCL	0.626

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	0.533
SD	0.203
SE of Mean	0.0282
95% KM (t) UCL	0.58
95% KM (z) UCL	0.58
95% KM (jackknife) UCL	0.58
95% KM (bootstrap t) UCL	0.579
95% KM (BCA) UCL	0.577
95% KM (Percentile Bootstrap) UCL	0.579
95% KM (Chebyshev) UCL	0.656
97.5% KM (Chebyshev) UCL	0.709
99% KM (Chebyshev) UCL	0.814

Potential UCLs to Use

95% KM (Percentile Bootstrap) UCL	0.579

Cadmium

General Statistics

Number of Valid Data	61	Number of Detected Data	32
Number of Distinct Detected Data	27	Number of Non-Detect Data	29
		Percent Non-Detects	47.54%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.28	Minimum Detected	-1.273
Maximum Detected	6.9	Maximum Detected	1.932
Mean of Detected	0.825	Mean of Detected	-0.473
SD of Detected	1.151	SD of Detected	0.587
Minimum Non-Detect	0.23	Minimum Non-Detect	-1.47
Maximum Non-Detect	0.64	Maximum Non-Detect	-0.446

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	11
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	81.97%

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.371	Shapiro Wilk Test Statistic	0.78
5% Shapiro Wilk Critical Value	0.93	5% Shapiro Wilk Critical Value	0.93
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	0.558	Mean	-0.907
SD	0.875	SD	0.673
95% DL/2 (t) UCL	0.745	95% H-Stat (DL/2) UCL	0.644
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE yields a negative mean		Mean in Log Scale	-0.795
		SD in Log Scale	0.601
		Mean in Original Scale	0.593
		SD in Original Scale	0.867
		95% Percentile Bootstrap UCL	0.794
		95% BCA Bootstrap UCL	0.959

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	1.772
Theta Star	0.465
nu star	113.4
A-D Test Statistic	3.799
5% A-D Critical Value	0.76
K-S Test Statistic	0.76
5% K-S Critical Value	0.158

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	0.28
Maximum	6.9
Mean	0.829
Median	0.771
SD	0.828
k star	3.373
Theta star	0.246
Nu star	411.5
AppChi2	365.5
95% Gamma Approximate UCL	0.933
95% Adjusted Gamma UCL	0.936

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	0.616
SD	0.852
SE of Mean	0.111
95% KM (t) UCL	0.802
95% KM (z) UCL	0.799
95% KM (jackknife) UCL	0.793
95% KM (bootstrap t) UCL	1.163
95% KM (BCA) UCL	0.847
95% KM (Percentile Bootstrap) UCL	0.815
95% KM (Chebyshev) UCL	1.101
97.5% KM (Chebyshev) UCL	1.311
99% KM (Chebyshev) UCL	1.724

Potential UCLs to Use

95% KM (t) UCL	0.802
95% KM (% Bootstrap) UCL	0.815

Chromium

General Statistics

Number of Valid Data	61	Number of Detected Data	60
Number of Distinct Detected Data	52	Number of Non-Detect Data	1
		Percent Non-Detects	1.64%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	2.3	Minimum Detected	0.833
Maximum Detected	50.7	Maximum Detected	3.926
Mean of Detected	15.63	Mean of Detected	2.67
SD of Detected	6.749	SD of Detected	0.414
Minimum Non-Detect	1.3	Minimum Non-Detect	0.262
Maximum Non-Detect	1.3	Maximum Non-Detect	0.262

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Lilliefors Test Statistic	0.131	Lilliefors Test Statistic	0.104
5% Lilliefors Critical Value	0.114	5% Lilliefors Critical Value	0.114
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	15.38	Mean	2.619
SD	6.961	SD	0.571
95% DL/2 (t) UCL	16.87	95% H-Stat (DL/2) UCL	17.96
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	15.35	Mean in Log Scale	2.653
SD	6.983	SD in Log Scale	0.431
95% MLE (t) UCL	16.84	Mean in Original Scale	15.46
95% MLE (Tiku) UCL	16.84	SD in Original Scale	6.824
		95% Percentile Bootstrap UCL	16.96
		95% BCA Bootstrap UCL	17.21

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	6.155
Theta Star	2.539
nu star	738.6
A-D Test Statistic	0.868
5% A-D Critical Value	0.753
K-S Test Statistic	0.753
5% K-S Critical Value	0.115

Data follow Appr. Gamma Distribution at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	1E-09
Maximum	50.7
Mean	15.37
Median	14.2
SD	6.985
k star	1.21
Theta star	12.7
Nu star	147.6
AppChi2	120.5
95% Gamma Approximate UCL	18.82
95% Adjusted Gamma UCL	18.92

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data Follow Appr. Gamma Distribution at 5% Significance Level

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	15.41
SD	6.849
SE of Mean	0.884
95% KM (t) UCL	16.88
95% KM (z) UCL	16.86
95% KM (jackknife) UCL	16.84
95% KM (bootstrap t) UCL	17.17
95% KM (BCA) UCL	17.27
95% KM (Percentile Bootstrap) UCL	16.85
95% KM (Chebyshev) UCL	19.26
97.5% KM (Chebyshev) UCL	20.93
99% KM (Chebyshev) UCL	24.21

Potential UCLs to Use

95% KM (BCA) UCL	17.27

Copper

General Statistics

Number of Valid Data	61	Number of Detected Data	60
Number of Distinct Detected Data	57	Number of Non-Detect Data	1
		Percent Non-Detects	1.64%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	3.7	Minimum Detected	1.308
Maximum Detected	57.6	Maximum Detected	4.054
Mean of Detected	17.46	Mean of Detected	2.697
SD of Detected	10.38	SD of Detected	0.588
Minimum Non-Detect	2.8	Minimum Non-Detect	1.03
Maximum Non-Detect	2.8	Maximum Non-Detect	1.03

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Lilliefors Test Statistic	0.115	Lilliefors Test Statistic	0.0656
5% Lilliefors Critical Value	0.114	5% Lilliefors Critical Value	0.114
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	17.19	Mean	2.658
SD	10.49	SD	0.657
95% DL/2 (t) UCL	19.44	95% H-Stat (DL/2) UCL	20.82
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	17.14	Mean in Log Scale	2.671
SD	10.52	SD in Log Scale	0.616
95% MLE (t) UCL	19.39	Mean in Original Scale	17.22
95% MLE (Tiku) UCL	19.32	SD in Original Scale	10.45
		95% Percentile Bootstrap UCL	19.55
		95% BCA Bootstrap UCL	19.77

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	3.075
Theta Star	5.676
nu star	369
A-D Test Statistic	0.257
5% A-D Critical Value	0.757
K-S Test Statistic	0.757
5% K-S Critical Value	0.115

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	1E-09
Maximum	57.6
Mean	17.17
Median	15
SD	10.53
k star	1.037
Theta star	16.56
Nu star	126.5
AppChi2	101.5
95% Gamma Approximate UCL	21.4
95% Adjusted Gamma UCL	21.51

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	17.23
SD	10.35
SE of Mean	1.337
95% KM (t) UCL	19.46
95% KM (z) UCL	19.43
95% KM (jackknife) UCL	19.45
95% KM (bootstrap t) UCL	19.77
95% KM (BCA) UCL	19.72
95% KM (Percentile Bootstrap) UCL	19.42
95% KM (Chebyshev) UCL	23.06
97.5% KM (Chebyshev) UCL	25.58
99% KM (Chebyshev) UCL	30.53

Potential UCLs to Use

95% KM (BCA) UCL	19.72

Mercury

General Statistics

Number of Valid Data	61	Number of Detected Data	40
Number of Distinct Detected Data	29	Number of Non-Detect Data	21
		Percent Non-Detects	34.43%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.016	Minimum Detected	-4.135
Maximum Detected	0.76	Maximum Detected	-0.274
Mean of Detected	0.0782	Mean of Detected	-3.176
SD of Detected	0.158	SD of Detected	0.857
Minimum Non-Detect	0.013	Minimum Non-Detect	-4.343
Maximum Non-Detect	0.042	Maximum Non-Detect	-3.17

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	46
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	15
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	75.41%

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.376	Shapiro Wilk Test Statistic	0.763
5% Shapiro Wilk Critical Value	0.94	5% Shapiro Wilk Critical Value	0.94
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	0.0576	Mean	-3.479
SD	0.131	SD	0.836
95% DL/2 (t) UCL	0.0856	95% H-Stat (DL/2) UCL	0.0619
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE yields a negative mean		Mean in Log Scale	-3.451
		SD in Log Scale	0.853
		Mean in Original Scale	0.0587
		SD in Original Scale	0.131
		95% Percentile Bootstrap UCL	0.0894
		95% BCA Bootstrap UCL	0.1

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.874
Theta Star	0.0895
nu star	69.93
A-D Test Statistic	5.968
5% A-D Critical Value	0.782
K-S Test Statistic	0.782
5% K-S Critical Value	0.144

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	1E-09
Maximum	0.76
Mean	0.0728
Median	0.035
SD	0.132
k star	0.31
Theta star	0.235
Nu star	37.82
AppChi2	24.73
95% Gamma Approximate UCL	0.111
95% Adjusted Gamma UCL	0.112

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	0.0596
SD	0.129
SE of Mean	0.0168
95% KM (t) UCL	0.0876
95% KM (z) UCL	0.0871
95% KM (jackknife) UCL	0.0873
95% KM (bootstrap t) UCL	0.183
95% KM (BCA) UCL	0.0873
95% KM (Percentile Bootstrap) UCL	0.0909
95% KM (Chebyshev) UCL	0.133
97.5% KM (Chebyshev) UCL	0.164
99% KM (Chebyshev) UCL	0.226

Potential UCLs to Use

95% KM (BCA) UCL	0.0873

Nickel

General Statistics

Number of Valid Data	61	Number of Detected Data	59
Number of Distinct Detected Data	53	Number of Non-Detect Data	2
		Percent Non-Detects	3.28%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	5.8	Minimum Detected	1.758
Maximum Detected	57.8	Maximum Detected	4.057
Mean of Detected	18.26	Mean of Detected	2.77
SD of Detected	10.21	SD of Detected	0.519
Minimum Non-Detect	4.6	Minimum Non-Detect	1.526
Maximum Non-Detect	5.1	Maximum Non-Detect	1.629

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	59
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	3.28%

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Lilliefors Test Statistic	0.167	Lilliefors Test Statistic	0.0653
5% Lilliefors Critical Value	0.115	5% Lilliefors Critical Value	0.115
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	17.74	Mean	2.708
SD	10.43	SD	0.613
95% DL/2 (t) UCL	19.97	95% H-Stat (DL/2) UCL	20.95
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	17.66	Mean in Log Scale	2.728
SD	10.51	SD in Log Scale	0.56
95% MLE (t) UCL	19.91	Mean in Original Scale	17.81
95% MLE (Tiku) UCL	19.84	SD in Original Scale	10.34
		95% Percentile Bootstrap UCL	19.94
		95% BCA Bootstrap UCL	20.14

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	3.682
Theta Star	4.96
nu star	434.5
A-D Test Statistic	0.509
5% A-D Critical Value	0.754
K-S Test Statistic	0.754
5% K-S Critical Value	0.116

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	1E-09
Maximum	57.8
Mean	17.66
Median	15.9
SD	10.56
k star	0.671
Theta star	26.33
Nu star	81.85
AppChi2	62
95% Gamma Approximate UCL	23.32
95% Adjusted Gamma UCL	23.48

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	17.85
SD	10.2
SE of Mean	1.317
95% KM (t) UCL	20.05
95% KM (z) UCL	20.02
95% KM (jackknife) UCL	20.04
95% KM (bootstrap t) UCL	20.43
95% KM (BCA) UCL	20.04
95% KM (Percentile Bootstrap) UCL	20.02
95% KM (Chebyshev) UCL	23.59
97.5% KM (Chebyshev) UCL	26.08
99% KM (Chebyshev) UCL	30.96

Potential UCLs to Use

95% KM (BCA) UCL	20.04

Lead

General Statistics

Number of Valid Observations	61	Number of Distinct Observations	59

Raw Statistics		Log-transformed Statistics	
Minimum	4.1	Minimum of Log Data	1.411
Maximum	770	Maximum of Log Data	6.646
Mean	68.03	Mean of log Data	3.162
Median	14.4	SD of log Data	1.304
SD	143.4		
Coefficient of Variation	2.108		
Skewness	3.694		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Lilliefors Test Statistic	0.328	Lilliefors Test Statistic	0.182
Lilliefors Critical Value	0.113	Lilliefors Critical Value	0.113
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	98.7	95% H-UCL	81.66
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	104.4
95% Adjusted-CLT UCL	107.5	97.5% Chebyshev (MVUE) UCL	126.2
95% Modified-t UCL	100.1	99% Chebyshev (MVUE) UCL	169

Gamma Distribution Test		Data Distribution
k star (bias corrected)	0.568	Data do not follow a Discernable Distribution (0.05)
Theta Star	119.7	
MLE of Mean	68.03	
MLE of Standard Deviation	90.24	
nu star	69.34	
Approximate Chi Square Value (.05)	51.17	**Nonparametric Statistics**
Adjusted Level of Significance	0.0461	95% CLT UCL 98.23
Adjusted Chi Square Value	50.79	95% Jackknife UCL 98.7
		95% Standard Bootstrap UCL 97.04
Anderson-Darling Test Statistic	4.794	95% Bootstrap-t UCL 117.9
Anderson-Darling 5% Critical Value	0.808	95% Hall's Bootstrap UCL 102.7
Kolmogorov-Smirnov Test Statistic	0.251	95% Percentile Bootstrap UCL 101
Kolmogorov-Smirnov 5% Critical Value	0.12	95% BCA Bootstrap UCL 110.2
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL 148.1
		97.5% Chebyshev(Mean, Sd) UCL 182.7
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL 250.7
95% Approximate Gamma UCL	92.19	
95% Adjusted Gamma UCL	92.87	

Potential UCL to Use	Use 97.5% Chebyshev (Mean, Sd) UCL 182.7

Antimony

General Statistics

Number of Valid Data	61	Number of Detected Data	1
Number of Distinct Detected Data	1	Number of Non-Detect Data	60
		Percent Non-Detects	98.36%

Warning: Only one distinct data value was detected! ProUCL (or any other software) should not be used on such a data set!

It is suggested to use alternative site specific values determined by the Project Team to estimate environmental parameters (e.g., EPC, BTV).

The data set for variable SB was not processed!

Vanadium

General Statistics

Number of Valid Data	61	Number of Detected Data	59
Number of Distinct Detected Data	57	Number of Non-Detect Data	2
		Percent Non-Detects	3.28%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	9.4	Minimum Detected	2.241
Maximum Detected	51.7	Maximum Detected	3.945
Mean of Detected	26.15	Mean of Detected	3.214
SD of Detected	8.286	SD of Detected	0.322
Minimum Non-Detect	5.7	Minimum Non-Detect	1.74
Maximum Non-Detect	6.4	Maximum Non-Detect	1.856

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	59
Observations < Largest ND are treated as NDs		Single DL Non-Detect Percentage	3.28%

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Lilliefors Test Statistic	0.102	Lilliefors Test Statistic	0.0558
5% Lilliefors Critical Value	0.115	5% Lilliefors Critical Value	0.115
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	25.4	Mean	3.145
SD	9.144	SD	0.494
95% DL/2 (t) UCL	27.35	95% H-Stat (DL/2) UCL	29.01
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	25.4	Mean in Log Scale	3.189
SD	9.078	SD in Log Scale	0.347
95% MLE (t) UCL	27.34	Mean in Original Scale	25.67
95% MLE (Tiku) UCL	27.36	SD in Original Scale	8.57
		95% Percentile Bootstrap UCL	27.55
		95% BCA Bootstrap UCL	27.5

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	9.735
Theta Star	2.687
nu star	1149

A-D Test Statistic	0.204
5% A-D Critical Value	0.751
K-S Test Statistic	0.751
5% K-S Critical Value	0.116

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data

Minimum	5.046
Maximum	51.7
Mean	25.46
Median	24.1
SD	8.985
k star	6.495
Theta star	3.92
Nu star	792.4
AppChi2	728.1
95% Gamma Approximate UCL	27.71
95% Adjusted Gamma UCL	27.77

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	25.6
SD	8.613
SE of Mean	1.112
95% KM (t) UCL	27.46
95% KM (z) UCL	27.43
95% KM (jackknife) UCL	27.41
95% KM (bootstrap t) UCL	27.52
95% KM (BCA) UCL	27.55
95% KM (Percentile Bootstrap) UCL	27.43
95% KM (Chebyshev) UCL	30.45
97.5% KM (Chebyshev) UCL	32.55
99% KM (Chebyshev) UCL	36.67

Potential UCLs to Use

95% KM (t) UCL	27.46
95% KM (Percentile Bootstrap) UCL	27.43

2,4-Dinitrotoluene

General Statistics

Number of Valid Data	41	Number of Detected Data	6
Number of Distinct Detected Data	6	Number of Non-Detect Data	35
		Percent Non-Detects	85.37%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	120	Minimum Detected	4.787
Maximum Detected	2500	Maximum Detected	7.824
Mean of Detected	830	Mean of Detected	5.948
SD of Detected	1047	SD of Detected	1.355
Minimum Non-Detect	100	Minimum Non-Detect	4.605
Maximum Non-Detect	250	Maximum Non-Detect	5.521

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	38
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	92.68%

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	0.733	Shapiro Wilk Test Statistic	0.805
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	173.2	Mean	4.362
SD	461.5	SD	0.831
95% DL/2 (t) UCL	294.5	95% H-Stat (DL/2) UCL	120.5
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE yields a negative mean		Mean in Log Scale	0.848
		SD in Log Scale	2.986
		Mean in Original Scale	125.7
		SD in Original Scale	473.6
		95% Percentile Bootstrap UCL	252
		95% BCA Bootstrap UCL	339.7

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.497
Theta Star	1671
nu star	5.961
A-D Test Statistic	0.757
5% A-D Critical Value	0.72
K-S Test Statistic	0.72
5% K-S Critical Value	0.343

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	1E-09
Maximum	2500
Mean	615
Median	576.9
SD	549.4
k star	0.164
Theta star	3743
Nu star	13.47
AppChi2	6.212
95% Gamma Approximate UCL	1334
95% Adjusted Gamma UCL	1374

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	223.9
SD	443.5
SE of Mean	75.87
95% KM (t) UCL	351.7
95% KM (z) UCL	348.8
95% KM (jackknife) UCL	334.9
95% KM (bootstrap t) UCL	1976
95% KM (BCA) UCL	507.3
95% KM (Percentile Bootstrap) UCL	380.5
95% KM (Chebyshev) UCL	554.7
97.5% KM (Chebyshev) UCL	697.8
99% KM (Chebyshev) UCL	978.9

Potential UCLs to Use

95% KM (BCA) UCL	507.3

PCB 1254

General Statistics

Number of Valid Data	54	Number of Detected Data	27
Number of Distinct Detected Data	26	Number of Non-Detect Data	27
		Percent Non-Detects	50.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	4.4	Minimum Detected	1.482
Maximum Detected	7100	Maximum Detected	8.868
Mean of Detected	2465	Mean of Detected	6.754
SD of Detected	2372	SD of Detected	2.091
Minimum Non-Detect	4	Minimum Non-Detect	1.386
Maximum Non-Detect	2900	Maximum Non-Detect	7.972

Note: Data have multiple DLs - Use of KM Method is recommended		Number treated as Non-Detect	43
For all methods (except KM, DL/2, and ROS Methods),		Number treated as Detected	11
Observations < Largest ND are treated as NDs		Single DL Non-Detect Percentage	79.63%

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.87	Shapiro Wilk Test Statistic	0.853
5% Shapiro Wilk Critical Value	0.923	5% Shapiro Wilk Critical Value	0.923
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	1296	Mean	4.689
SD	2054	SD	2.891
95% DL/2 (t) UCL	1764	95% H-Stat (DL/2) UCL	46757
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	115.3	Mean in Log Scale	4.575
SD	3439	SD in Log Scale	2.705
95% MLE (t) UCL	898.8	Mean in Original Scale	1240
95% MLE (Tiku) UCL	1956	SD in Original Scale	2071
		95% Percentile Bootstrap UCL	1709
		95% BCA Bootstrap UCL	1748

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.547
Theta Star	4511
nu star	29.51
A-D Test Statistic	0.644
5% A-D Critical Value	0.799
K-S Test Statistic	0.799
5% K-S Critical Value	0.177

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	4.4
Maximum	7100
Mean	2403
Median	2254
SD	1677
k star	1.027
Theta star	2339
Nu star	111
AppChi2	87.65
95% Gamma Approximate UCL	3042
95% Adjusted Gamma UCL	3062

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	1245
SD	2052
SE of Mean	284.9
95% KM (t) UCL	1722
95% KM (z) UCL	1714
95% KM (jackknife) UCL	1716
95% KM (bootstrap t) UCL	1806
95% KM (BCA) UCL	1721
95% KM (Percentile Bootstrap) UCL	1732
95% KM (Chebyshev) UCL	2487
97.5% KM (Chebyshev) UCL	3024
99% KM (Chebyshev) UCL	4080

Potential UCLs to Use

95% KM (t) UCL	1722

PCB 1260

General Statistics

Number of Valid Data	54	Number of Detected Data	38
Number of Distinct Detected Data	35	Number of Non-Detect Data	16
		Percent Non-Detects	29.63%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	4.2	Minimum Detected	1.435
Maximum Detected	18000	Maximum Detected	9.798
Mean of Detected	3559	Mean of Detected	6.594
SD of Detected	4425	SD of Detected	2.488
Minimum Non-Detect	4	Minimum Non-Detect	1.386
Maximum Non-Detect	41	Maximum Non-Detect	3.714

Note: Data have multiple DLs - Use of KM Method is recommended		Number treated as Non-Detect	21
For all methods (except KM, DL/2, and ROS Methods),		Number treated as Detected	33
Observations < Largest ND are treated as NDs		Single DL Non-Detect Percentage	38.89%

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.8	Shapiro Wilk Test Statistic	0.898
5% Shapiro Wilk Critical Value	0.938	5% Shapiro Wilk Critical Value	0.938
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	2507	Mean	5.134
SD	4043	SD	3.13
95% DL/2 (t) UCL	3428	95% H-Stat (DL/2) UCL	135174
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	848.3	Mean in Log Scale	5.106
SD	5738	SD in Log Scale	3.146
95% MLE (t) UCL	2156	Mean in Original Scale	2506
95% MLE (Tiku) UCL	2304	SD in Original Scale	4044
		95% Percentile Bootstrap UCL	3424
		95% BCA Bootstrap UCL	3605

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.398
Theta Star	8935
nu star	30.27
A-D Test Statistic	0.567
5% A-D Critical Value	0.832
K-S Test Statistic	0.832
5% K-S Critical Value	0.153

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	1E-09
Maximum	18000
Mean	2538
Median	260
SD	4026
k star	0.128
Theta star	19849
Nu star	13.81
AppChi2	6.442
95% Gamma Approximate UCL	5442
95% Adjusted Gamma UCL	5561

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	2506
SD	4006
SE of Mean	552.5
95% KM (t) UCL	3431
95% KM (z) UCL	3415
95% KM (jackknife) UCL	3427
95% KM (bootstrap t) UCL	3628
95% KM (BCA) UCL	3483
95% KM (Percentile Bootstrap) UCL	3466
95% KM (Chebyshev) UCL	4914
97.5% KM (Chebyshev) UCL	5956
99% KM (Chebyshev) UCL	8003

Potential UCLs to Use

95% KM (Chebyshev) UCL	4914

Naphthalene

General Statistics

Number of Valid Data	61	Number of Detected Data	3
Number of Distinct Detected Data	3	Number of Non-Detect Data	58
		Percent Non-Detects	95.08%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	64	Minimum Detected	4.159
Maximum Detected	160	Maximum Detected	5.075
Mean of Detected	103.3	Mean of Detected	4.563
SD of Detected	50.29	SD of Detected	0.468
Minimum Non-Detect	34	Minimum Non-Detect	3.526
Maximum Non-Detect	420	Maximum Non-Detect	6.04

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	61
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 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	0.911	Shapiro Wilk Test Statistic	0.96
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	88.98	Mean	3.89
SD	87.03	SD	1.126
95% DL/2 (t) UCL	107.6	95% H-Stat (DL/2) UCL	132.6
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	1.225
		SD in Log Scale	1.419
		Mean in Original Scale	10.38
		SD in Original Scale	24.14
		95% Percentile Bootstrap UCL	16.02
		95% BCA Bootstrap UCL	18.71

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	N/A
95% Adjusted Gamma UCL	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	67.03
SD	15.48
SE of Mean	3.035
95% KM (t) UCL	72.1
95% KM (z) UCL	72.02
95% KM (jackknife) UCL	81.16
95% KM (bootstrap t) UCL	74.19
95% KM (BCA) UCL	N/A
95% KM (Percentile Bootstrap) UCL	160
95% KM (Chebyshev) UCL	80.26
97.5% KM (Chebyshev) UCL	85.98
99% KM (Chebyshev) UCL	97.23

Potential UCLs to Use

95% KM (t) UCL	72.1
95% KM (Percentile Bootstrap) UCL	160

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	G:\DATAMGMT\Projects\PlumBrook\Stats_2009_AcidArea1\stats_SO_HH\ProUCLStats\ProUCL_Input.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Acid Area I Surface Soil Chemicals of Potential Concern (human health)

Arsenic

General Statistics

Number of Valid Data	38	Number of Detected Data	37
Number of Distinct Detected Data	30	Number of Non-Detect Data	1
		Percent Non-Detects	2.63%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	1.4	Minimum Detected	0.336
Maximum Detected	18.1	Maximum Detected	2.896
Mean of Detected	6.751	Mean of Detected	1.78
SD of Detected	3.618	SD of Detected	0.525
Minimum Non-Detect	1.3	Minimum Non-Detect	0.262
Maximum Non-Detect	1.3	Maximum Non-Detect	0.262

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.88	Shapiro Wilk Test Statistic	0.98
5% Shapiro Wilk Critical Value	0.936	5% Shapiro Wilk Critical Value	0.936
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	6.591	Mean	1.722
SD	3.703	SD	0.63
95% DL/2 (t) UCL	7.604	95% H-Stat (DL/2) UCL	8.178
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	6.564	Mean in Log Scale	1.745
SD	3.709	SD in Log Scale	0.56
95% MLE (t) UCL	7.579	Mean in Original Scale	6.615
95% MLE (Tiku) UCL	7.559	SD in Original Scale	3.666
		95% Percentile Bootstrap UCL	7.657
		95% BCA Bootstrap UCL	7.828

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	3.708
Theta Star	1.821
nu star	274.4
A-D Test Statistic	0.304
5% A-D Critical Value	0.753
K-S Test Statistic	0.753
5% K-S Critical Value	0.146

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data

Minimum	1E-09
Maximum	18.1
Mean	6.574
Median	6.05
SD	3.733
k star	0.798
Theta star	8.237
Nu star	60.65
AppChi2	43.74
95% Gamma Approximate UCL	9.115
95% Adjusted Gamma UCL	9.241

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	6.611
SD	3.624
SE of Mean	0.596
95% KM (t) UCL	7.616
95% KM (z) UCL	7.591
95% KM (jackknife) UCL	7.595
95% KM (bootstrap t) UCL	7.795
95% KM (BCA) UCL	7.642
95% KM (Percentile Bootstrap) UCL	7.633
95% KM (Chebyshev) UCL	9.208
97.5% KM (Chebyshev) UCL	10.33
99% KM (Chebyshev) UCL	12.54

Potential UCLs to Use

95% KM (BCA) UCL	7.642

Cobalt

General Statistics

Number of Valid Data	38	Number of Detected Data	33
Number of Distinct Detected Data	26	Number of Non-Detect Data	5
		Percent Non-Detects	13.16%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	1.5	Minimum Detected	0.405
Maximum Detected	26.5	Maximum Detected	3.277
Mean of Detected	7.456	Mean of Detected	1.816
SD of Detected	5.017	SD of Detected	0.64
Minimum Non-Detect	5.7	Minimum Non-Detect	1.74
Maximum Non-Detect	6.4	Maximum Non-Detect	1.856

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	21
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	17
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	55.26%

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.839	Shapiro Wilk Test Statistic	0.981
5% Shapiro Wilk Critical Value	0.931	5% Shapiro Wilk Critical Value	0.931
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	6.881	Mean	1.725
SD	4.9	SD	0.641
95% DL/2 (t) UCL	8.222	95% H-Stat (DL/2) UCL	9.737
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	4.92	Mean in Log Scale	1.746
SD	6.959	SD in Log Scale	0.622
95% MLE (t) UCL	6.824	Mean in Original Scale	6.953
95% MLE (Tiku) UCL	7.445	SD in Original Scale	4.846
		95% Percentile Bootstrap UCL	8.282
		95% BCA Bootstrap UCL	8.554

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	2.512
Theta Star	2.968
nu star	165.8
A-D Test Statistic	0.366
5% A-D Critical Value	0.755
K-S Test Statistic	0.755
5% K-S Critical Value	0.155

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data

Minimum	1.5
Maximum	26.5
Mean	7.144
Median	6
SD	4.739
k star	2.776
Theta star	2.573
Nu star	211
AppChi2	178.4
95% Gamma Approximate UCL	8.45
95% Adjusted Gamma UCL	8.509

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	6.974
SD	4.796
SE of Mean	0.796
95% KM (t) UCL	8.317
95% KM (z) UCL	8.283
95% KM (jackknife) UCL	8.315
95% KM (bootstrap t) UCL	8.698
95% KM (BCA) UCL	8.37
95% KM (Percentile Bootstrap) UCL	8.392
95% KM (Chebyshev) UCL	10.44
97.5% KM (Chebyshev) UCL	11.94
99% KM (Chebyshev) UCL	14.89

Potential UCLs to Use

95% KM (BCA) UCL	8.37

Lead

General Statistics

Number of Valid Observations	38	Number of Distinct Observations	38

Raw Statistics		Log-transformed Statistics	
Minimum	4.1	Minimum of Log Data	1.411
Maximum	770	Maximum of Log Data	6.646
Mean	99.61	Mean of log Data	3.582
Median	27.25	SD of log Data	1.413
SD	174.5		
Coefficient of Variation	1.752		
Skewness	2.835		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.567	Shapiro Wilk Test Statistic	0.946
Shapiro Wilk Critical Value	0.938	Shapiro Wilk Critical Value	0.938
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	147.4	95% H-UCL	191.8
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	211
95% Adjusted-CLT UCL	160.1	97.5% Chebyshev (MVUE) UCL	262.1
95% Modified-t UCL	149.5	99% Chebyshev (MVUE) UCL	362.5

Gamma Distribution Test		Data Distribution
k star (bias corrected)	0.575	Data appear Lognormal at 5% Significance Level
Theta Star	173.2	
MLE of Mean	99.61	
MLE of Standard Deviation	131.4	
nu star	43.71	
Approximate Chi Square Value (.05)	29.55	**Nonparametric Statistics**
Adjusted Level of Significance	0.0434	95% CLT UCL 146.2
Adjusted Chi Square Value	29.07	95% Jackknife UCL 147.4
		95% Standard Bootstrap UCL 144.7
Anderson-Darling Test Statistic	1.702	95% Bootstrap-t UCL 181.7
Anderson-Darling 5% Critical Value	0.803	95% Hall's Bootstrap UCL 150.1
Kolmogorov-Smirnov Test Statistic	0.179	95% Percentile Bootstrap UCL 149.1
Kolmogorov-Smirnov 5% Critical Value	0.15	95% BCA Bootstrap UCL 164.3
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL 223
		97.5% Chebyshev(Mean, Sd) UCL 276.4
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL 381.3
95% Approximate Gamma UCL	147.4	
95% Adjusted Gamma UCL	149.8	

Potential UCL to Use		Use 95% H-UCL	191.8

PCB 1254

General Statistics

Number of Valid Data	38	Number of Detected Data	22
Number of Distinct Detected Data	22	Number of Non-Detect Data	16
		Percent Non-Detects	42.11%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	68	Minimum Detected	4.22
Maximum Detected	7100	Maximum Detected	8.868
Mean of Detected	2897	Mean of Detected	7.347
SD of Detected	2404	SD of Detected	1.386
Minimum Non-Detect	5.1	Minimum Non-Detect	1.629
Maximum Non-Detect	2900	Maximum Non-Detect	7.972

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	27
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	11
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	71.05%

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.897	Shapiro Wilk Test Statistic	0.886
5% Shapiro Wilk Critical Value	0.911	5% Shapiro Wilk Critical Value	0.911
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	1766	Mean	5.874
SD	2274	SD	2.289
95% DL/2 (t) UCL	2388	95% H-Stat (DL/2) UCL	27608
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	1282	Mean in Log Scale	6.114
SD	3062	SD in Log Scale	1.829
95% MLE (t) UCL	2120	Mean in Original Scale	1716
95% MLE (Tiku) UCL	2767	SD in Original Scale	2291
		95% Percentile Bootstrap UCL	2334
		95% BCA Bootstrap UCL	2357

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.835
Theta Star	3468
nu star	36.75
A-D Test Statistic	0.846
5% A-D Critical Value	0.774
K-S Test Statistic	0.774
5% K-S Critical Value	0.191

Data follow Appr. Gamma Distribution at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	68
Maximum	7100
Mean	2410
Median	1935
SD	1966
k star	1.191
Theta star	2023
Nu star	90.55
AppChi2	69.61
95% Gamma Approximate UCL	3135
95% Adjusted Gamma UCL	3170

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data Follow Appr. Gamma Distribution at 5% Significance Level

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	1721
SD	2261
SE of Mean	376
95% KM (t) UCL	2355
95% KM (z) UCL	2339
95% KM (jackknife) UCL	2314
95% KM (bootstrap t) UCL	2396
95% KM (BCA) UCL	2397
95% KM (Percentile Bootstrap) UCL	2390
95% KM (Chebyshev) UCL	3360
97.5% KM (Chebyshev) UCL	4069
99% KM (Chebyshev) UCL	5462

Potential UCLs to Use

95% KM (BCA) UCL	2397

PCB 1260

General Statistics

Number of Valid Data	38	Number of Detected Data	31
Number of Distinct Detected Data	28	Number of Non-Detect Data	7
		Percent Non-Detects	18.42%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	45	Minimum Detected	3.807
Maximum Detected	18000	Maximum Detected	9.798
Mean of Detected	4100	Mean of Detected	7.236
SD of Detected	4656	SD of Detected	1.829
Minimum Non-Detect	5.1	Minimum Non-Detect	1.629
Maximum Non-Detect	41	Maximum Non-Detect	3.714

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	31
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	18.42%

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.829	Shapiro Wilk Test Statistic	0.915
5% Shapiro Wilk Critical Value	0.929	5% Shapiro Wilk Critical Value	0.929
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	3348	Mean	6.4
SD	4489	SD	2.448
95% DL/2 (t) UCL	4576	95% H-Stat (DL/2) UCL	56384
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	2751	Mean in Log Scale	6.507
SD	5144	SD in Log Scale	2.271
95% MLE (t) UCL	4159	Mean in Original Scale	3350
95% MLE (Tiku) UCL	4143	SD in Original Scale	4488
		95% Percentile Bootstrap UCL	4616
		95% BCA Bootstrap UCL	4800

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.54
Theta Star	7586
nu star	33.51
A-D Test Statistic	0.675
5% A-D Critical Value	0.803
K-S Test Statistic	0.803
5% K-S Critical Value	0.166

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data

Minimum	1E-09
Maximum	18000
Mean	3345
Median	1015
SD	4492
k star	0.137
Theta star	24349
Nu star	10.44
AppChi2	4.218
95% Gamma Approximate UCL	8277
95% Adjusted Gamma UCL	8611

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	3353
SD	4426
SE of Mean	729.8
95% KM (t) UCL	4584
95% KM (z) UCL	4553
95% KM (jackknife) UCL	4578
95% KM (bootstrap t) UCL	4770
95% KM (BCA) UCL	4691
95% KM (Percentile Bootstrap) UCL	4589
95% KM (Chebyshev) UCL	6534
97.5% KM (Chebyshev) UCL	7911
99% KM (Chebyshev) UCL	10615

Potential UCLs to Use

95% KM (Chebyshev) UCL	6534

Benzo(a)anthracene

General Statistics

Number of Valid Data	38	Number of Detected Data	11
Number of Distinct Detected Data	11	Number of Non-Detect Data	27
		Percent Non-Detects	71.05%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	36	Minimum Detected	3.584
Maximum Detected	660	Maximum Detected	6.492
Mean of Detected	178.4	Mean of Detected	4.84
SD of Detected	178.6	SD of Detected	0.842
Minimum Non-Detect	40	Minimum Non-Detect	3.689
Maximum Non-Detect	420	Maximum Non-Detect	6.04

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	37
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	97.37%

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.734	Shapiro Wilk Test Statistic	0.973
5% Shapiro Wilk Critical Value	0.85	5% Shapiro Wilk Critical Value	0.85
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	123.3	Mean	4.286
SD	125.1	SD	1.102
95% DL/2 (t) UCL	157.5	95% H-Stat (DL/2) UCL	222.3
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	3.84
		SD in Log Scale	0.94
		Mean in Original Scale	78.45
		SD in Original Scale	115.5
		95% Percentile Bootstrap UCL	111.9
		95% BCA Bootstrap UCL	125.1

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	1.224
Theta Star	145.7
nu star	26.93
A-D Test Statistic	0.374
5% A-D Critical Value	0.742
K-S Test Statistic	0.742
5% K-S Critical Value	0.259

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	36
Maximum	660
Mean	161.2
Median	159.9
SD	99.01
k star	3.793
Theta star	42.51
Nu star	288.2
AppChi2	249.9
95% Gamma Approximate UCL	185.9
95% Adjusted Gamma UCL	187

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	89.11
SD	115.6
SE of Mean	21.23
95% KM (t) UCL	124.9
95% KM (z) UCL	124
95% KM (jackknife) UCL	119.9
95% KM (bootstrap t) UCL	151.2
95% KM (BCA) UCL	151.2
95% KM (Percentile Bootstrap) UCL	136.2
95% KM (Chebyshev) UCL	181.6
97.5% KM (Chebyshev) UCL	221.7
99% KM (Chebyshev) UCL	300.3

Potential UCLs to Use

95% KM (t) UCL	124.9

Benzo(a)pyrene

General Statistics

Number of Valid Data	38	Number of Detected Data	9
Number of Distinct Detected Data	9	Number of Non-Detect Data	29
		Percent Non-Detects	76.32%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	21	Minimum Detected	3.045
Maximum Detected	850	Maximum Detected	6.745
Mean of Detected	193.1	Mean of Detected	4.641
SD of Detected	260.6	SD of Detected	1.156
Minimum Non-Detect	25	Minimum Non-Detect	3.219
Maximum Non-Detect	420	Maximum Non-Detect	6.04

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	37
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	97.37%

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	0.672	Shapiro Wilk Test Statistic	0.968
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	105.3	Mean	3.797
SD	152.8	SD	1.343
95% DL/2 (t) UCL	147.1	95% H-Stat (DL/2) UCL	168.3
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	3.081
		SD in Log Scale	1.265
		Mean in Original Scale	60.09
		SD in Original Scale	143.4
		95% Percentile Bootstrap UCL	102.7
		95% BCA Bootstrap UCL	126.7

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.698
Theta Star	276.7
nu star	12.56
A-D Test Statistic	0.413
5% A-D Critical Value	0.746
K-S Test Statistic	0.746
5% K-S Critical Value	0.288

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data

Minimum	1E-09
Maximum	850
Mean	170.4
Median	162.1
SD	134.5
k star	0.667
Theta star	255.4
Nu star	50.71
AppChi2	35.36
95% Gamma Approximate UCL	244.4
95% Adjusted Gamma UCL	248.1

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	68.76
SD	142.2
SE of Mean	25.29
95% KM (t) UCL	111.4
95% KM (z) UCL	110.4
95% KM (jackknife) UCL	103.7
95% KM (bootstrap t) UCL	163.9
95% KM (BCA) UCL	143
95% KM (Percentile Bootstrap) UCL	121.4
95% KM (Chebyshev) UCL	179
97.5% KM (Chebyshev) UCL	226.7
99% KM (Chebyshev) UCL	320.4

Potential UCLs to Use

95% KM (t) UCL	111.4

Benzo(b)fluoranthene

General Statistics

Number of Valid Data	38	Number of Detected Data	6
Number of Distinct Detected Data	6	Number of Non-Detect Data	32
		Percent Non-Detects	84.21%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	94	Minimum Detected	4.543
Maximum Detected	1400	Maximum Detected	7.244
Mean of Detected	394	Mean of Detected	5.51
SD of Detected	499.9	SD of Detected	0.961
Minimum Non-Detect	33	Minimum Non-Detect	3.497
Maximum Non-Detect	420	Maximum Non-Detect	6.04

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	37
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	97.37%

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	0.651	Shapiro Wilk Test Statistic	0.898
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	139.8	Mean	4.14
SD	230.4	SD	1.292
95% DL/2 (t) UCL	202.8	95% H-Stat (DL/2) UCL	221.1
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	2.971
		SD in Log Scale	1.495
		Mean in Original Scale	78.87
		SD in Original Scale	231
		95% Percentile Bootstrap UCL	147.5
		95% BCA Bootstrap UCL	200.8

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.717
Theta Star	549.7
nu star	8.601
A-D Test Statistic	0.61
5% A-D Critical Value	0.712
K-S Test Statistic	0.712
5% K-S Critical Value	0.339

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data

Minimum	1E-09
Maximum	1873
Mean	599.3
Median	477.7
SD	491.2
k star	0.237
Theta star	2530
Nu star	18
AppChi2	9.394
95% Gamma Approximate UCL	1149
95% Adjusted Gamma UCL	1181

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	148.4
SD	212.9
SE of Mean	38.51
95% KM (t) UCL	213.4
95% KM (z) UCL	211.8
95% KM (jackknife) UCL	198.8
95% KM (bootstrap t) UCL	319.8
95% KM (BCA) UCL	340.2
95% KM (Percentile Bootstrap) UCL	260.8
95% KM (Chebyshev) UCL	316.3
97.5% KM (Chebyshev) UCL	388.9
99% KM (Chebyshev) UCL	531.6

Potential UCLs to Use

95% KM (t) UCL	213.4

Dibenz(a,h)anthracene

General Statistics

Number of Valid Data	38	Number of Detected Data	1
Number of Distinct Detected Data	1	Number of Non-Detect Data	37
		Percent Non-Detects	97.37%

Warning: Only one distinct data value was detected! ProUCL (or any other software) should not be used on such a data set!

It is suggested to use alternative site specific values determined by the Project Team to estimate environmental parameters (e.g., EPC, BTV).

The data set for variable DBAHA was not processed!

Indeno(1,2,3-cd)pyrene

General Statistics

Number of Valid Data	38	Number of Detected Data	3
Number of Distinct Detected Data	3	Number of Non-Detect Data	35
		Percent Non-Detects	92.11%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	43	Minimum Detected	3.761
Maximum Detected	720	Maximum Detected	6.579
Mean of Detected	279.3	Mean of Detected	4.886
SD of Detected	382	SD of Detected	1.493
Minimum Non-Detect	49	Minimum Non-Detect	3.892
Maximum Non-Detect	420	Maximum Non-Detect	6.04

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	37
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	97.37%

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	0.785	Shapiro Wilk Test Statistic	0.891
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	106.1	Mean	4.109
SD	130.8	SD	1.026
95% DL/2 (t) UCL	141.9	95% H-Stat (DL/2) UCL	142.7
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	3.647
		SD in Log Scale	0.715
		Mean in Original Scale	58.3
		SD in Original Scale	112.2
		95% Percentile Bootstrap UCL	93.35
		95% BCA Bootstrap UCL	116.4

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	N/A
95% Adjusted Gamma UCL	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	62.11
SD	108.3
SE of Mean	21.54
95% KM (t) UCL	98.46
95% KM (z) UCL	97.55
95% KM (jackknife) UCL	91.31
95% KM (bootstrap t) UCL	263.7
95% KM (BCA) UCL	720
95% KM (Percentile Bootstrap) UCL	N/A
95% KM (Chebyshev) UCL	156
97.5% KM (Chebyshev) UCL	196.7
99% KM (Chebyshev) UCL	276.5

Potential UCLs to Use

95% KM (t) UCL	98.46
95% KM (Percentile Bootstrap) UCL	N/A

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	G:\DATAMGMT\Projects\PlumBrook\Stats_2009_AcidArea1\stats_SX_HH\ProUCLStats\ProUCL_Input.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Acid Area I Subsurface Soil Chemicals of Potential Concern (human health)

Arsenic

General Statistics

Number of Valid Observations	37	Number of Distinct Observations	30

Raw Statistics		Log-transformed Statistics	
Minimum	3	Minimum of Log Data	1.099
Maximum	15.35	Maximum of Log Data	2.731
Mean	7.874	Mean of log Data	1.977
Median	6.6	SD of log Data	0.417
SD	3.436		
Coefficient of Variation	0.436		
Skewness	0.881		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.876	Shapiro Wilk Test Statistic	0.948
Shapiro Wilk Critical Value	0.936	Shapiro Wilk Critical Value	0.936
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	8.828	95% H-UCL	8.963
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	10.29
95% Adjusted-CLT UCL	8.891	97.5% Chebyshev (MVUE) UCL	11.34
95% Modified-t UCL	8.842	99% Chebyshev (MVUE) UCL	13.4

Gamma Distribution Test		Data Distribution
k star (bias corrected)	5.485	Data appear Lognormal at 5% Significance Level
Theta Star	1.436	
MLE of Mean	7.874	
MLE of Standard Deviation	3.362	
nu star	405.9	
Approximate Chi Square Value (.05)	360.2	
Adjusted Level of Significance	0.0431	
Adjusted Chi Square Value	358.3	
Anderson-Darling Test Statistic	1.04	
Anderson-Darling 5% Critical Value	0.75	
Kolmogorov-Smirnov Test Statistic	0.165	
Kolmogorov-Smirnov 5% Critical Value	0.145	
Data not Gamma Distributed at 5% Significance Level		
Assuming Gamma Distribution		
95% Approximate Gamma UCL	8.873	
95% Adjusted Gamma UCL	8.92	

Nonparametric Statistics	
95% CLT UCL	8.803
95% Jackknife UCL	8.828
95% Standard Bootstrap UCL	8.782
95% Bootstrap-t UCL	8.939
95% Hall's Bootstrap UCL	8.875
95% Percentile Bootstrap UCL	8.8
95% BCA Bootstrap UCL	8.919
95% Chebyshev(Mean, Sd) UCL	10.34
97.5% Chebyshev(Mean, Sd) UCL	11.4
99% Chebyshev(Mean, Sd) UCL	13.49

Potential UCL to Use	
Use 95% Student's-t UCL	8.828
or 95% Modified-t UCL	8.842
or 95% H-UCL	8.963

Cobalt

General Statistics

Number of Valid Observations	37	Number of Distinct Observations	33

Raw Statistics		Log-transformed Statistics	
Minimum	1.6	Minimum of Log Data	0.47
Maximum	23.6	Maximum of Log Data	3.161
Mean	10.16	Mean of log Data	2.227
Median	10.4	SD of log Data	0.478
SD	3.967		
Coefficient of Variation	0.391		
Skewness	0.655		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.943	Shapiro Wilk Test Statistic	0.882
Shapiro Wilk Critical Value	0.936	Shapiro Wilk Critical Value	0.936
Data appear Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	11.26	95% H-UCL	12.08
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	14.05
95% Adjusted-CLT UCL	11.3	97.5% Chebyshev (MVUE) UCL	15.65
95% Modified-t UCL	11.27	99% Chebyshev (MVUE) UCL	18.79

Gamma Distribution Test		Data Distribution
k star (bias corrected)	5.199	Data appear Normal at 5% Significance Level
Theta Star	1.953	
MLE of Mean	10.16	
MLE of Standard Deviation	4.454	
nu star	384.7	
Approximate Chi Square Value (.05)	340.3	**Nonparametric Statistics**
Adjusted Level of Significance	0.0431	95% CLT UCL 11.23
Adjusted Chi Square Value	338.4	95% Jackknife UCL 11.26
		95% Standard Bootstrap UCL 11.22
Anderson-Darling Test Statistic	1.023	95% Bootstrap-t UCL 11.32
Anderson-Darling 5% Critical Value	0.75	95% Hall's Bootstrap UCL 11.42
Kolmogorov-Smirnov Test Statistic	0.146	95% Percentile Bootstrap UCL 11.24
Kolmogorov-Smirnov 5% Critical Value	0.145	95% BCA Bootstrap UCL 11.26
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL 13
		97.5% Chebyshev(Mean, Sd) UCL 14.23
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL 16.64
95% Approximate Gamma UCL	11.48	
95% Adjusted Gamma UCL	11.54	

Potential UCL to Use	Use 95% Student's-t UCL 11.26

PCB 1254

General Statistics

Number of Valid Data	22	Number of Detected Data	8
Number of Distinct Detected Data	8	Number of Non-Detect Data	14
		Percent Non-Detects	63.64%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	3.9	Minimum Detected	1.361
Maximum Detected	1900	Maximum Detected	7.55
Mean of Detected	357.2	Mean of Detected	3.265
SD of Detected	698.8	SD of Detected	2.463
Minimum Non-Detect	3.6	Minimum Non-Detect	1.281
Maximum Non-Detect	5.3	Maximum Non-Detect	1.668

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	16
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	72.73%

Warning: There are only 8 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	0.603	Shapiro Wilk Test Statistic	0.737
5% Shapiro Wilk Critical Value	0.818	5% 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	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	131.3	Mean	1.696
SD	439.7	SD	1.873
95% DL/2 (t) UCL	292.6	95% H-Stat (DL/2) UCL	71.9
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE yields a negative mean		Mean in Log Scale	-0.418
		SD in Log Scale	3.343
		Mean in Original Scale	130
		SD in Original Scale	440.1
		95% Percentile Bootstrap UCL	301.7
		95% BCA Bootstrap UCL	429.7

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.251
Theta Star	1422
nu star	4.02
A-D Test Statistic	1.323
5% A-D Critical Value	0.809
K-S Test Statistic	0.809
5% K-S Critical Value	0.319

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	3.9
Maximum	1900
Mean	359.4
Median	361.4
SD	403.6
k star	0.586
Theta star	613.5
Nu star	25.78
AppChi2	15.21
95% Gamma Approximate UCL	609.2
95% Adjusted Gamma UCL	634.5

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	132.4
SD	429.2
SE of Mean	97.83
95% KM (t) UCL	300.7
95% KM (z) UCL	293.3
95% KM (jackknife) UCL	293.3
95% KM (bootstrap t) UCL	22424
95% KM (BCA) UCL	304.3
95% KM (Percentile Bootstrap) UCL	301.9
95% KM (Chebyshev) UCL	558.8
97.5% KM (Chebyshev) UCL	743.3
99% KM (Chebyshev) UCL	1106

Potential UCLs to Use

99% KM (Chebyshev) UCL	1106

PCB 1260

General Statistics

Number of Valid Data	22	Number of Detected Data	12
Number of Distinct Detected Data	11	Number of Non-Detect Data	10
		Percent Non-Detects	45.45%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	4.2	Minimum Detected	1.435
Maximum Detected	4900	Maximum Detected	8.497
Mean of Detected	682.2	Mean of Detected	3.066
SD of Detected	1614	SD of Detected	2.486
Minimum Non-Detect	4	Minimum Non-Detect	1.386
Maximum Non-Detect	5.3	Maximum Non-Detect	1.668

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	9
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	59.09%

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.49	Shapiro Wilk Test Statistic	0.641
5% Shapiro Wilk Critical Value	0.859	5% Shapiro Wilk Critical Value	0.859
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	373.2	Mean	2.06
SD	1219	SD	2.125
95% DL/2 (t) UCL	820.3	95% H-Stat (DL/2) UCL	352.4
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE yields a negative mean		Mean in Log Scale	0.928
		SD in Log Scale	3.079
		Mean in Original Scale	372.3
		SD in Original Scale	1219
		95% Percentile Bootstrap UCL	817
		95% BCA Bootstrap UCL	1039

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.214
Theta Star	3191
nu star	5.13
A-D Test Statistic	2.653
5% A-D Critical Value	0.861
K-S Test Statistic	0.861
5% K-S Critical Value	0.27

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	4.2
Maximum	4900
Mean	746.4
Median	716.9
SD	1172
k star	0.336
Theta star	2219
Nu star	14.8
AppChi2	7.123
95% Gamma Approximate UCL	1551
95% Adjusted Gamma UCL	1642

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	374.1
SD	1190
SE of Mean	265.1
95% KM (t) UCL	830.2
95% KM (z) UCL	810.1
95% KM (jackknife) UCL	821
95% KM (bootstrap t) UCL	112900
95% KM (BCA) UCL	886.6
95% KM (Percentile Bootstrap) UCL	819.1
95% KM (Chebyshev) UCL	1529
97.5% KM (Chebyshev) UCL	2029
99% KM (Chebyshev) UCL	3011

Potential UCLs to Use

99% KM (Chebyshev) UCL	3011

Benzo(a)pyrene

General Statistics

Number of Valid Data	37	Number of Detected Data	1
Number of Distinct Detected Data	1	Number of Non-Detect Data	36
		Percent Non-Detects	97.30%

Warning: Only one distinct data value was detected! ProUCL (or any other software) should not be used on such a data set!

It is suggested to use alternative site specific values determined by the Project Team to estimate environmental parameters (e.g., EPC, BTV).

The data set for variable BZAP was not processed!

Tetrachloroethene (PCE)

General Statistics

Number of Valid Data	37	Number of Detected Data	2
Number of Distinct Detected Data	2	Number of Non-Detect Data	35
		Percent Non-Detects	94.59%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	240	Minimum Detected	5.481
Maximum Detected	1600	Maximum Detected	7.378
Mean of Detected	920	Mean of Detected	6.429
SD of Detected	961.7	SD of Detected	1.341
Minimum Non-Detect	0.81	Minimum Non-Detect	-0.211
Maximum Non-Detect	41	Maximum Non-Detect	3.714

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	35
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	2
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	94.59%

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		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	N/A	Shapiro Wilk Test Statistic	N/A
5% Shapiro Wilk Critical Value	N/A	5% Shapiro Wilk Critical Value	N/A
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	51.71	Mean	0.456
SD	264.5	SD	1.785
95% DL/2 (t) UCL	125.1	95% H-Stat (DL/2) UCL	15.37
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		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% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap 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
95% Gamma Approximate UCL	N/A
95% Adjusted Gamma UCL	N/A

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	276.8
SD	220.5
SE of Mean	51.27
95% KM (t) UCL	363.3
95% KM (z) UCL	361.1
95% KM (jackknife) UCL	1165
95% KM (bootstrap t) UCL	276.8
95% KM (BCA) UCL	N/A
95% KM (Percentile Bootstrap) UCL	1600
95% KM (Chebyshev) UCL	500.3
97.5% KM (Chebyshev) UCL	597
99% KM (Chebyshev) UCL	786.9

Potential UCLs to Use

95% KM (BCA) UCL	N/A

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	G:\DATAMGMT\Projects\PlumBrook\Stats_2009_AcidArea1\stats_WS_Eco\ProUCLStats\ProUCL_Input.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Acid Area I Surface Water Chemicals of Potential Ecological Concern

Aluminum

General Statistics

Number of Valid Data	12	Number of Detected Data	8
Number of Distinct Detected Data	8	Number of Non-Detect Data	4
		Percent Non-Detects	33.33%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	317	Minimum Detected	5.759
Maximum Detected	10200	Maximum Detected	9.23
Mean of Detected	1924	Mean of Detected	6.844
SD of Detected	3359	SD of Detected	1.077
Minimum Non-Detect	100	Minimum Non-Detect	4.605
Maximum Non-Detect	100	Maximum Non-Detect	4.605

Warning: There are only 8 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	0.509	Shapiro Wilk Test Statistic	0.828
5% Shapiro Wilk Critical Value	0.818	5% Shapiro Wilk Critical Value	0.818
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	1300	Mean	5.867
SD	2834	SD	1.68
95% DL/2 (t) UCL	2769	95% H-Stat (DL/2) UCL	10578
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	406.8	Mean in Log Scale	5.96
SD	3555	SD in Log Scale	1.6
95% MLE (t) UCL	2250	Mean in Original Scale	1308
95% MLE (Tiku) UCL	2370	SD in Original Scale	2830
		95% Percentile Bootstrap UCL	2858
		95% BCA Bootstrap UCL	3744

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.598
Theta Star	3219
nu star	9.564
A-D Test Statistic	1.145
5% A-D Critical Value	0.742
K-S Test Statistic	0.742
5% K-S Critical Value	0.303

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data

Minimum	1E-09
Maximum	10200
Mean	1348
Median	648.2
SD	2817
k star	0.167
Theta star	8067
Nu star	4.012
AppChi2	0.726
95% Gamma Approximate UCL	7448
95% Adjusted Gamma UCL	9937

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	1389
SD	2675
SE of Mean	825.5
95% KM (t) UCL	2871
95% KM (z) UCL	2746
95% KM (jackknife) UCL	2824
95% KM (bootstrap t) UCL	11018
95% KM (BCA) UCL	3057
95% KM (Percentile Bootstrap) UCL	2980
95% KM (Chebyshev) UCL	4987
97.5% KM (Chebyshev) UCL	6544
99% KM (Chebyshev) UCL	9602

Potential UCLs to Use

97.5% KM (Chebyshev) UCL	6544

Barium

General Statistics

Number of Valid Observations	12	Number of Distinct Observations	12

Raw Statistics		Log-transformed Statistics	
Minimum	11.55	Minimum of Log Data	2.447
Maximum	194	Maximum of Log Data	5.268
Mean	59.17	Mean of log Data	3.767
Median	45.8	SD of log Data	0.84
SD	51.84		
Coefficient of Variation	0.876		
Skewness	1.851		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.804	Shapiro Wilk Test Statistic	0.964
Shapiro Wilk Critical Value	0.859	Shapiro Wilk Critical Value	0.859
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	86.04	95% H-UCL	120
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	125.5
95% Adjusted-CLT UCL	92.33	97.5% Chebyshev (MVUE) UCL	154.1
95% Modified-t UCL	87.38	99% Chebyshev (MVUE) UCL	210.4

Gamma Distribution Test		Data Distribution
k star (bias corrected)	1.364	Data appear Gamma Distributed at 5% Significance Level
Theta Star	43.37	
MLE of Mean	59.17	
MLE of Standard Deviation	50.65	
nu star	32.74	
Approximate Chi Square Value (.05)	20.66	**Nonparametric Statistics**
Adjusted Level of Significance	0.029	95% CLT UCL 83.78
Adjusted Chi Square Value	19.21	95% Jackknife UCL 86.04
		95% Standard Bootstrap UCL 82.87
Anderson-Darling Test Statistic	0.279	95% Bootstrap-t UCL 109.5
Anderson-Darling 5% Critical Value	0.744	95% Hall's Bootstrap UCL 218.8
Kolmogorov-Smirnov Test Statistic	0.147	95% Percentile Bootstrap UCL 84.33
Kolmogorov-Smirnov 5% Critical Value	0.249	95% BCA Bootstrap UCL 91.12
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL 124.4
		97.5% Chebyshev(Mean, Sd) UCL 152.6
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL 208.1
95% Approximate Gamma UCL	93.76	
95% Adjusted Gamma UCL	100.9	

Potential UCL to Use	Use 95% Approximate Gamma UCL 93.76

Copper

General Statistics

Number of Valid Data	12	Number of Detected Data	1
Number of Distinct Detected Data	1	Number of Non-Detect Data	11
		Percent Non-Detects	91.67%

Warning: Only one distinct data value was detected! ProUCL (or any other software) should not be used on such a data set!

It is suggested to use alternative site specific values determined by the Project Team to estimate environmental parameters (e.g., EPC, BTV).

The data set for variable CU was not processed!

Iron

General Statistics

Number of Valid Observations	12	Number of Distinct Observations	12

Raw Statistics		Log-transformed Statistics	
Minimum	76.7	Minimum of Log Data	4.34
Maximum	50000	Maximum of Log Data	10.82
Mean	6173	Mean of log Data	7.313
Median	1440	SD of log Data	1.783
SD	13974		
Coefficient of Variation	2.264		
Skewness	3.317		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.457	Shapiro Wilk Test Statistic	0.957
Shapiro Wilk Critical Value	0.859	Shapiro Wilk Critical Value	0.859
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	13418	95% H-UCL	82303
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	19492
95% Adjusted-CLT UCL	16936	97.5% Chebyshev (MVUE) UCL	25484
95% Modified-t UCL	14062	99% Chebyshev (MVUE) UCL	37253

Gamma Distribution Test		Data Distribution
k star (bias corrected)	0.397	Data appear Gamma Distributed at 5% Significance Level
Theta Star	15546	
MLE of Mean	6173	
MLE of Standard Deviation	9796	
nu star	9.53	
Approximate Chi Square Value (.05)	3.65	
Adjusted Level of Significance	0.029	
Adjusted Chi Square Value	3.116	
Anderson-Darling Test Statistic	0.766	
Anderson-Darling 5% Critical Value	0.794	
Kolmogorov-Smirnov Test Statistic	0.238	
Kolmogorov-Smirnov 5% Critical Value	0.26	
Data appear Gamma Distributed at 5% Significance Level		

Nonparametric Statistics	
95% CLT UCL	12809
95% Jackknife UCL	13418
95% Standard Bootstrap UCL	12607
95% Bootstrap-t UCL	43949
95% Hall's Bootstrap UCL	37331
95% Percentile Bootstrap UCL	13977
95% BCA Bootstrap UCL	17893
95% Chebyshev(Mean, Sd) UCL	23757
97.5% Chebyshev(Mean, Sd) UCL	31365
99% Chebyshev(Mean, Sd) UCL	46311

Assuming Gamma Distribution	
95% Approximate Gamma UCL	16117
95% Adjusted Gamma UCL	18883

Potential UCL to Use	Use 95% Adjusted Gamma UCL 18883

Manganese

General Statistics

Number of Valid Observations	12	Number of Distinct Observations	12

Raw Statistics		Log-transformed Statistics	
Minimum	64.55	Minimum of Log Data	4.167
Maximum	8840	Maximum of Log Data	9.087
Mean	1330	Mean of log Data	6.304
Median	524.5	SD of log Data	1.34
SD	2438		
Coefficient of Variation	1.833		
Skewness	3.135		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.514	Shapiro Wilk Test Statistic	0.939
Shapiro Wilk Critical Value	0.859	Shapiro Wilk Critical Value	0.859
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	2594	95% H-UCL	5669
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	3377
95% Adjusted-CLT UCL	3168	97.5% Chebyshev (MVUE) UCL	4324
95% Modified-t UCL	2700	99% Chebyshev (MVUE) UCL	6183

Gamma Distribution Test		Data Distribution
k star (bias corrected)	0.567	Data appear Lognormal at 5% Significance Level
Theta Star	2345	
MLE of Mean	1330	
MLE of Standard Deviation	1766	
nu star	13.61	
Approximate Chi Square Value (.05)	6.308	**Nonparametric Statistics**
Adjusted Level of Significance	0.029	95% CLT UCL 2488
Adjusted Chi Square Value	5.566	95% Jackknife UCL 2594
		95% Standard Bootstrap UCL 2419
Anderson-Darling Test Statistic	0.844	95% Bootstrap-t UCL 8831
Anderson-Darling 5% Critical Value	0.771	95% Hall's Bootstrap UCL 8409
Kolmogorov-Smirnov Test Statistic	0.291	95% Percentile Bootstrap UCL 2642
Kolmogorov-Smirnov 5% Critical Value	0.256	95% BCA Bootstrap UCL 3286
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL 4398
		97.5% Chebyshev(Mean, Sd) UCL 5725
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL 8333
95% Approximate Gamma UCL	2871	
95% Adjusted Gamma UCL	3254	

Potential UCL to Use	Use 95% Chebyshev (MVUE) UCL 3377

Nickel

General Statistics

Number of Valid Data	12	Number of Detected Data	9
Number of Distinct Detected Data	9	Number of Non-Detect Data	3
		Percent Non-Detects	25.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	3.4	Minimum Detected	1.224
Maximum Detected	51.7	Maximum Detected	3.945
Mean of Detected	17.97	Mean of Detected	2.302
SD of Detected	20.1	SD of Detected	1.148
Minimum Non-Detect	3	Minimum Non-Detect	1.099
Maximum Non-Detect	3	Maximum Non-Detect	1.099

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	0.733	Shapiro Wilk Test Statistic	0.821
5% Shapiro Wilk Critical Value	0.829	5% Shapiro Wilk Critical Value	0.829
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	13.85	Mean	1.828
SD	18.69	SD	1.302
95% DL/2 (t) UCL	23.55	95% H-Stat (DL/2) UCL	35.34
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	10.52	Mean in Log Scale	1.609
SD	21.7	SD in Log Scale	1.609
95% MLE (t) UCL	21.77	Mean in Original Scale	13.65
95% MLE (Tiku) UCL	21.94	SD in Original Scale	18.84
		95% Percentile Bootstrap UCL	22.71
		95% BCA Bootstrap UCL	25.11

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.731
Theta Star	24.6
nu star	13.15
A-D Test Statistic	0.826
5% A-D Critical Value	0.744
K-S Test Statistic	0.744
5% K-S Critical Value	0.287

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	1E-09
Maximum	51.7
Mean	13.62
Median	4.05
SD	18.87
k star	0.187
Theta star	72.94
Nu star	4.482
AppChi2	0.921
95% Gamma Approximate UCL	66.3
95% Adjusted Gamma UCL	86.69

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	14.33
SD	17.59
SE of Mean	5.385
95% KM (t) UCL	24
95% KM (z) UCL	23.19
95% KM (jackknife) UCL	23.82
95% KM (bootstrap t) UCL	37.35
95% KM (BCA) UCL	25.14
95% KM (Percentile Bootstrap) UCL	23.66
95% KM (Chebyshev) UCL	37.8
97.5% KM (Chebyshev) UCL	47.96
99% KM (Chebyshev) UCL	67.91

Potential UCLs to Use

97.5% KM (Chebyshev) UCL	47.96

Zinc

General Statistics

Number of Valid Data	12	Number of Detected Data	7
Number of Distinct Detected Data	7	Number of Non-Detect Data	5
		Percent Non-Detects	41.67%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	7	Minimum Detected	1.946
Maximum Detected	71.6	Maximum Detected	4.271
Mean of Detected	25.32	Mean of Detected	2.932
SD of Detected	22.47	SD of Detected	0.826
Minimum Non-Detect	5	Minimum Non-Detect	1.609
Maximum Non-Detect	5	Maximum Non-Detect	1.609

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	0.802	Shapiro Wilk Test Statistic	0.943
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	15.81	Mean	2.092
SD	20.33	SD	1.204
95% DL/2 (t) UCL	26.35	95% H-Stat (DL/2) UCL	32.95
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	7.975	Mean in Log Scale	1.964
SD	28.02	SD in Log Scale	1.402
95% MLE (t) UCL	22.5	Mean in Original Scale	15.67
95% MLE (Tiku) UCL	24.52	SD in Original Scale	20.45
		95% Percentile Bootstrap UCL	26.06
		95% BCA Bootstrap UCL	29.3

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	1.134
Theta Star	22.33
nu star	15.88
A-D Test Statistic	0.337
5% A-D Critical Value	0.717
K-S Test Statistic	0.717
5% K-S Critical Value	0.316

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data

Minimum	1E-09
Maximum	71.6
Mean	21.27
Median	18.12
SD	18.85
k star	0.296
Theta star	71.76
Nu star	7.112
AppChi2	2.232
95% Gamma Approximate UCL	67.76
95% Adjusted Gamma UCL	82.25

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	17.69
SD	18.27
SE of Mean	5.698
95% KM (t) UCL	27.92
95% KM (z) UCL	27.06
95% KM (jackknife) UCL	27.18
95% KM (bootstrap t) UCL	36.69
95% KM (BCA) UCL	30.93
95% KM (Percentile Bootstrap) UCL	28.19
95% KM (Chebyshev) UCL	42.52
97.5% KM (Chebyshev) UCL	53.27
99% KM (Chebyshev) UCL	74.38

Potential UCLs to Use

95% KM (t) UCL	27.92

1,1,1-Trichloroethane

General Statistics

Number of Valid Data	12	Number of Detected Data	2
Number of Distinct Detected Data	2	Number of Non-Detect Data	10
		Percent Non-Detects	83.33%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	4.9	Minimum Detected	1.589
Maximum Detected	14	Maximum Detected	2.639
Mean of Detected	9.45	Mean of Detected	2.114
SD of Detected	6.435	SD of Detected	0.742
Minimum Non-Detect	0.15	Minimum Non-Detect	-1.897
Maximum Non-Detect	0.15	Maximum Non-Detect	-1.897

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		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	N/A	Shapiro Wilk Test Statistic	N/A
5% Shapiro Wilk Critical Value	N/A	5% Shapiro Wilk Critical Value	N/A
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	1.638	Mean	-1.806
SD	4.133	SD	1.845
95% DL/2 (t) UCL	3.78	95% H-Stat (DL/2) UCL	5.933
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		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% Percentile Bootstrap UCL	N/A
		95% BCA Bootstrap 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
95% Gamma Approximate UCL	N/A
95% Adjusted Gamma UCL	N/A

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	5.658
SD	2.515
SE of Mean	1.027
95% KM (t) UCL	7.502
95% KM (z) UCL	7.347
95% KM (jackknife) UCL	N/A
95% KM (bootstrap t) UCL	N/A
95% KM (BCA) UCL	N/A
95% KM (Percentile Bootstrap) UCL	N/A
95% KM (Chebyshev) UCL	10.13
97.5% KM (Chebyshev) UCL	12.07
99% KM (Chebyshev) UCL	15.87

Potential UCLs to Use

95% KM (t) UCL	7.502
95% KM (% Bootstrap) UCL	N/A

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	G:\DATAMGMT\Projects\PlumBrook\Stats_2009_AcidArea1\stats_WS_HH\ProUCLStats\ProUCL_Input.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Acid Area I Surface Water Chemicals of Potential Concern (human health)

Arsenic

General Statistics

Number of Valid Data	12	Number of Detected Data	3
Number of Distinct Detected Data	3	Number of Non-Detect Data	9
		Percent Non-Detects	75.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	4	Minimum Detected	1.386
Maximum Detected	49.3	Maximum Detected	3.898
Mean of Detected	19.5	Mean of Detected	2.311
SD of Detected	25.81	SD of Detected	1.381
Minimum Non-Detect	3	Minimum Non-Detect	1.099
Maximum Non-Detect	3	Maximum Non-Detect	1.099

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	0.77	Shapiro Wilk Test Statistic	0.827
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	6	Mean	0.882
SD	13.69	SD	1.044
95% DL/2 (t) UCL	13.1	95% H-Stat (DL/2) UCL	6.656
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE yields a negative mean		Mean in Log Scale	-2.435
		SD in Log Scale	3.615
		Mean in Original Scale	4.954
		SD in Original Scale	14.08
		95% Percentile Bootstrap UCL	12.79
		95% BCA Bootstrap UCL	17.64

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	N/A
95% Adjusted Gamma UCL	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	7.875
SD	12.49
SE of Mean	4.417
95% KM (t) UCL	15.81
95% KM (z) UCL	15.14
95% KM (jackknife) UCL	14.08
95% KM (bootstrap t) UCL	158.7
95% KM (BCA) UCL	49.3
95% KM (Percentile Bootstrap) UCL	49.3
95% KM (Chebyshev) UCL	27.13
97.5% KM (Chebyshev) UCL	35.46
99% KM (Chebyshev) UCL	51.83

Potential UCLs to Use

95% KM (t) UCL	15.81
95% KM (Percentile Bootstrap) UCL	49.3

Cobalt

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	6.15	Minimum Detected	1.816
Maximum Detected	12.8	Maximum Detected	2.549
Mean of Detected	9.138	Mean of Detected	2.16
SD of Detected	3.371	SD of Detected	0.377
Minimum Non-Detect	3	Minimum Non-Detect	1.099
Maximum Non-Detect	3	Maximum Non-Detect	1.099

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	0.848	Shapiro Wilk Test Statistic	0.835
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	4.046	Mean	0.99
SD	4.152	SD	0.886
95% DL/2 (t) UCL	6.198	95% H-Stat (DL/2) UCL	4.739
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	9.297	Mean in Log Scale	1.214
SD	2.919	SD in Log Scale	0.84
95% MLE (t) UCL	10.81	Mean in Original Scale	4.615
95% MLE (Tiku) UCL	11.9	SD in Original Scale	3.882
		95% Percentile Bootstrap UCL	6.474
		95% BCA Bootstrap UCL	6.624

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	2.572
Theta Star	3.552
nu star	20.58
A-D Test Statistic	0.499
5% A-D Critical Value	0.657
K-S Test Statistic	0.657
5% K-S Critical Value	0.395

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data

Minimum	5.231
Maximum	18.45
Mean	11.55
Median	11.84
SD	4.398
k star	5.134
Theta star	2.249
Nu star	123.2
AppChi2	98.58
95% Gamma Approximate UCL	14.43
95% Adjusted Gamma UCL	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	7.146
SD	2.196
SE of Mean	0.732
95% KM (t) UCL	8.461
95% KM (z) UCL	8.35
95% KM (jackknife) UCL	8.245
95% KM (bootstrap t) UCL	8.049
95% KM (BCA) UCL	12.8
95% KM (Percentile Bootstrap) UCL	11.47
95% KM (Chebyshev) UCL	10.34
97.5% KM (Chebyshev) UCL	11.72
99% KM (Chebyshev) UCL	14.43

Potential UCLs to Use

95% KM (t) UCL	8.461
95% KM (Percentile Bootstrap) UCL	11.47

Iron

General Statistics

Number of Valid Observations	12	Number of Distinct Observations	12

Raw Statistics		Log-transformed Statistics	
Minimum	76.7	Minimum of Log Data	4.34
Maximum	50000	Maximum of Log Data	10.82
Mean	6173	Mean of log Data	7.313
Median	1440	SD of log Data	1.783
SD	13974		
Coefficient of Variation	2.264		
Skewness	3.317		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.457	Shapiro Wilk Test Statistic	0.957
Shapiro Wilk Critical Value	0.859	Shapiro Wilk Critical Value	0.859
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	13418	95% H-UCL	82303
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	19492
95% Adjusted-CLT UCL	16936	97.5% Chebyshev (MVUE) UCL	25484
95% Modified-t UCL	14062	99% Chebyshev (MVUE) UCL	37253

Gamma Distribution Test		Data Distribution
k star (bias corrected)	0.397	Data appear Gamma Distributed at 5% Significance Level
Theta Star	15546	
MLE of Mean	6173	
MLE of Standard Deviation	9796	
nu star	9.53	
Approximate Chi Square Value (.05)	3.65	
Adjusted Level of Significance	0.029	
Adjusted Chi Square Value	3.116	
Anderson-Darling Test Statistic	0.766	
Anderson-Darling 5% Critical Value	0.794	
Kolmogorov-Smirnov Test Statistic	0.238	
Kolmogorov-Smirnov 5% Critical Value	0.26	
Data appear Gamma Distributed at 5% Significance Level		

Nonparametric Statistics	
95% CLT UCL	12809
95% Jackknife UCL	13418
95% Standard Bootstrap UCL	12468
95% Bootstrap-t UCL	43738
95% Hall's Bootstrap UCL	37810
95% Percentile Bootstrap UCL	13898
95% BCA Bootstrap UCL	18272
95% Chebyshev(Mean, Sd) UCL	23757
97.5% Chebyshev(Mean, Sd) UCL	31365
99% Chebyshev(Mean, Sd) UCL	46311

Assuming Gamma Distribution	
95% Approximate Gamma UCL	16117
95% Adjusted Gamma UCL	18883

Potential UCL to Use	Use 95% Adjusted Gamma UCL 18883

Manganese

General Statistics

Number of Valid Observations	12	Number of Distinct Observations	12

Raw Statistics		Log-transformed Statistics	
Minimum	64.55	Minimum of Log Data	4.167
Maximum	8840	Maximum of Log Data	9.087
Mean	1330	Mean of log Data	6.304
Median	524.5	SD of log Data	1.34
SD	2438		
Coefficient of Variation	1.833		
Skewness	3.135		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.514	Shapiro Wilk Test Statistic	0.939
Shapiro Wilk Critical Value	0.859	Shapiro Wilk Critical Value	0.859
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	2594	95% H-UCL	5669
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	3377
95% Adjusted-CLT UCL	3168	97.5% Chebyshev (MVUE) UCL	4324
95% Modified-t UCL	2700	99% Chebyshev (MVUE) UCL	6183

Gamma Distribution Test		Data Distribution
k star (bias corrected)	0.567	Data appear Lognormal at 5% Significance Level
Theta Star	2345	
MLE of Mean	1330	
MLE of Standard Deviation	1766	
nu star	13.61	
Approximate Chi Square Value (.05)	6.308	**Nonparametric Statistics**
Adjusted Level of Significance	0.029	95% CLT UCL 2488
Adjusted Chi Square Value	5.566	95% Jackknife UCL 2594
		95% Standard Bootstrap UCL 2409
Anderson-Darling Test Statistic	0.844	95% Bootstrap-t UCL 8890
Anderson-Darling 5% Critical Value	0.771	95% Hall's Bootstrap UCL 8480
Kolmogorov-Smirnov Test Statistic	0.291	95% Percentile Bootstrap UCL 2618
Kolmogorov-Smirnov 5% Critical Value	0.256	95% BCA Bootstrap UCL 3521
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL 4398
		97.5% Chebyshev(Mean, Sd) UCL 5725
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL 8333
95% Approximate Gamma UCL	2871	
95% Adjusted Gamma UCL	3254	

Potential UCL to Use	Use 95% Chebyshev (MVUE) UCL 3377

Thallium

General Statistics

Number of Valid Data	12	Number of Detected Data	2
Number of Distinct Detected Data	2	Number of Non-Detect Data	10
		Percent Non-Detects	83.33%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	3.7	Minimum Detected	1.308
Maximum Detected	4.3	Maximum Detected	1.459
Mean of Detected	4	Mean of Detected	1.383
SD of Detected	0.424	SD of Detected	0.106
Minimum Non-Detect	3	Minimum Non-Detect	1.099
Maximum Non-Detect	3	Maximum Non-Detect	1.099

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		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	N/A	Shapiro Wilk Test Statistic	N/A
5% Shapiro Wilk Critical Value	N/A	5% Shapiro Wilk Critical Value	N/A
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	1.917	Mean	0.568
SD	0.981	SD	0.382
95% DL/2 (t) UCL	2.426	95% H-Stat (DL/2) UCL	2.236
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		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% Percentile Bootstrap UCL	N/A
		95% BCA Bootstrap 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
95% Gamma Approximate UCL	N/A
95% Adjusted Gamma UCL	N/A

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	3.75
SD	0.166
SE of Mean	0.0677
95% KM (t) UCL	3.872
95% KM (z) UCL	3.861
95% KM (jackknife) UCL	N/A
95% KM (bootstrap t) UCL	N/A
95% KM (BCA) UCL	N/A
95% KM (Percentile Bootstrap) UCL	N/A
95% KM (Chebyshev) UCL	4.045
97.5% KM (Chebyshev) UCL	4.173
99% KM (Chebyshev) UCL	4.424

Potential UCLs to Use

95% KM (t) UCL	3.872
95% KM (% Bootstrap) UCL	N/A

Carbon Tetrachloride

General Statistics

Number of Valid Data	12	Number of Detected Data	1
Number of Distinct Detected Data	1	Number of Non-Detect Data	11
		Percent Non-Detects	91.67%

Warning: Only one distinct data value was detected! ProUCL (or any other software) should not be used on such a data set!

It is suggested to use alternative site specific values determined by the Project Team to estimate environmental parameters (e.g., EPC, BTV).

The data set for variable CTCL was not processed!

1,1-Dichloroethane

General Statistics

Number of Valid Data	12	Number of Detected Data	2
Number of Distinct Detected Data	2	Number of Non-Detect Data	10
		Percent Non-Detects	83.33%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	2.6	Minimum Detected	0.956
Maximum Detected	3.9	Maximum Detected	1.361
Mean of Detected	3.25	Mean of Detected	1.158
SD of Detected	0.919	SD of Detected	0.287
Minimum Non-Detect	0.15	Minimum Non-Detect	-1.897
Maximum Non-Detect	0.15	Maximum Non-Detect	-1.897

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		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	N/A	Shapiro Wilk Test Statistic	N/A
5% Shapiro Wilk Critical Value	N/A	5% Shapiro Wilk Critical Value	N/A
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	0.604	Mean	-1.966
SD	1.267	SD	1.462
95% DL/2 (t) UCL	1.261	95% H-Stat (DL/2) UCL	1.336
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		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% Percentile Bootstrap UCL	N/A
		95% BCA Bootstrap 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
95% Gamma Approximate UCL	N/A
95% Adjusted Gamma UCL	N/A

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	2.708
SD	0.359
SE of Mean	0.147
95% KM (t) UCL	2.972
95% KM (z) UCL	2.95
95% KM (jackknife) UCL	N/A
95% KM (bootstrap t) UCL	N/A
95% KM (BCA) UCL	N/A
95% KM (Percentile Bootstrap) UCL	N/A
95% KM (Chebyshev) UCL	3.348
97.5% KM (Chebyshev) UCL	3.624
99% KM (Chebyshev) UCL	4.168

Potential UCLs to Use

95% KM (t) UCL	2.972
95% KM (% Bootstrap) UCL	N/A

Trichloroethene (TCE)

General Statistics

Number of Valid Data	12	Number of Detected Data	2
Number of Distinct Detected Data	2	Number of Non-Detect Data	10
		Percent Non-Detects	83.33%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	1.7	Minimum Detected	0.531
Maximum Detected	4.9	Maximum Detected	1.589
Mean of Detected	3.3	Mean of Detected	1.06
SD of Detected	2.263	SD of Detected	0.749
Minimum Non-Detect	0.28	Minimum Non-Detect	-1.273
Maximum Non-Detect	0.28	Maximum Non-Detect	-1.273

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		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	N/A	Shapiro Wilk Test Statistic	N/A
5% Shapiro Wilk Critical Value	N/A	5% Shapiro Wilk Critical Value	N/A
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	0.667	Mean	-1.462
SD	1.407	SD	1.199
95% DL/2 (t) UCL	1.396	95% H-Stat (DL/2) UCL	1.011
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		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% Percentile Bootstrap UCL	N/A
		95% BCA Bootstrap 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
95% Gamma Approximate UCL	N/A
95% Adjusted Gamma UCL	N/A

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	1.967
SD	0.884
SE of Mean	0.361
95% KM (t) UCL	2.615
95% KM (z) UCL	2.561
95% KM (jackknife) UCL	N/A
95% KM (bootstrap t) UCL	N/A
95% KM (BCA) UCL	N/A
95% KM (Percentile Bootstrap) UCL	N/A
95% KM (Chebyshev) UCL	3.541
97.5% KM (Chebyshev) UCL	4.222
99% KM (Chebyshev) UCL	5.559

Potential UCLs to Use

95% KM (t) UCL	2.615
95% KM (% Bootstrap) UCL	N/A

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	G:\DATAMGMT\Projects\PlumBrook\Stats_2009_AcidArea1\stats_SE_Eco\ProUCLStats\ProUCL_Input.
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Acid Area I Sediment Chemicals of Potential Ecological Concern

Chromium

General Statistics

Number of Valid Observations	15	Number of Distinct Observations	15

Raw Statistics

Minimum	2
Maximum	34.4
Mean	16.38
Median	16.7
SD	7.073
Coefficient of Variation	0.432
Skewness	0.668

Log-transformed Statistics

Minimum of Log Data	0.693
Maximum of Log Data	3.538
Mean of log Data	2.668
SD of log Data	0.623

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.917
Shapiro Wilk Critical Value	0.881

Data appear Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.748
Shapiro Wilk Critical Value	0.881

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	19.6

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL	19.72
95% Modified-t UCL	19.65

Assuming Lognormal Distribution

95% H-UCL	25.27
95% Chebyshev (MVUE) UCL	29.85
97.5% Chebyshev (MVUE) UCL	35.31
99% Chebyshev (MVUE) UCL	46.04

Gamma Distribution Test

k star (bias corrected)	3.302
Theta Star	4.961
MLE of Mean	16.38
MLE of Standard Deviation	9.015
nu star	99.05
Approximate Chi Square Value (.05)	77.09
Adjusted Level of Significance	0.0324
Adjusted Chi Square Value	74.7

Anderson-Darling Test Statistic	0.88
Anderson-Darling 5% Critical Value	0.74
Kolmogorov-Smirnov Test Statistic	0.197
Kolmogorov-Smirnov 5% Critical Value	0.223

Data follow Appr. Gamma Distribution at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	21.05
95% Adjusted Gamma UCL	21.72

Data Distribution

Data appear Normal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	19.38
95% Jackknife UCL	19.6
95% Standard Bootstrap UCL	19.39
95% Bootstrap-t UCL	20.04
95% Hall's Bootstrap UCL	21.17
95% Percentile Bootstrap UCL	19.39
95% BCA Bootstrap UCL	19.67
95% Chebyshev(Mean, Sd) UCL	24.34
97.5% Chebyshev(Mean, Sd) UCL	27.78
99% Chebyshev(Mean, Sd) UCL	34.55

Potential UCL to Use

Use 95% Student's-t UCL 19.6

Mercury

General Statistics

Number of Valid Observations	15	Number of Distinct Observations	15

Raw Statistics		Log-transformed Statistics	
Minimum	0.0205	Minimum of Log Data	-3.887
Maximum	2.2	Maximum of Log Data	0.788
Mean	0.202	Mean of log Data	-2.76
Median	0.046	SD of log Data	1.143
SD	0.554		
Coefficient of Variation	2.741		
Skewness	3.834		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.342	Shapiro Wilk Test Statistic	0.756
Shapiro Wilk Critical Value	0.881	Shapiro Wilk Critical Value	0.881
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	0.454	95% H-UCL	0.302
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	0.277
95% Adjusted-CLT UCL	0.589	97.5% Chebyshev (MVUE) UCL	0.347
95% Modified-t UCL	0.478	99% Chebyshev (MVUE) UCL	0.485

Gamma Distribution Test		Data Distribution
k star (bias corrected)	0.477	Data do not follow a Discernable Distribution (0.05)
Theta Star	0.424	
MLE of Mean	0.202	
MLE of Standard Deviation	0.293	
nu star	14.3	
Approximate Chi Square Value (.05)	6.776	
Adjusted Level of Significance	0.0324	
Adjusted Chi Square Value	6.148	
Anderson-Darling Test Statistic	2.787	
Anderson-Darling 5% Critical Value	0.79	
Kolmogorov-Smirnov Test Statistic	0.348	
Kolmogorov-Smirnov 5% Critical Value	0.233	
Data not Gamma Distributed at 5% Significance Level		

Assuming Gamma Distribution		Nonparametric Statistics	
95% Approximate Gamma UCL	0.427	95% CLT UCL	0.438
95% Adjusted Gamma UCL	0.47	95% Jackknife UCL	0.454
		95% Standard Bootstrap UCL	0.432
		95% Bootstrap-t UCL	3.417
		95% Hall's Bootstrap UCL	2.088
		95% Percentile Bootstrap UCL	0.485
		95% BCA Bootstrap UCL	0.631
		95% Chebyshev(Mean, Sd) UCL	0.826
		97.5% Chebyshev(Mean, Sd) UCL	1.096
		99% Chebyshev(Mean, Sd) UCL	1.626

Potential UCL to Use	Use 99% Chebyshev (Mean, Sd) UCL 1.626

Nickel

General Statistics

Number of Valid Observations	15	Number of Distinct Observations	15

Raw Statistics

Minimum	9.2
Maximum	243
Mean	43.39
Median	24.15
SD	59.4
Coefficient of Variation	1.369
Skewness	3.084

Log-transformed Statistics

Minimum of Log Data	2.219
Maximum of Log Data	5.493
Mean of log Data	3.301
SD of log Data	0.887

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.573
Shapiro Wilk Critical Value	0.881

Data not Normal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	70.4

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL	81.67
95% Modified-t UCL	72.44

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.91
Shapiro Wilk Critical Value	0.881

Data appear Lognormal at 5% Significance Level

Assuming Lognormal Distribution

95% H-UCL	73.95
95% Chebyshev (MVUE) UCL	80.7
97.5% Chebyshev (MVUE) UCL	98.8
99% Chebyshev (MVUE) UCL	134.4

Gamma Distribution Test

k star (bias corrected)	1.009
Theta Star	43.01
MLE of Mean	43.39
MLE of Standard Deviation	43.2
nu star	30.27
Approximate Chi Square Value (.05)	18.7
Adjusted Level of Significance	0.0324
Adjusted Chi Square Value	17.59
Anderson-Darling Test Statistic	1.053
Anderson-Darling 5% Critical Value	0.759
Kolmogorov-Smirnov Test Statistic	0.242
Kolmogorov-Smirnov 5% Critical Value	0.227

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	70.22
95% Adjusted Gamma UCL	74.67

Data Distribution

Data appear Lognormal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	68.62
95% Jackknife UCL	70.4
95% Standard Bootstrap UCL	68.85
95% Bootstrap-t UCL	118.9
95% Hall's Bootstrap UCL	155
95% Percentile Bootstrap UCL	69.61
95% BCA Bootstrap UCL	83.89
95% Chebyshev(Mean, Sd) UCL	110.2
97.5% Chebyshev(Mean, Sd) UCL	139.2
99% Chebyshev(Mean, Sd) UCL	196

Potential UCL to Use

Use 95% H-UCL 73.95

Lead

General Statistics

Number of Valid Observations	15	Number of Distinct Observations	15

Raw Statistics

Minimum	5.6
Maximum	77.3
Mean	27.71
Median	22.5
SD	20.68
Coefficient of Variation	0.746
Skewness	1.588

Log-transformed Statistics

Minimum of Log Data	1.723
Maximum of Log Data	4.348
Mean of log Data	3.09
SD of log Data	0.709

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.813
Shapiro Wilk Critical Value	0.881

Data not Normal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	37.12

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL	38.83
95% Modified-t UCL	37.48

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.972
Shapiro Wilk Critical Value	0.881

Data appear Lognormal at 5% Significance Level

Assuming Lognormal Distribution

95% H-UCL	43.89
95% Chebyshev (MVUE) UCL	51.07
97.5% Chebyshev (MVUE) UCL	61.17
99% Chebyshev (MVUE) UCL	81.01

Gamma Distribution Test

k star (bias corrected)	1.895
Theta Star	14.62
MLE of Mean	27.71
MLE of Standard Deviation	20.13
nu star	56.85
Approximate Chi Square Value (.05)	40.52
Adjusted Level of Significance	0.0324
Adjusted Chi Square Value	38.83
Anderson-Darling Test Statistic	0.348
Anderson-Darling 5% Critical Value	0.746
Kolmogorov-Smirnov Test Statistic	0.142
Kolmogorov-Smirnov 5% Critical Value	0.224

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	38.88
95% Adjusted Gamma UCL	40.58

Data Distribution

Data appear Gamma Distributed at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	36.49
95% Jackknife UCL	37.12
95% Standard Bootstrap UCL	36.24
95% Bootstrap-t UCL	44.58
95% Hall's Bootstrap UCL	91
95% Percentile Bootstrap UCL	36.87
95% BCA Bootstrap UCL	38.94
95% Chebyshev(Mean, Sd) UCL	50.98
97.5% Chebyshev(Mean, Sd) UCL	61.05
99% Chebyshev(Mean, Sd) UCL	80.83

Potential UCL to Use

Use 95% Approximate Gamma UCL 38.88

PCB 1254

General Statistics

Number of Valid Data	15	Number of Detected Data	14
Number of Distinct Detected Data	14	Number of Non-Detect Data	1
		Percent Non-Detects	6.67%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	4.6	Minimum Detected	1.526
Maximum Detected	750	Maximum Detected	6.62
Mean of Detected	199.1	Mean of Detected	4.089
SD of Detected	272.4	SD of Detected	1.783
Minimum Non-Detect	4.9	Minimum Non-Detect	1.589
Maximum Non-Detect	4.9	Maximum Non-Detect	1.589

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.726	Shapiro Wilk Test Statistic	0.931
5% Shapiro Wilk Critical Value	0.874	5% Shapiro Wilk Critical Value	0.874
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	186	Mean	3.876
SD	267.3	SD	1.905
95% DL/2 (t) UCL	307.6	95% H-Stat (DL/2) UCL	2207
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	162.2	Mean in Log Scale	3.866
SD	286.2	SD in Log Scale	1.922
95% MLE (t) UCL	292.4	Mean in Original Scale	186
95% MLE (Tiku) UCL	287.3	SD in Original Scale	267.4
		95% Percentile Bootstrap UCL	304.2
		95% BCA Bootstrap UCL	326

Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only
k star (bias corrected)	0.459	Data appear Gamma Distributed at 5% Significance Level
Theta Star	434	
nu star	12.85	
A-D Test Statistic	0.605	
5% A-D Critical Value	0.791	
K-S Test Statistic	0.791	
5% K-S Critical Value	0.241	
Data appear Gamma Distributed at 5% Significance Level		

Assuming Gamma Distribution		Nonparametric Statistics	
Gamma ROS Statistics using Extrapolated Data		Kaplan-Meier (KM) Method	
Minimum	1E-09	Mean	186.2
Maximum	750	SD	258.2
Mean	185.9	SE of Mean	69.18
Median	40	95% KM (t) UCL	308
SD	267.5	95% KM (z) UCL	299.9
k star	0.248	95% KM (jackknife) UCL	307.6
Theta star	750.7	95% KM (bootstrap t) UCL	357
Nu star	7.427	95% KM (BCA) UCL	298.7
AppChi2	2.408	95% KM (Percentile Bootstrap) UCL	300.7
95% Gamma Approximate UCL	573.3	95% KM (Chebyshev) UCL	487.7
95% Adjusted Gamma UCL	666.5	97.5% KM (Chebyshev) UCL	618.2
		99% KM (Chebyshev) UCL	874.5
		Potential UCLs to Use	
		95% KM (Chebyshev) UCL	487.7

Note: DL/2 is not a recommended method.

PCB 1260

General Statistics

Number of Valid Data	15	Number of Detected Data	14
Number of Distinct Detected Data	14	Number of Non-Detect Data	1
		Percent Non-Detects	6.67%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	6.5	Minimum Detected	1.872
Maximum Detected	1800	Maximum Detected	7.496
Mean of Detected	287.1	Mean of Detected	4.488
SD of Detected	490	SD of Detected	1.65
Minimum Non-Detect	5.9	Minimum Non-Detect	1.775
Maximum Non-Detect	5.9	Maximum Non-Detect	1.775

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.62	Shapiro Wilk Test Statistic	0.976
5% Shapiro Wilk Critical Value	0.874	5% Shapiro Wilk Critical Value	0.874
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	268.2	Mean	4.26
SD	477.9	SD	1.817
95% DL/2 (t) UCL	485.5	95% H-Stat (DL/2) UCL	1888
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	247.7	Mean in Log Scale	4.215
SD	483.8	SD in Log Scale	1.908
95% MLE (t) UCL	467.7	Mean in Original Scale	268.1
95% MLE (Tiku) UCL	450.5	SD in Original Scale	477.9
		95% Percentile Bootstrap UCL	472.3
		95% BCA Bootstrap UCL	560.5

Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only
k star (bias corrected)	0.469	Data appear Gamma Distributed at 5% Significance Level
Theta Star	612.4	
nu star	13.13	
A-D Test Statistic	0.56	
5% A-D Critical Value	0.79	
K-S Test Statistic	0.79	
5% K-S Critical Value	0.241	
Data appear Gamma Distributed at 5% Significance Level		

Assuming Gamma Distribution		Nonparametric Statistics	
Gamma ROS Statistics using Extrapolated Data		Kaplan-Meier (KM) Method	
Minimum	1E-09	Mean	268.4
Maximum	1800	SD	461.5
Mean	268	SE of Mean	123.7
Median	68	95% KM (t) UCL	486.2
SD	478	95% KM (z) UCL	471.8
k star	0.248	95% KM (jackknife) UCL	485.5
Theta star	1081	95% KM (bootstrap t) UCL	760.5
Nu star	7.439	95% KM (BCA) UCL	522.1
AppChi2	2.415	95% KM (Percentile Bootstrap) UCL	485.6
95% Gamma Approximate UCL	825.5	95% KM (Chebyshev) UCL	807.4
95% Adjusted Gamma UCL	959.6	97.5% KM (Chebyshev) UCL	1041
		99% KM (Chebyshev) UCL	1499
		Potential UCLs to Use	
		95% KM (Chebyshev) UCL	807.4

Note: DL/2 is not a recommended method.

Anthracene

General Statistics

Number of Valid Data	15	Number of Detected Data	2
Number of Distinct Detected Data	2	Number of Non-Detect Data	13
		Percent Non-Detects	86.67%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	41	Minimum Detected	3.714
Maximum Detected	61	Maximum Detected	4.111
Mean of Detected	51	Mean of Detected	3.912
SD of Detected	14.14	SD of Detected	0.281
Minimum Non-Detect	33	Minimum Non-Detect	3.497
Maximum Non-Detect	53	Maximum Non-Detect	3.97

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	1
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	93.33%

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		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	N/A	Shapiro Wilk Test Statistic	N/A
5% Shapiro Wilk Critical Value	N/A	5% Shapiro Wilk Critical Value	N/A
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	23.48	Mean	3.075
SD	12.17	SD	0.376
95% DL/2 (t) UCL	29.02	95% H-Stat (DL/2) UCL	27.65
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		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% Percentile Bootstrap UCL	N/A
		95% BCA Bootstrap 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
95% Gamma Approximate UCL	N/A
95% Adjusted Gamma UCL	N/A

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	42.33
SD	4.989
SE of Mean	1.822
95% KM (t) UCL	45.54
95% KM (z) UCL	45.33
95% KM (jackknife) UCL	55.79
95% KM (bootstrap t) UCL	N/A
95% KM (BCA) UCL	61
95% KM (Percentile Bootstrap) UCL	61
95% KM (Chebyshev) UCL	50.27
97.5% KM (Chebyshev) UCL	53.71
99% KM (Chebyshev) UCL	60.46

Potential UCLs to Use

95% KM (t) UCL	45.54
95% KM (% Bootstrap) UCL	61

Benzo(a)anthracene

General Statistics

Number of Valid Data	15	Number of Detected Data	8
Number of Distinct Detected Data	8	Number of Non-Detect Data	7
		Percent Non-Detects	46.67%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	103.5	Minimum Detected	4.64
Maximum Detected	350	Maximum Detected	5.858
Mean of Detected	204.2	Mean of Detected	5.246
SD of Detected	83.73	SD of Detected	0.411
Minimum Non-Detect	45	Minimum Non-Detect	3.807
Maximum Non-Detect	69	Maximum Non-Detect	4.234

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	8
Single DL Non-Detect Percentage	46.67%

Warning: There are only 8 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

Shapiro Wilk Test Statistic	0.951
5% Shapiro Wilk Critical Value	0.818

Data appear Normal at 5% Significance Level

Lognormal Distribution Test with Detected Values Only

Shapiro Wilk Test Statistic	0.984
5% Shapiro Wilk Critical Value	0.818

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

DL/2 Substitution Method	
Mean	121
SD	109.5
95% DL/2 (t) UCL	170.8
Maximum Likelihood Estimate(MLE) Method	
Mean	89.74
SD	147
95% MLE (t) UCL	156.6
95% MLE (Tiku) UCL	169.4

Assuming Lognormal Distribution

DL/2 Substitution Method	
Mean	4.311
SD	1.079
95% H-Stat (DL/2) UCL	170.9
Log ROS Method	
Mean in Log Scale	4.714
SD in Log Scale	0.657
Mean in Original Scale	137.2
SD in Original Scale	94.86
95% Percentile Bootstrap UCL	176.9
95% BCA Bootstrap UCL	185

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	4.453
Theta Star	45.86
nu star	71.24
A-D Test Statistic	0.162
5% A-D Critical Value	0.717
K-S Test Statistic	0.717
5% K-S Critical Value	0.295

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	103.5
Maximum	350
Mean	194.5
Median	183.4
SD	60.17
k star	10.06
Theta star	19.34
Nu star	301.7
AppChi2	262.4
95% Gamma Approximate UCL	223.5
95% Adjusted Gamma UCL	227.4

Note: DL/2 is not a recommended method.

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	157.2
SD	76.12
SE of Mean	21.01
95% KM (t) UCL	194.2
95% KM (z) UCL	191.8
95% KM (jackknife) UCL	190.1
95% KM (bootstrap t) UCL	205.2
95% KM (BCA) UCL	218
95% KM (Percentile Bootstrap) UCL	204.3
95% KM (Chebyshev) UCL	248.8
97.5% KM (Chebyshev) UCL	288.4
99% KM (Chebyshev) UCL	366.3

Potential UCLs to Use

95% KM (t) UCL	194.2
95% KM (Percentile Bootstrap) UCL	204.3

Benzo(a)pyrene

General Statistics

Number of Valid Data	15	Number of Detected Data	6
Number of Distinct Detected Data	6	Number of Non-Detect Data	9
		Percent Non-Detects	60.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	91	Minimum Detected	4.511
Maximum Detected	310	Maximum Detected	5.737
Mean of Detected	168.5	Mean of Detected	5.043
SD of Detected	79.41	SD of Detected	0.442
Minimum Non-Detect	28	Minimum Non-Detect	3.332
Maximum Non-Detect	45	Maximum Non-Detect	3.807

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	9
Number treated as Detected	6
Single DL Non-Detect Percentage	60.00%

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	0.892	Shapiro Wilk Test Statistic	0.964
5% Shapiro Wilk Critical Value	0.788	5% Shapiro Wilk Critical Value	0.788
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	77.88	Mean	3.724
SD	90.13	SD	1.153
95% DL/2 (t) UCL	118.9	95% H-Stat (DL/2) UCL	105.9
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	174.8	Mean in Log Scale	4.175
SD	72.49	SD in Log Scale	0.779
95% MLE (t) UCL	207.7	Mean in Original Scale	89.3
95% MLE (Tiku) UCL	226.1	SD in Original Scale	82.05
		95% Percentile Bootstrap UCL	124.2
		95% BCA Bootstrap UCL	134.7

Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only
k star (bias corrected)	3.155	Data appear Normal at 5% Significance Level
Theta Star	53.4	
nu star	37.86	
A-D Test Statistic	0.263	
5% A-D Critical Value	0.698	
K-S Test Statistic	0.698	
5% K-S Critical Value	0.333	
Data appear Gamma Distributed at 5% Significance Level		

Assuming Gamma Distribution		Nonparametric Statistics	
Gamma ROS Statistics using Extrapolated Data		Kaplan-Meier (KM) Method	
Minimum	91	Mean	122
Maximum	310	SD	59.53
Mean	168.5	SE of Mean	16.84
Median	168.5	95% KM (t) UCL	151.7
SD	47.45	95% KM (z) UCL	149.7
k star	12.03	95% KM (jackknife) UCL	147.3
Theta star	14.01	95% KM (bootstrap t) UCL	168.3
Nu star	360.9	95% KM (BCA) UCL	197.3
AppChi2	317.9	95% KM (Percentile Bootstrap) UCL	169.3
95% Gamma Approximate UCL	191.3	95% KM (Chebyshev) UCL	195.4
95% Adjusted Gamma UCL	194.3	97.5% KM (Chebyshev) UCL	227.1
		99% KM (Chebyshev) UCL	289.5
		Potential UCLs to Use	
		95% KM (t) UCL	151.7
		95% KM (Percentile Bootstrap) UCL	169.3

Note: DL/2 is not a recommended method.

Benzo(b)fluoranthene

General Statistics

Number of Valid Data	15	Number of Detected Data	12
Number of Distinct Detected Data	11	Number of Non-Detect Data	3
		Percent Non-Detects	20.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	59	Minimum Detected	4.078
Maximum Detected	500	Maximum Detected	6.215
Mean of Detected	199.1	Mean of Detected	5.012
SD of Detected	155.5	SD of Detected	0.783
Minimum Non-Detect	39	Minimum Non-Detect	3.664
Maximum Non-Detect	60	Maximum Non-Detect	4.094

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	4
Number treated as Detected	11
Single DL Non-Detect Percentage	26.67%

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.829	Shapiro Wilk Test Statistic	0.889
5% Shapiro Wilk Critical Value	0.859	5% Shapiro Wilk Critical Value	0.859
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	163.9	Mean	4.635
SD	155.9	SD	1.048
95% DL/2 (t) UCL	234.8	95% H-Stat (DL/2) UCL	306.8
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	139.3	Mean in Log Scale	4.662
SD	182.4	SD in Log Scale	1.005
95% MLE (t) UCL	222.2	Mean in Original Scale	164.5
95% MLE (Tiku) UCL	225	SD in Original Scale	155.3
		95% Percentile Bootstrap UCL	231.3
		95% BCA Bootstrap UCL	236.1

Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only
k star (bias corrected)	1.498	Data appear Gamma Distributed at 5% Significance Level
Theta Star	132.9	
nu star	35.95	
A-D Test Statistic	0.695	
5% A-D Critical Value	0.742	
K-S Test Statistic	0.742	
5% K-S Critical Value	0.249	
Data appear Gamma Distributed at 5% Significance Level		

Assuming Gamma Distribution		Nonparametric Statistics	
Gamma ROS Statistics using Extrapolated Data		Kaplan-Meier (KM) Method	
Minimum	2.697	Mean	171.1
Maximum	500	SD	144.5
Mean	162.2	SE of Mean	38.97
Median	100	95% KM (t) UCL	239.7
SD	157.8	95% KM (z) UCL	235.2
k star	0.715	95% KM (jackknife) UCL	238.5
Theta star	226.8	95% KM (bootstrap t) UCL	260.8
Nu star	21.46	95% KM (BCA) UCL	230.9
AppChi2	11.93	95% KM (Percentile Bootstrap) UCL	236.3
95% Gamma Approximate UCL	291.7	95% KM (Chebyshev) UCL	340.9
95% Adjusted Gamma UCL	314.5	97.5% KM (Chebyshev) UCL	414.4
		99% KM (Chebyshev) UCL	558.8
		Potential UCLs to Use	
		95% KM (BCA) UCL	230.9

Note: DL/2 is not a recommended method.

Benzo(g,h,i)perylene

General Statistics

Number of Valid Data	15	Number of Detected Data	1
Number of Distinct Detected Data	1	Number of Non-Detect Data	14
		Percent Non-Detects	93.33%

Warning: Only one distinct data value was detected! ProUCL (or any other software) should not be used on such a data set!
is suggested to use alternative site specific values determined by the Project Team to estimate environmental parameters (e.g., EPC, BTV).

The data set for variable BZGHIP was not processed!

Benzo(k)fluoranthene

General Statistics

Number of Valid Data	15	Number of Detected Data	10
Number of Distinct Detected Data	9	Number of Non-Detect Data	5
		Percent Non-Detects	33.33%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	68	Minimum Detected	4.22
Maximum Detected	380	Maximum Detected	5.94
Mean of Detected	205.2	Mean of Detected	5.156
SD of Detected	119.3	SD of Detected	0.627
Minimum Non-Detect	49	Minimum Non-Detect	3.892
Maximum Non-Detect	74	Maximum Non-Detect	4.304

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	6
Number treated as Detected	9
Single DL Non-Detect Percentage	40.00%

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.881	Shapiro Wilk Test Statistic	0.918
5% Shapiro Wilk Critical Value	0.842	5% Shapiro Wilk Critical Value	0.842
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	146.1	Mean	4.542
SD	129	SD	1.033
95% DL/2 (t) UCL	204.7	95% H-Stat (DL/2) UCL	205.3
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	114.5	Mean in Log Scale	4.659
SD	165.5	SD in Log Scale	0.885
95% MLE (t) UCL	189.8	Mean in Original Scale	149.8
95% MLE (Tiku) UCL	199.4	SD in Original Scale	125.3
		95% Percentile Bootstrap UCL	203.2
		95% BCA Bootstrap UCL	208.1

Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only
k star (bias corrected)	2.26	Data appear Normal at 5% Significance Level
Theta Star	90.77	
nu star	45.2	
A-D Test Statistic	0.427	
5% A-D Critical Value	0.732	
K-S Test Statistic	0.732	
5% K-S Critical Value	0.268	
Data appear Gamma Distributed at 5% Significance Level		

Assuming Gamma Distribution		Nonparametric Statistics	
Gamma ROS Statistics using Extrapolated Data		Kaplan-Meier (KM) Method	
Minimum	68	Mean	159.4
Maximum	380	SD	112.8
Mean	171.5	SE of Mean	30.69
Median	129.1	95% KM (t) UCL	213.5
SD	107.8	95% KM (z) UCL	209.9
k star	2.661	95% KM (jackknife) UCL	209.3
Theta star	64.46	95% KM (bootstrap t) UCL	225.9
Nu star	79.84	95% KM (BCA) UCL	227.3
AppChi2	60.25	95% KM (Percentile Bootstrap) UCL	214.7
95% Gamma Approximate UCL	227.3	95% KM (Chebyshev) UCL	293.2
95% Adjusted Gamma UCL	235.5	97.5% KM (Chebyshev) UCL	351.1
		99% KM (Chebyshev) UCL	464.8
		Potential UCLs to Use	
		95% KM (t) UCL	213.5
		95% KM (Percentile Bootstrap) UCL	214.7

Note: DL/2 is not a recommended method.

Chrysene

General Statistics

Number of Valid Data	15	Number of Detected Data	10
Number of Distinct Detected Data	10	Number of Non-Detect Data	5
		Percent Non-Detects	33.33%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	50	Minimum Detected	3.912
Maximum Detected	410	Maximum Detected	6.016
Mean of Detected	220.2	Mean of Detected	5.173
SD of Detected	137.3	SD of Detected	0.754
Minimum Non-Detect	38	Minimum Non-Detect	3.638
Maximum Non-Detect	59	Maximum Non-Detect	4.078

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	6
Number treated as Detected	9
Single DL Non-Detect Percentage	40.00%

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.903	Shapiro Wilk Test Statistic	0.92
5% Shapiro Wilk Critical Value	0.842	5% Shapiro Wilk Critical Value	0.842
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	154.3	Mean	4.482
SD	146.4	SD	1.181
95% DL/2 (t) UCL	220.9	95% H-Stat (DL/2) UCL	285.1
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	111.7	Mean in Log Scale	4.586
SD	195.5	SD in Log Scale	1.051
95% MLE (t) UCL	200.7	Mean in Original Scale	156.9
95% MLE (Tiku) UCL	212.1	SD in Original Scale	143.9
		95% Percentile Bootstrap UCL	217.3
		95% BCA Bootstrap UCL	224.5

Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only
k star (bias corrected)	1.754	Data appear Normal at 5% Significance Level
Theta Star	125.5	
nu star	35.08	
A-D Test Statistic	0.297	
5% A-D Critical Value	0.734	
K-S Test Statistic	0.734	
5% K-S Critical Value	0.269	
Data appear Gamma Distributed at 5% Significance Level		

Assuming Gamma Distribution		Nonparametric Statistics	
Gamma ROS Statistics using Extrapolated Data		Kaplan-Meier (KM) Method	
Minimum	50	Mean	163.5
Maximum	410	SD	133.2
Mean	181.8	SE of Mean	36.27
Median	131.6	95% KM (t) UCL	227.3
SD	123.9	95% KM (z) UCL	223.1
k star	2.115	95% KM (jackknife) UCL	224.2
Theta star	85.95	95% KM (bootstrap t) UCL	234.7
Nu star	63.45	95% KM (BCA) UCL	244
AppChi2	46.12	95% KM (Percentile Bootstrap) UCL	232.7
95% Gamma Approximate UCL	250	95% KM (Chebyshev) UCL	321.5
95% Adjusted Gamma UCL	260.3	97.5% KM (Chebyshev) UCL	389.9
		99% KM (Chebyshev) UCL	524.3
		Potential UCLs to Use	
		95% KM (t) UCL	227.3
		95% KM (Percentile Bootstrap) UCL	232.7

Note: DL/2 is not a recommended method.

Fluoranthene

General Statistics

Number of Valid Data	15	Number of Detected Data	9
Number of Distinct Detected Data	9	Number of Non-Detect Data	6
		Percent Non-Detects	40.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	100	Minimum Detected	4.605
Maximum Detected	640	Maximum Detected	6.461
Mean of Detected	346.1	Mean of Detected	5.714
SD of Detected	177.2	SD of Detected	0.576
Minimum Non-Detect	66	Minimum Non-Detect	4.19
Maximum Non-Detect	100	Maximum Non-Detect	4.605

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	6
Number treated as Detected	9
Single DL Non-Detect Percentage	40.00%

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

Shapiro Wilk Test Statistic	0.948
5% Shapiro Wilk Critical Value	0.829

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

DL/2 Substitution Method	
Mean	223
SD	205.8
95% DL/2 (t) UCL	316.5
Maximum Likelihood Estimate(MLE) Method	
Mean	172.6
SD	265.8
95% MLE (t) UCL	293.4
95% MLE (Tiku) UCL	309.1

Lognormal Distribution Test with Detected Values Only

Shapiro Wilk Test Statistic	0.955
5% Shapiro Wilk Critical Value	0.829

Data appear Lognormal at 5% Significance Level

Assuming Lognormal Distribution

DL/2 Substitution Method	
Mean	4.881
SD	1.145
95% H-Stat (DL/2) UCL	371.9
Log ROS Method	
Mean in Log Scale	5.139
SD in Log Scale	0.848
Mean in Original Scale	236.5
SD in Original Scale	193
95% Percentile Bootstrap UCL	318.6
95% BCA Bootstrap UCL	333.9

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	2.681
Theta Star	129.1
nu star	48.27
A-D Test Statistic	0.215
5% A-D Critical Value	0.725
K-S Test Statistic	0.725
5% K-S Critical Value	0.281

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	100
Maximum	640
Mean	302.9
Median	238.1
SD	144.7
k star	4.33
Theta star	69.96
Nu star	129.9
AppChi2	104.6
95% Gamma Approximate UCL	376.3
95% Adjusted Gamma UCL	386.6

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	247.7
SD	176.9
SE of Mean	48.44
95% KM (t) UCL	333
95% KM (z) UCL	327.3
95% KM (jackknife) UCL	327.6
95% KM (bootstrap t) UCL	344.6
95% KM (BCA) UCL	377.3
95% KM (Percentile Bootstrap) UCL	356.7
95% KM (Chebyshev) UCL	458.8
97.5% KM (Chebyshev) UCL	550.2
99% KM (Chebyshev) UCL	729.7

Potential UCLs to Use

95% KM (t) UCL	333
95% KM (Percentile Bootstrap) UCL	356.7

Indeno(1,2,3-cd)pyrene

General Statistics

Number of Valid Data	15	Number of Detected Data	3
Number of Distinct Detected Data	3	Number of Non-Detect Data	12
		Percent Non-Detects	80.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	240	Minimum Detected	5.481
Maximum Detected	360	Maximum Detected	5.886
Mean of Detected	313.3	Mean of Detected	5.732
SD of Detected	64.29	SD of Detected	0.219
Minimum Non-Detect	56	Minimum Non-Detect	4.025
Maximum Non-Detect	90	Maximum Non-Detect	4.5

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	12
Number treated as Detected	3
Single DL Non-Detect Percentage	80.00%

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	0.871	Shapiro Wilk Test Statistic	0.853
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	89.58	Mean	3.948
SD	118.5	SD	0.94
95% DL/2 (t) UCL	143.5	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	4.939
		SD in Log Scale	0.435
		Mean in Original Scale	155
		SD in Original Scale	86.54
		95% Percentile Bootstrap UCL	194.1
		95% BCA Bootstrap UCL	204.5

Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only
k star (bias corrected)	N/A	Data appear Normal at 5% Significance Level
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		Nonparametric Statistics	
Gamma ROS Statistics using Extrapolated Data		Kaplan-Meier (KM) Method	
Minimum	N/A	Mean	254.7
Maximum	N/A	SD	37.57
Mean	N/A	SE of Mean	11.88
Median	N/A	95% KM (t) UCL	275.6
SD	N/A	95% KM (z) UCL	274.2
k star	N/A	95% KM (jackknife) UCL	318.5
Theta star	N/A	95% KM (bootstrap t) UCL	263.5
Nu star	N/A	95% KM (BCA) UCL	N/A
AppChi2	N/A	95% KM (Percentile Bootstrap) UCL	360
95% Gamma Approximate UCL	N/A	95% KM (Chebyshev) UCL	306.5
95% Adjusted Gamma UCL	N/A	97.5% KM (Chebyshev) UCL	328.9
		99% KM (Chebyshev) UCL	372.9
		Potential UCLs to Use	
		95% KM (t) UCL	275.6
		95% KM (Percentile Bootstrap) UCL	360

Note: DL/2 is not a recommended method.

4-Methylphenol (p-Cresol)

General Statistics

Number of Valid Data	15	Number of Detected Data	1
Number of Distinct Detected Data	1	Number of Non-Detect Data	14
		Percent Non-Detects	93.33%

Warning: Only one distinct data value was detected! ProUCL (or any other software) should not be used on such a data set!
is suggested to use alternative site specific values determined by the Project Team to estimate environmental parameters (e.g., EPC, BTV).

The data set for variable MEPH4 was not processed!

2-Methylnaphthalene

General Statistics

Number of Valid Data	15	Number of Detected Data	1
Number of Distinct Detected Data	1	Number of Non-Detect Data	14
		Percent Non-Detects	93.33%

Warning: Only one distinct data value was detected! ProUCL (or any other software) should not be used on such a data set!
is suggested to use alternative site specific values determined by the Project Team to estimate environmental parameters (e.g., EPC, BTV).

The data set for variable MTNPH2 was not processed!

Phenanthrene

General Statistics

Number of Valid Data	15	Number of Detected Data	9
Number of Distinct Detected Data	9	Number of Non-Detect Data	6
		Percent Non-Detects	40.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	46	Minimum Detected	3.829
Maximum Detected	310	Maximum Detected	5.737
Mean of Detected	147.9	Mean of Detected	4.856
SD of Detected	81.85	SD of Detected	0.576
Minimum Non-Detect	28	Minimum Non-Detect	3.332
Maximum Non-Detect	43	Maximum Non-Detect	3.761

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	6
Number treated as Detected	9
Single DL Non-Detect Percentage	40.00%

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

Shapiro Wilk Test Statistic	0.917
5% Shapiro Wilk Critical Value	0.829

Data appear Normal at 5% Significance Level

Lognormal Distribution Test with Detected Values Only

Shapiro Wilk Test Statistic	0.959
5% Shapiro Wilk Critical Value	0.829

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

DL/2 Substitution Method	
Mean	95.25
SD	91.02
95% DL/2 (t) UCL	136.6
Maximum Likelihood Estimate(MLE) Method	
Mean	72.28
SD	117.8
95% MLE (t) UCL	125.9
95% MLE (Tiku) UCL	132.7

Assuming Lognormal Distribution

DL/2 Substitution Method	
Mean	4.026
SD	1.143
95% H-Stat (DL/2) UCL	155.3
Log ROS Method	
Mean in Log Scale	4.273
SD in Log Scale	0.858
Mean in Original Scale	100.7
SD in Original Scale	86.07
95% Percentile Bootstrap UCL	137.8
95% BCA Bootstrap UCL	142.9

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	2.557
Theta Star	57.84
nu star	46.03
A-D Test Statistic	0.295
5% A-D Critical Value	0.725
K-S Test Statistic	0.725
5% K-S Critical Value	0.281

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	46
Maximum	310
Mean	128.8
Median	100.2
SD	66.44
k star	4.103
Theta star	31.39
Nu star	123.1
AppChi2	98.47
95% Gamma Approximate UCL	161
95% Adjusted Gamma UCL	165.6

Note: DL/2 is not a recommended method.

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	107.1
SD	77.87
SE of Mean	21.33
95% KM (t) UCL	144.7
95% KM (z) UCL	142.2
95% KM (jackknife) UCL	142.3
95% KM (bootstrap t) UCL	155.9
95% KM (BCA) UCL	164.6
95% KM (Percentile Bootstrap) UCL	153.7
95% KM (Chebyshev) UCL	200.1
97.5% KM (Chebyshev) UCL	240.3
99% KM (Chebyshev) UCL	319.3

Potential UCLs to Use

95% KM (t) UCL	144.7
95% KM (Percentile Bootstrap) UCL	153.7

Pyrene

General Statistics

Number of Valid Data	15	Number of Detected Data	10
Number of Distinct Detected Data	10	Number of Non-Detect Data	5
		Percent Non-Detects	33.33%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	65	Minimum Detected	4.174
Maximum Detected	540	Maximum Detected	6.292
Mean of Detected	293.5	Mean of Detected	5.518
SD of Detected	158.6	SD of Detected	0.653
Minimum Non-Detect	49	Minimum Non-Detect	3.892
Maximum Non-Detect	75	Maximum Non-Detect	4.317

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	6
Number treated as Detected	9
Single DL Non-Detect Percentage	40.00%

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.948	Shapiro Wilk Test Statistic	0.936
5% Shapiro Wilk Critical Value	0.842	5% Shapiro Wilk Critical Value	0.842
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	205.2	Mean	4.793
SD	181.3	SD	1.186
95% DL/2 (t) UCL	287.7	95% H-Stat (DL/2) UCL	356.4
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	154.4	Mean in Log Scale	5.013
SD	242.5	SD in Log Scale	0.906
95% MLE (t) UCL	264.7	Mean in Original Scale	214
95% MLE (Tiku) UCL	279.4	SD in Original Scale	172.4
		95% Percentile Bootstrap UCL	288.5
		95% BCA Bootstrap UCL	289.3

Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only
k star (bias corrected)	2.31	Data appear Normal at 5% Significance Level
Theta Star	127.1	
nu star	46.2	
A-D Test Statistic	0.213	
5% A-D Critical Value	0.732	
K-S Test Statistic	0.732	
5% K-S Critical Value	0.268	
Data appear Gamma Distributed at 5% Significance Level		

Assuming Gamma Distribution		Nonparametric Statistics	
Gamma ROS Statistics using Extrapolated Data		Kaplan-Meier (KM) Method	
Minimum	65	Mean	217.3
Maximum	540	SD	163.4
Mean	250.3	SE of Mean	44.46
Median	195.8	95% KM (t) UCL	295.6
SD	142.3	95% KM (z) UCL	290.5
k star	2.913	95% KM (jackknife) UCL	289.7
Theta star	85.92	95% KM (bootstrap t) UCL	302
Nu star	87.39	95% KM (BCA) UCL	327.3
AppChi2	66.84	95% KM (Percentile Bootstrap) UCL	310
95% Gamma Approximate UCL	327.2	95% KM (Chebyshev) UCL	411.1
95% Adjusted Gamma UCL	338.4	97.5% KM (Chebyshev) UCL	495
		99% KM (Chebyshev) UCL	659.7
		Potential UCLs to Use	
		95% KM (t) UCL	295.6
		95% KM (Percentile Bootstrap) UCL	310

Note: DL/2 is not a recommended method.

Acetone

General Statistics

Number of Valid Data	15	Number of Detected Data	8
Number of Distinct Detected Data	8	Number of Non-Detect Data	7
		Percent Non-Detects	46.67%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	19	Minimum Detected	2.944
Maximum Detected	260	Maximum Detected	5.561
Mean of Detected	121.8	Mean of Detected	4.425
SD of Detected	102.6	SD of Detected	0.976
Minimum Non-Detect	19	Minimum Non-Detect	2.944
Maximum Non-Detect	64	Maximum Non-Detect	4.159

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	10
Number treated as Detected	5
Single DL Non-Detect Percentage	66.67%

Warning: There are only 8 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

Shapiro Wilk Test Statistic	0.802
5% Shapiro Wilk Critical Value	0.818

Data not Normal at 5% Significance Level

Assuming Normal Distribution

DL/2 Substitution Method	
Mean	71.98
SD	91.23
95% DL/2 (t) UCL	113.5
Maximum Likelihood Estimate(MLE) Method	N/A

MLE yields a negative mean

Lognormal Distribution Test with Detected Values Only

Shapiro Wilk Test Statistic	0.905
5% Shapiro Wilk Critical Value	0.818

Data appear Lognormal at 5% Significance Level

Assuming Lognormal Distribution

DL/2 Substitution Method	
Mean	3.587
SD	1.187
95% H-Stat (DL/2) UCL	103.3
Log ROS Method	
Mean in Log Scale	3.445
SD in Log Scale	1.313
Mean in Original Scale	70.03
SD in Original Scale	92.45
95% Percentile Bootstrap UCL	112.7
95% BCA Bootstrap UCL	119

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	1.002
Theta Star	121.5
nu star	16.04
A-D Test Statistic	0.535
5% A-D Critical Value	0.729
K-S Test Statistic	0.729
5% K-S Critical Value	0.299

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	19
Maximum	260
Mean	112.2
Median	104.7
SD	76.63
k star	1.888
Theta star	59.43
Nu star	56.65
AppChi2	40.35
95% Gamma Approximate UCL	157.6
95% Adjusted Gamma UCL	164.4

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	74.17
SD	86.66
SE of Mean	23.94
95% KM (t) UCL	116.3
95% KM (z) UCL	113.5
95% KM (jackknife) UCL	111.8
95% KM (bootstrap t) UCL	124.7
95% KM (BCA) UCL	127.9
95% KM (Percentile Bootstrap) UCL	119.2
95% KM (Chebyshev) UCL	178.5
97.5% KM (Chebyshev) UCL	223.7
99% KM (Chebyshev) UCL	312.3

Potential UCLs to Use

95% KM (t) UCL	116.3

Carbon Disulfide

General Statistics

Number of Valid Data	15	Number of Detected Data	7
Number of Distinct Detected Data	7	Number of Non-Detect Data	8
		Percent Non-Detects	53.33%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	2.6	Minimum Detected	0.956
Maximum Detected	30	Maximum Detected	3.401
Mean of Detected	10.89	Mean of Detected	2.075
SD of Detected	9.737	SD of Detected	0.842
Minimum Non-Detect	1.3	Minimum Non-Detect	0.262
Maximum Non-Detect	3.1	Maximum Non-Detect	1.131

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	9
Number treated as Detected	6
Single DL Non-Detect Percentage	60.00%

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

Shapiro Wilk Test Statistic	0.82
5% Shapiro Wilk Critical Value	0.803

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

DL/2 Substitution Method	
Mean	5.587
SD	8.187
95% DL/2 (t) UCL	9.31
Maximum Likelihood Estimate(MLE) Method	N/A

MLE yields a negative mean

Lognormal Distribution Test with Detected Values Only

Shapiro Wilk Test Statistic	0.954
5% Shapiro Wilk Critical Value	0.803

Data appear Lognormal at 5% Significance Level

Assuming Lognormal Distribution

DL/2 Substitution Method	
Mean	0.904
SD	1.291
95% H-Stat (DL/2) UCL	8.963
Log ROS Method	
Mean in Log Scale	0.769
SD in Log Scale	1.42
Mean in Original Scale	5.481
SD in Original Scale	8.25
95% Percentile Bootstrap UCL	9.032
95% BCA Bootstrap UCL	10.47

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	1.095
Theta Star	9.943
nu star	15.33
A-D Test Statistic	0.368
5% A-D Critical Value	0.718
K-S Test Statistic	0.718
5% K-S Critical Value	0.316

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	1.843
Maximum	30
Mean	10.02
Median	8.737
SD	7.167
k star	1.854
Theta star	5.401
Nu star	55.63
AppChi2	39.49
95% Gamma Approximate UCL	14.11
95% Adjusted Gamma UCL	14.73

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	6.467
SD	7.417
SE of Mean	2.068
95% KM (t) UCL	10.11
95% KM (z) UCL	9.869
95% KM (jackknife) UCL	9.591
95% KM (bootstrap t) UCL	15.47
95% KM (BCA) UCL	12.27
95% KM (Percentile Bootstrap) UCL	10.8
95% KM (Chebyshev) UCL	15.48
97.5% KM (Chebyshev) UCL	19.38
99% KM (Chebyshev) UCL	27.05

Potential UCLs to Use

95% KM (t) UCL	10.11
95% KM (Percentile Bootstrap) UCL	10.8

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	G:\DATAMGMT\Projects\PlumBrook\Stats_2009_AcidArea1\stats_SE_HH\ProUCLStats\ProUCL_Input.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Acid Area I Sediment Chemicals of Potential Concern (human health)

Arsenic

General Statistics

Number of Valid Observations	15	Number of Distinct Observations	14

Raw Statistics		Log-transformed Statistics	
Minimum	1.7	Minimum of Log Data	0.531
Maximum	20.8	Maximum of Log Data	3.035
Mean	7.467	Mean of log Data	1.876
Median	6.7	SD of log Data	0.545
SD	4.37		
Coefficient of Variation	0.585		
Skewness	2.147		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.793	Shapiro Wilk Test Statistic	0.928
Shapiro Wilk Critical Value	0.881	Shapiro Wilk Critical Value	0.881
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	9.454	95% H-UCL	10.3
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	12.24
95% Adjusted-CLT UCL	9.991	97.5% Chebyshev (MVUE) UCL	14.29
95% Modified-t UCL	9.558	99% Chebyshev (MVUE) UCL	18.33

Gamma Distribution Test		Data Distribution
k star (bias corrected)	3.137	Data appear Gamma Distributed at 5% Significance Level
Theta Star	2.38	
MLE of Mean	7.467	
MLE of Standard Deviation	4.216	
nu star	94.11	
Approximate Chi Square Value (.05)	72.74	**Nonparametric Statistics**
Adjusted Level of Significance	0.0324	95% CLT UCL 9.322
Adjusted Chi Square Value	70.43	95% Jackknife UCL 9.454
		95% Standard Bootstrap UCL 9.205
Anderson-Darling Test Statistic	0.533	95% Bootstrap-t UCL 10.88
Anderson-Darling 5% Critical Value	0.741	95% Hall's Bootstrap UCL 19.07
Kolmogorov-Smirnov Test Statistic	0.153	95% Percentile Bootstrap UCL 9.36
Kolmogorov-Smirnov 5% Critical Value	0.223	95% BCA Bootstrap UCL 9.76
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL 12.38
		97.5% Chebyshev(Mean, Sd) UCL 14.51
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL 18.69
95% Approximate Gamma UCL	9.661	
95% Adjusted Gamma UCL	9.978	

Potential UCL to Use	Use 95% Approximate Gamma UCL 9.661

Cobalt

General Statistics

Number of Valid Observations	15	Number of Distinct Observations	15

Raw Statistics		Log-transformed Statistics	
Minimum	2.8	Minimum of Log Data	1.03
Maximum	77.3	Maximum of Log Data	4.348
Mean	14.66	Mean of log Data	2.277
Median	9.1	SD of log Data	0.842
SD	18.57		
Coefficient of Variation	1.267		
Skewness	3.109		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.585	Shapiro Wilk Test Statistic	0.944
Shapiro Wilk Critical Value	0.881	Shapiro Wilk Critical Value	0.881
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	23.1	95% H-UCL	24.41
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	27.18
95% Adjusted-CLT UCL	26.66	97.5% Chebyshev (MVUE) UCL	33.11
95% Modified-t UCL	23.75	99% Chebyshev (MVUE) UCL	44.75

Gamma Distribution Test		Data Distribution
k star (bias corrected)	1.138	Data Follow Appr. Gamma Distribution at 5% Significance Level
Theta Star	12.88	
MLE of Mean	14.66	
MLE of Standard Deviation	13.74	
nu star	34.13	
Approximate Chi Square Value (.05)	21.77	**Nonparametric Statistics**
Adjusted Level of Significance	0.0324	95% CLT UCL 22.55
Adjusted Chi Square Value	20.56	95% Jackknife UCL 23.1
		95% Standard Bootstrap UCL 22.6
Anderson-Darling Test Statistic	0.846	95% Bootstrap-t UCL 38.46
Anderson-Darling 5% Critical Value	0.756	95% Hall's Bootstrap UCL 51.17
Kolmogorov-Smirnov Test Statistic	0.218	95% Percentile Bootstrap UCL 23.07
Kolmogorov-Smirnov 5% Critical Value	0.226	95% BCA Bootstrap UCL 28.72
Data follow Appr. Gamma Distribution at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL 35.56
		97.5% Chebyshev(Mean, Sd) UCL 44.6
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL 62.36
95% Approximate Gamma UCL	22.98	
95% Adjusted Gamma UCL	24.34	

Potential UCL to Use		Use 95% Approximate Gamma UCL	22.98

PCB 1254

General Statistics

Number of Valid Data	15	Number of Detected Data	14
Number of Distinct Detected Data	14	Number of Non-Detect Data	1
		Percent Non-Detects	6.67%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	4.6	Minimum Detected	1.526
Maximum Detected	750	Maximum Detected	6.62
Mean of Detected	199.1	Mean of Detected	4.089
SD of Detected	272.4	SD of Detected	1.783
Minimum Non-Detect	4.9	Minimum Non-Detect	1.589
Maximum Non-Detect	4.9	Maximum Non-Detect	1.589

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.726	Shapiro Wilk Test Statistic	0.931
5% Shapiro Wilk Critical Value	0.874	5% Shapiro Wilk Critical Value	0.874
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	186	Mean	3.876
SD	267.3	SD	1.905
95% DL/2 (t) UCL	307.6	95% H-Stat (DL/2) UCL	2207
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	162.2	Mean in Log Scale	3.866
SD	286.2	SD in Log Scale	1.922
95% MLE (t) UCL	292.4	Mean in Original Scale	186
95% MLE (Tiku) UCL	287.3	SD in Original Scale	267.4
		95% Percentile Bootstrap UCL	301.9
		95% BCA Bootstrap UCL	321.1

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.459
Theta Star	434
nu star	12.85
A-D Test Statistic	0.605
5% A-D Critical Value	0.791
K-S Test Statistic	0.791
5% K-S Critical Value	0.241

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data

Minimum	1E-09
Maximum	750
Mean	185.9
Median	40
SD	267.5
k star	0.248
Theta star	750.7
Nu star	7.427
AppChi2	2.408
95% Gamma Approximate UCL	573.3
95% Adjusted Gamma UCL	666.5

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	186.2
SD	258.2
SE of Mean	69.18
95% KM (t) UCL	308
95% KM (z) UCL	299.9
95% KM (jackknife) UCL	307.6
95% KM (bootstrap t) UCL	363.3
95% KM (BCA) UCL	301.9
95% KM (Percentile Bootstrap) UCL	300.6
95% KM (Chebyshev) UCL	487.7
97.5% KM (Chebyshev) UCL	618.2
99% KM (Chebyshev) UCL	874.5

Potential UCLs to Use

95% KM (Chebyshev) UCL	487.7

PCB 1260

General Statistics

Number of Valid Data	15	Number of Detected Data	14
Number of Distinct Detected Data	14	Number of Non-Detect Data	1
		Percent Non-Detects	6.67%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	6.5	Minimum Detected	1.872
Maximum Detected	1800	Maximum Detected	7.496
Mean of Detected	287.1	Mean of Detected	4.488
SD of Detected	490	SD of Detected	1.65
Minimum Non-Detect	5.9	Minimum Non-Detect	1.775
Maximum Non-Detect	5.9	Maximum Non-Detect	1.775

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.62	Shapiro Wilk Test Statistic	0.976
5% Shapiro Wilk Critical Value	0.874	5% Shapiro Wilk Critical Value	0.874
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	268.2	Mean	4.26
SD	477.9	SD	1.817
95% DL/2 (t) UCL	485.5	95% H-Stat (DL/2) UCL	1888
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	247.7	Mean in Log Scale	4.215
SD	483.8	SD in Log Scale	1.908
95% MLE (t) UCL	467.7	Mean in Original Scale	268.1
95% MLE (Tiku) UCL	450.5	SD in Original Scale	477.9
		95% Percentile Bootstrap UCL	482.2
		95% BCA Bootstrap UCL	562.2

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.469
Theta Star	612.4
nu star	13.13
A-D Test Statistic	0.56
5% A-D Critical Value	0.79
K-S Test Statistic	0.79
5% K-S Critical Value	0.241

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data

Minimum	1E-09
Maximum	1800
Mean	268
Median	68
SD	478
k star	0.248
Theta star	1081
Nu star	7.439
AppChi2	2.415
95% Gamma Approximate UCL	825.5
95% Adjusted Gamma UCL	959.6

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	268.4
SD	461.5
SE of Mean	123.7
95% KM (t) UCL	486.2
95% KM (z) UCL	471.8
95% KM (jackknife) UCL	485.5
95% KM (bootstrap t) UCL	763.1
95% KM (BCA) UCL	482
95% KM (Percentile Bootstrap) UCL	490.4
95% KM (Chebyshev) UCL	807.4
97.5% KM (Chebyshev) UCL	1041
99% KM (Chebyshev) UCL	1499

Potential UCLs to Use

95% KM (Chebyshev) UCL	807.4

Benzo(a)anthracene

General Statistics

Number of Valid Data	15	Number of Detected Data	8
Number of Distinct Detected Data	8	Number of Non-Detect Data	7
		Percent Non-Detects	46.67%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	103.5	Minimum Detected	4.64
Maximum Detected	350	Maximum Detected	5.858
Mean of Detected	204.2	Mean of Detected	5.246
SD of Detected	83.73	SD of Detected	0.411
Minimum Non-Detect	45	Minimum Non-Detect	3.807
Maximum Non-Detect	69	Maximum Non-Detect	4.234

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	8
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	46.67%

Warning: There are only 8 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	0.951	Shapiro Wilk Test Statistic	0.984
5% Shapiro Wilk Critical Value	0.818	5% Shapiro Wilk Critical Value	0.818
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	121	Mean	4.311
SD	109.5	SD	1.079
95% DL/2 (t) UCL	170.8	95% H-Stat (DL/2) UCL	170.9
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	89.74	Mean in Log Scale	4.714
SD	147	SD in Log Scale	0.657
95% MLE (t) UCL	156.6	Mean in Original Scale	137.2
95% MLE (Tiku) UCL	169.4	SD in Original Scale	94.86
		95% Percentile Bootstrap UCL	177.6
		95% BCA Bootstrap UCL	184.6

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	4.453
Theta Star	45.86
nu star	71.24
A-D Test Statistic	0.162
5% A-D Critical Value	0.717
K-S Test Statistic	0.717
5% K-S Critical Value	0.295

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data

Minimum	103.5
Maximum	350
Mean	194.5
Median	183.4
SD	60.17
k star	10.06
Theta star	19.34
Nu star	301.7
AppChi2	262.4
95% Gamma Approximate UCL	223.5
95% Adjusted Gamma UCL	227.4

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	157.2
SD	76.12
SE of Mean	21.01
95% KM (t) UCL	194.2
95% KM (z) UCL	191.8
95% KM (jackknife) UCL	190.1
95% KM (bootstrap t) UCL	207.5
95% KM (BCA) UCL	214
95% KM (Percentile Bootstrap) UCL	205.6
95% KM (Chebyshev) UCL	248.8
97.5% KM (Chebyshev) UCL	288.4
99% KM (Chebyshev) UCL	366.3

Potential UCLs to Use

95% KM (t) UCL	194.2
95% KM (Percentile Bootstrap) UCL	205.6

Benzo(a)pyrene

General Statistics

Number of Valid Data	15	Number of Detected Data	6
Number of Distinct Detected Data	6	Number of Non-Detect Data	9
		Percent Non-Detects	60.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	91	Minimum Detected	4.511
Maximum Detected	310	Maximum Detected	5.737
Mean of Detected	168.5	Mean of Detected	5.043
SD of Detected	79.41	SD of Detected	0.442
Minimum Non-Detect	28	Minimum Non-Detect	3.332
Maximum Non-Detect	45	Maximum Non-Detect	3.807

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	9
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	60.00%

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	0.892	Shapiro Wilk Test Statistic	0.964
5% Shapiro Wilk Critical Value	0.788	5% Shapiro Wilk Critical Value	0.788
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	77.88	Mean	3.724
SD	90.13	SD	1.153
95% DL/2 (t) UCL	118.9	95% H-Stat (DL/2) UCL	105.9
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	174.8	Mean in Log Scale	4.175
SD	72.49	SD in Log Scale	0.779
95% MLE (t) UCL	207.7	Mean in Original Scale	89.3
95% MLE (Tiku) UCL	226.1	SD in Original Scale	82.05
		95% Percentile Bootstrap UCL	125.4
		95% BCA Bootstrap UCL	134.6

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	3.155
Theta Star	53.4
nu star	37.86
A-D Test Statistic	0.263
5% A-D Critical Value	0.698
K-S Test Statistic	0.698
5% K-S Critical Value	0.333

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data

Minimum	91
Maximum	310
Mean	168.5
Median	168.5
SD	47.45
k star	12.03
Theta star	14.01
Nu star	360.9
AppChi2	317.9
95% Gamma Approximate UCL	191.3
95% Adjusted Gamma UCL	194.3

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	122
SD	59.53
SE of Mean	16.84
95% KM (t) UCL	151.7
95% KM (z) UCL	149.7
95% KM (jackknife) UCL	147.3
95% KM (bootstrap t) UCL	169.4
95% KM (BCA) UCL	188.7
95% KM (Percentile Bootstrap) UCL	170
95% KM (Chebyshev) UCL	195.4
97.5% KM (Chebyshev) UCL	227.1
99% KM (Chebyshev) UCL	289.5

Potential UCLs to Use

95% KM (t) UCL	151.7
95% KM (Percentile Bootstrap) UCL	170

Benzo(b)fluoranthene

General Statistics

Number of Valid Data	15	Number of Detected Data	12
Number of Distinct Detected Data	11	Number of Non-Detect Data	3
		Percent Non-Detects	20.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	59	Minimum Detected	4.078
Maximum Detected	500	Maximum Detected	6.215
Mean of Detected	199.1	Mean of Detected	5.012
SD of Detected	155.5	SD of Detected	0.783
Minimum Non-Detect	39	Minimum Non-Detect	3.664
Maximum Non-Detect	60	Maximum Non-Detect	4.094

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	4
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	11
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	26.67%

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.829	Shapiro Wilk Test Statistic	0.889
5% Shapiro Wilk Critical Value	0.859	5% Shapiro Wilk Critical Value	0.859
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	163.9	Mean	4.635
SD	155.9	SD	1.048
95% DL/2 (t) UCL	234.8	95% H-Stat (DL/2) UCL	306.8
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	139.3	Mean in Log Scale	4.662
SD	182.4	SD in Log Scale	1.005
95% MLE (t) UCL	222.2	Mean in Original Scale	164.5
95% MLE (Tiku) UCL	225	SD in Original Scale	155.3
		95% Percentile Bootstrap UCL	229.7
		95% BCA Bootstrap UCL	233.7

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	1.498
Theta Star	132.9
nu star	35.95
A-D Test Statistic	0.695
5% A-D Critical Value	0.742
K-S Test Statistic	0.742
5% K-S Critical Value	0.249

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data

Minimum	2.697
Maximum	500
Mean	162.2
Median	100
SD	157.8
k star	0.715
Theta star	226.8
Nu star	21.46
AppChi2	11.93
95% Gamma Approximate UCL	291.7
95% Adjusted Gamma UCL	314.5

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	171.1
SD	144.5
SE of Mean	38.97
95% KM (t) UCL	239.7
95% KM (z) UCL	235.2
95% KM (jackknife) UCL	238.5
95% KM (bootstrap t) UCL	264.1
95% KM (BCA) UCL	241.8
95% KM (Percentile Bootstrap) UCL	238.1
95% KM (Chebyshev) UCL	340.9
97.5% KM (Chebyshev) UCL	414.4
99% KM (Chebyshev) UCL	558.8

Potential UCLs to Use

95% KM (BCA) UCL	241.8

Indeno(1,2,3-cd)pyrene

General Statistics

Number of Valid Data	15	Number of Detected Data	3
Number of Distinct Detected Data	3	Number of Non-Detect Data	12
		Percent Non-Detects	80.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	240	Minimum Detected	5.481
Maximum Detected	360	Maximum Detected	5.886
Mean of Detected	313.3	Mean of Detected	5.732
SD of Detected	64.29	SD of Detected	0.219
Minimum Non-Detect	56	Minimum Non-Detect	4.025
Maximum Non-Detect	90	Maximum Non-Detect	4.5

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	12
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	80.00%

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	0.871	Shapiro Wilk Test Statistic	0.853
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	89.58	Mean	3.948
SD	118.5	SD	0.94
95% DL/2 (t) UCL	143.5	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	4.939
		SD in Log Scale	0.435
		Mean in Original Scale	155
		SD in Original Scale	86.54
		95% Percentile Bootstrap UCL	193.1
		95% BCA Bootstrap UCL	200.4

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	N/A
95% Adjusted Gamma UCL	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	254.7
SD	37.57
SE of Mean	11.88
95% KM (t) UCL	275.6
95% KM (z) UCL	274.2
95% KM (jackknife) UCL	318.5
95% KM (bootstrap t) UCL	267.4
95% KM (BCA) UCL	N/A
95% KM (Percentile Bootstrap) UCL	N/A
95% KM (Chebyshev) UCL	306.5
97.5% KM (Chebyshev) UCL	328.9
99% KM (Chebyshev) UCL	372.9

Potential UCLs to Use

95% KM (t) UCL	275.6
95% KM (Percentile Bootstrap) UCL	N/A

N-Nitroso-di-n-propylamine

General Statistics

Number of Valid Data	15	Number of Detected Data	1
Number of Distinct Detected Data	1	Number of Non-Detect Data	14
		Percent Non-Detects	93.33%

Warning: Only one distinct data value was detected! ProUCL (or any other software) should not be used on such a data set!
It is suggested to use alternative site specific values determined by the Project Team to estimate environmental parameters (e.g., EPC, BTV).

The data set for variable NNSPR was not processed!

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	G:\DATAMGMT\Projects\PlumBrook\Stats_2009_AcidArea1\stats_WG_Deep_HH\ProUCLStats\ProUCL_Input.w
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Acid Area I Deep Groundwater Chemicals of Potential Concern (human health)

Cyanide

General Statistics

Number of Valid Data	11	Number of Detected Data	2
Number of Distinct Detected Data	2	Number of Non-Detect Data	9
		Percent Non-Detects	81.82%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	16.6	Minimum Detected	2.809
Maximum Detected	594.1	Maximum Detected	6.387
Mean of Detected	305.3	Mean of Detected	4.598
SD of Detected	408.3	SD of Detected	2.53
Minimum Non-Detect	5	Minimum Non-Detect	1.609
Maximum Non-Detect	10	Maximum Non-Detect	2.303

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	9
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	2
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	81.82%

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		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	N/A	Shapiro Wilk Test Statistic	N/A
5% Shapiro Wilk Critical Value	N/A	5% Shapiro Wilk Critical Value	N/A
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	58.2	Mean	1.771
SD	177.8	SD	1.634
95% DL/2 (t) UCL	155.3	95% H-Stat (DL/2) UCL	82.32
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		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% Percentile Bootstrap UCL	N/A
		95% BCA Bootstrap 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
95% Gamma Approximate UCL	N/A
95% Adjusted Gamma UCL	N/A

Warning: Recommended UCL exceeds the maximum observation

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	69.1
SD	166
SE of Mean	70.78
95% KM (t) UCL	197.4
95% KM (z) UCL	185.5
95% KM (jackknife) UCL	467.6
95% KM (bootstrap t) UCL	N/A
95% KM (BCA) UCL	N/A
95% KM (Percentile Bootstrap) UCL	N/A
95% KM (Chebyshev) UCL	377.6
97.5% KM (Chebyshev) UCL	511.1
99% KM (Chebyshev) UCL	773.4
Potential UCLs to Use	
99% KM (Chebyshev) UCL	773.4

Arsenic (filtered)

General Statistics

Number of Valid Data	6	Number of Detected Data	2
Number of Distinct Detected Data	2	Number of Non-Detect Data	4
		Percent Non-Detects	66.67%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	6.5	Minimum Detected	1.872
Maximum Detected	19.6	Maximum Detected	2.976
Mean of Detected	13.05	Mean of Detected	2.424
SD of Detected	9.263	SD of Detected	0.78
Minimum Non-Detect	3	Minimum Non-Detect	1.099
Maximum Non-Detect	30	Maximum Non-Detect	3.401

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	6
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: 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		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	N/A	Shapiro Wilk Test Statistic	N/A
5% Shapiro Wilk Critical Value	N/A	5% Shapiro Wilk Critical Value	N/A
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	7.6	Mean	1.462
SD	7.894	SD	1.213
95% DL/2 (t) UCL	14.09	95% H-Stat (DL/2) UCL	40.34
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		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% Percentile Bootstrap UCL	N/A
		95% BCA Bootstrap 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
95% Gamma Approximate UCL	N/A
95% Adjusted Gamma UCL	N/A

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	9.12
SD	5.24
SE of Mean	3.314
95% KM (t) UCL	15.8
95% KM (z) UCL	14.57
95% KM (jackknife) UCL	19.5
95% KM (bootstrap t) UCL	N/A
95% KM (BCA) UCL	19.6
95% KM (Percentile Bootstrap) UCL	19.6
95% KM (Chebyshev) UCL	23.57
97.5% KM (Chebyshev) UCL	29.82
99% KM (Chebyshev) UCL	42.09

Potential UCLs to Use

95% KM (t) UCL	15.8
95% KM (% Bootstrap) UCL	19.6

Arsenic (total)

General Statistics

Number of Valid Data	11	Number of Detected Data	4
Number of Distinct Detected Data	4	Number of Non-Detect Data	7
		Percent Non-Detects	63.64%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	4.7	Minimum Detected	1.548
Maximum Detected	21.2	Maximum Detected	3.054
Mean of Detected	14.83	Mean of Detected	2.548
SD of Detected	7.601	SD of Detected	0.698
Minimum Non-Detect	3	Minimum Non-Detect	1.099
Maximum Non-Detect	3	Maximum Non-Detect	1.099

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	0.899	Shapiro Wilk Test Statistic	0.834
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	6.345	Mean	1.184
SD	7.907	SD	1.146
95% DL/2 (t) UCL	10.67	95% H-Stat (DL/2) UCL	7.408
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE yields a negative mean		Mean in Log Scale	1.09
		SD in Log Scale	1.377
		Mean in Original Scale	6.458
		SD in Original Scale	7.886
		95% Percentile Bootstrap UCL	10.45
		95% BCA Bootstrap UCL	11.22

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	1.046
Theta Star	14.17
nu star	8.37
A-D Test Statistic	0.439
5% A-D Critical Value	0.659
K-S Test Statistic	0.659
5% K-S Critical Value	0.396

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	4.7
Maximum	39.97
Mean	20.16
Median	20.1
SD	11.09
k star	2.267
Theta star	8.895
Nu star	49.87
AppChi2	34.65
95% Gamma Approximate UCL	29.01
95% Adjusted Gamma UCL	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	8.382
SD	6.283
SE of Mean	2.188
95% KM (t) UCL	12.35
95% KM (z) UCL	11.98
95% KM (jackknife) UCL	14.07
95% KM (bootstrap t) UCL	10.57
95% KM (BCA) UCL	20.3
95% KM (Percentile Bootstrap) UCL	20.2
95% KM (Chebyshev) UCL	17.92
97.5% KM (Chebyshev) UCL	22.04
99% KM (Chebyshev) UCL	30.15

Potential UCLs to Use

95% KM (t) UCL	12.35
95% KM (Percentile Bootstrap) UCL	20.2

Manganese (filtered)

General Statistics

Number of Valid Observations	6	Number of Distinct Observations	6

Raw Statistics		Log-transformed Statistics	
Minimum	7	Minimum of Log Data	1.946
Maximum	1009	Maximum of Log Data	6.916
Mean	421.3	Mean of log Data	5.198
Median	355.5	SD of log Data	1.859
SD	404.3		
Coefficient of Variation	0.96		
Skewness	0.44		

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		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.889	Shapiro Wilk Test Statistic	0.868
Shapiro Wilk Critical Value	0.788	Shapiro Wilk Critical Value	0.788
Data appear Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	753.8	95% H-UCL	399585
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	2449
95% Adjusted-CLT UCL	724.4	97.5% Chebyshev (MVUE) UCL	3242
95% Modified-t UCL	758.8	99% Chebyshev (MVUE) UCL	4799

Gamma Distribution Test

k star (bias corrected)	0.468
Theta Star	900.5
MLE of Mean	421.3
MLE of Standard Deviation	615.9
nu star	5.613
Approximate Chi Square Value (.05)	1.446
Adjusted Level of Significance	0.0122
Adjusted Chi Square Value	0.816
Anderson-Darling Test Statistic	0.369
Anderson-Darling 5% Critical Value	0.723
Kolmogorov-Smirnov Test Statistic	0.259
Kolmogorov-Smirnov 5% Critical Value	0.344

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	1636
95% Adjusted Gamma UCL	2899

Data Distribution

Data appear Normal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	692.7
95% Jackknife UCL	753.8
95% Standard Bootstrap UCL	658
95% Bootstrap-t UCL	806.4
95% Hall's Bootstrap UCL	626.1
95% Percentile Bootstrap UCL	670.2
95% BCA Bootstrap UCL	668.8
95% Chebyshev(Mean, Sd) UCL	1141
97.5% Chebyshev(Mean, Sd) UCL	1452
99% Chebyshev(Mean, Sd) UCL	2063

Potential UCL to Use

Use 95% Student's-t UCL 753.8

Manganese (total)

General Statistics

Number of Valid Observations	11	Number of Distinct Observations	11

Raw Statistics		Log-transformed Statistics	
Minimum	8.4	Minimum of Log Data	2.128
Maximum	1155	Maximum of Log Data	7.052
Mean	286.6	Mean of log Data	4.649
Median	114	SD of log Data	1.666
SD	378.1		
Coefficient of Variation	1.319		
Skewness	1.554		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.757	Shapiro Wilk Test Statistic	0.949
Shapiro Wilk Critical Value	0.85	Shapiro Wilk Critical Value	0.85
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	493.2	95% H-UCL	4253
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	1110
95% Adjusted-CLT UCL	531.1	97.5% Chebyshev (MVUE) UCL	1447
95% Modified-t UCL	502.1	99% Chebyshev (MVUE) UCL	2110

Gamma Distribution Test		Data Distribution
k star (bias corrected)	0.505	Data appear Gamma Distributed at 5% Significance Level
Theta Star	567.8	
MLE of Mean	286.6	
MLE of Standard Deviation	403.4	
nu star	11.1	
Approximate Chi Square Value (.05)	4.642	
Adjusted Level of Significance	0.0278	
Adjusted Chi Square Value	3.983	
Anderson-Darling Test Statistic	0.348	
Anderson-Darling 5% Critical Value	0.773	
Kolmogorov-Smirnov Test Statistic	0.177	
Kolmogorov-Smirnov 5% Critical Value	0.267	
Data appear Gamma Distributed at 5% Significance Level		

Nonparametric Statistics	
95% CLT UCL	474.1
95% Jackknife UCL	493.2
95% Standard Bootstrap UCL	462.2
95% Bootstrap-t UCL	634.4
95% Hall's Bootstrap UCL	483.1
95% Percentile Bootstrap UCL	479.1
95% BCA Bootstrap UCL	510.4
95% Chebyshev(Mean, Sd) UCL	783.5
97.5% Chebyshev(Mean, Sd) UCL	998.5
99% Chebyshev(Mean, Sd) UCL	1421

Assuming Gamma Distribution	
95% Approximate Gamma UCL	685.4
95% Adjusted Gamma UCL	798.7

Potential UCL to Use	Use 95% Approximate Gamma UCL 685.4

Thallium (filtered)

General Statistics

Number of Valid Data	6	Number of Detected Data	3
Number of Distinct Detected Data	3	Number of Non-Detect Data	3
		Percent Non-Detects	50.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	3.1	Minimum Detected	1.131
Maximum Detected	3.8	Maximum Detected	1.335
Mean of Detected	3.55	Mean of Detected	1.263
SD of Detected	0.391	SD of Detected	0.114
Minimum Non-Detect	3	Minimum Non-Detect	1.099
Maximum Non-Detect	30	Maximum Non-Detect	3.401

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	6
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 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	0.803	Shapiro Wilk Test Statistic	0.799
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	5.358	Mean	1.419
SD	4.86	SD	0.752
95% DL/2 (t) UCL	9.356	95% H-Stat (DL/2) UCL	33.61
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	1.193
		SD in Log Scale	0.132
		Mean in Original Scale	3.321
		SD in Original Scale	0.424
		95% Percentile Bootstrap UCL	3.568
		95% BCA Bootstrap UCL	3.546

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	N/A
95% Adjusted Gamma UCL	N/A

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

Nonparametric Statistics	
Kaplan-Meier (KM) Method	
Mean	3.438
SD	0.338
SE of Mean	0.207
95% KM (t) UCL	3.855
95% KM (z) UCL	3.778
95% KM (jackknife) UCL	3.942
95% KM (bootstrap t) UCL	3.729
95% KM (BCA) UCL	3.8
95% KM (Percentile Bootstrap) UCL	N/A
95% KM (Chebyshev) UCL	4.34
97.5% KM (Chebyshev) UCL	4.73
99% KM (Chebyshev) UCL	5.497
Potential UCLs to Use	
95% KM (t) UCL	3.855
95% KM (Percentile Bootstrap) UCL	N/A

Warning: Recommended UCL exceeds the maximum observation

Note: DL/2 is not a recommended method.

Thallium (total)

General Statistics

Number of Valid Data	11	Number of Detected Data	3
Number of Distinct Detected Data	3	Number of Non-Detect Data	8
		Percent Non-Detects	72.73%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	3.5	Minimum Detected	1.253
Maximum Detected	4.7	Maximum Detected	1.548
Mean of Detected	4.167	Mean of Detected	1.42
SD of Detected	0.611	SD of Detected	0.151
Minimum Non-Detect	3	Minimum Non-Detect	1.099
Maximum Non-Detect	10	Maximum Non-Detect	2.303

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	11
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 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	0.964	Shapiro Wilk Test Statistic	0.95
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	2.864	Mean	0.901
SD	1.616	SD	0.577
95% DL/2 (t) UCL	3.747	95% H-Stat (DL/2) UCL	4.928
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	1.017
		SD in Log Scale	0.328
		Mean in Original Scale	2.904
		SD in Original Scale	0.967
		95% Percentile Bootstrap UCL	3.392
		95% BCA Bootstrap UCL	3.433

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	N/A
95% Adjusted Gamma UCL	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	3.722
SD	0.426
SE of Mean	0.174
95% KM (t) UCL	4.038
95% KM (z) UCL	4.008
95% KM (jackknife) UCL	4.251
95% KM (bootstrap t) UCL	3.876
95% KM (BCA) UCL	4.7
95% KM (Percentile Bootstrap) UCL	N/A
95% KM (Chebyshev) UCL	4.481
97.5% KM (Chebyshev) UCL	4.809
99% KM (Chebyshev) UCL	5.454

Potential UCLs to Use

95% KM (t) UCL	4.038
95% KM (Percentile Bootstrap) UCL	N/A

2-Nitrotoluene

General Statistics

Number of Valid Data	11	Number of Detected Data	2
Number of Distinct Detected Data	2	Number of Non-Detect Data	9
		Percent Non-Detects	81.82%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.087	Minimum Detected	-2.442
Maximum Detected	1.1	Maximum Detected	0.0953
Mean of Detected	0.594	Mean of Detected	-1.173
SD of Detected	0.716	SD of Detected	1.794
Minimum Non-Detect	0.074	Minimum Non-Detect	-2.604
Maximum Non-Detect	0.555	Maximum Non-Detect	-0.589

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	10
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	90.91%

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		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	N/A	Shapiro Wilk Test Statistic	N/A
5% Shapiro Wilk Critical Value	N/A	5% Shapiro Wilk Critical Value	N/A
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	0.174	Mean	-2.443
SD	0.314	SD	1.007
95% DL/2 (t) UCL	0.346	95% H-Stat (DL/2) UCL	0.23
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		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% Percentile Bootstrap UCL	N/A
		95% BCA Bootstrap 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
95% Gamma Approximate UCL	N/A
95% Adjusted Gamma UCL	N/A

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	0.179
SD	0.291
SE of Mean	0.124
95% KM (t) UCL	0.404
95% KM (z) UCL	0.383
95% KM (jackknife) UCL	0.878
95% KM (bootstrap t) UCL	0.179
95% KM (BCA) UCL	1.1
95% KM (Percentile Bootstrap) UCL	1.1
95% KM (Chebyshev) UCL	0.72
97.5% KM (Chebyshev) UCL	0.955
99% KM (Chebyshev) UCL	1.415

Potential UCLs to Use

97.5% KM (Chebyshev) UCL	0.955

RDX

General Statistics

Number of Valid Data	11	Number of Detected Data	5
Number of Distinct Detected Data	5	Number of Non-Detect Data	6
		Percent Non-Detects	54.55%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.14	Minimum Detected	-1.966
Maximum Detected	5.5	Maximum Detected	1.705
Mean of Detected	2.436	Mean of Detected	0.291
SD of Detected	2.148	SD of Detected	1.491
Minimum Non-Detect	0.074	Minimum Non-Detect	-2.604
Maximum Non-Detect	0.75	Maximum Non-Detect	-0.288

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	3
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	72.73%

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	0.936	Shapiro Wilk Test Statistic	0.895
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	1.164	Mean	-1.345
SD	1.827	SD	1.932
95% DL/2 (t) UCL	2.162	95% H-Stat (DL/2) UCL	6.573
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE yields a negative mean		Mean in Log Scale	-1.787
		SD in Log Scale	2.239
		Mean in Original Scale	1.126
		SD in Original Scale	1.849
		95% Percentile Bootstrap UCL	2.08
		95% BCA Bootstrap UCL	2.345

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.52
Theta Star	4.685
nu star	5.199
A-D Test Statistic	0.322
5% A-D Critical Value	0.692
K-S Test Statistic	0.692
5% K-S Critical Value	0.365

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data

Minimum	0.14
Maximum	5.5
Mean	2.617
Median	2.345
SD	1.626
k star	1.282
Theta star	2.041
Nu star	28.21
AppChi2	17.09
95% Gamma Approximate UCL	4.32
95% Adjusted Gamma UCL	4.704

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	1.19
SD	1.725
SE of Mean	0.582
95% KM (t) UCL	2.244
95% KM (z) UCL	2.147
95% KM (jackknife) UCL	2.106
95% KM (bootstrap t) UCL	2.143
95% KM (BCA) UCL	3.318
95% KM (Percentile Bootstrap) UCL	3.291
95% KM (Chebyshev) UCL	3.726
97.5% KM (Chebyshev) UCL	4.823
99% KM (Chebyshev) UCL	6.978

Potential UCLs to Use

95% KM (t) UCL	2.244
95% KM (Percentile Bootstrap) UCL	3.291

2,4,6-Trinitrotoluene (TNT)

General Statistics

Number of Valid Data	11	Number of Detected Data	2
Number of Distinct Detected Data	2	Number of Non-Detect Data	9
		Percent Non-Detects	81.82%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.99	Minimum Detected	-0.0101
Maximum Detected	2.7	Maximum Detected	0.993
Mean of Detected	1.845	Mean of Detected	0.492
SD of Detected	1.209	SD of Detected	0.709
Minimum Non-Detect	0.074	Minimum Non-Detect	-2.604
Maximum Non-Detect	0.3	Maximum Non-Detect	-1.204

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	9
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	2
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	81.82%

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		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	N/A	Shapiro Wilk Test Statistic	N/A
5% Shapiro Wilk Critical Value	N/A	5% Shapiro Wilk Critical Value	N/A
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	0.394	Mean	-2.157
SD	0.814	SD	1.394
95% DL/2 (t) UCL	0.838	95% H-Stat (DL/2) UCL	0.613
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		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% Percentile Bootstrap UCL	N/A
		95% BCA Bootstrap 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
95% Gamma Approximate UCL	N/A
95% Adjusted Gamma UCL	N/A

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	1.145
SD	0.492
SE of Mean	0.21
95% KM (t) UCL	1.525
95% KM (z) UCL	1.49
95% KM (jackknife) UCL	2.326
95% KM (bootstrap t) UCL	N/A
95% KM (BCA) UCL	N/A
95% KM (Percentile Bootstrap) UCL	N/A
95% KM (Chebyshev) UCL	2.059
97.5% KM (Chebyshev) UCL	2.454
99% KM (Chebyshev) UCL	3.231

Potential UCLs to Use

95% KM (t) UCL	1.525
95% KM (% Bootstrap) UCL	N/A

bis(2-Ethylhexyl)phthalate

General Statistics

Number of Valid Data	11	Number of Detected Data	4
Number of Distinct Detected Data	3	Number of Non-Detect Data	7
		Percent Non-Detects	63.64%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	2	Minimum Detected	0.693
Maximum Detected	28	Maximum Detected	3.332
Mean of Detected	13.75	Mean of Detected	1.963
SD of Detected	13.72	SD of Detected	1.469
Minimum Non-Detect	1.2	Minimum Non-Detect	0.182
Maximum Non-Detect	36	Maximum Non-Detect	3.584

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	11
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 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	0.81	Shapiro Wilk Test Statistic	0.763
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	6.973	Mean	0.713
SD	10.55	SD	1.615
95% DL/2 (t) UCL	12.74	95% H-Stat (DL/2) UCL	33.76
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	-0.903
		SD in Log Scale	2.653
		Mean in Original Scale	5.097
		SD in Original Scale	10.18
		95% Percentile Bootstrap UCL	10.13
		95% BCA Bootstrap UCL	12.07

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.389
Theta Star	35.33
nu star	3.114

A-D Test Statistic	0.619
5% A-D Critical Value	0.668
K-S Test Statistic	0.668
5% K-S Critical Value	0.404

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	2
Maximum	34.09
Mean	15.32
Median	15.48
SD	12.47
k star	0.918
Theta star	16.68
Nu star	20.2
AppChi2	11
95% Gamma Approximate UCL	28.13
95% Adjusted Gamma UCL	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	6.7
SD	9.466
SE of Mean	3.457
95% KM (t) UCL	12.96
95% KM (z) UCL	12.39
95% KM (jackknife) UCL	12.45
95% KM (bootstrap t) UCL	11.44
95% KM (BCA) UCL	24.5
95% KM (Percentile Bootstrap) UCL	23.91
95% KM (Chebyshev) UCL	21.77
97.5% KM (Chebyshev) UCL	28.29
99% KM (Chebyshev) UCL	41.09

Potential UCLs to Use

95% KM (t) UCL	12.96
95% KM (Percentile Bootstrap) UCL	23.91

2-Methylnaphthalene

General Statistics

Number of Valid Observations	11	Number of Distinct Observations	11

Raw Statistics		Log-transformed Statistics	
Minimum	0.81	Minimum of Log Data	-0.211
Maximum	290	Maximum of Log Data	5.67
Mean	42.77	Mean of log Data	2.648
Median	17	SD of log Data	1.613
SD	83.21		
Coefficient of Variation	1.945		
Skewness	3.144		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.503	Shapiro Wilk Test Statistic	0.967
Shapiro Wilk Critical Value	0.85	Shapiro Wilk Critical Value	0.85
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	88.25	95% H-UCL	460.8
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	137.3
95% Adjusted-CLT UCL	109.5	97.5% Chebyshev (MVUE) UCL	178.7
95% Modified-t UCL	92.21	99% Chebyshev (MVUE) UCL	259.8

Gamma Distribution Test		Data Distribution
k star (bias corrected)	0.47	Data appear Gamma Distributed at 5% Significance Level
Theta Star	91.01	
MLE of Mean	42.77	
MLE of Standard Deviation	62.39	
nu star	10.34	
Approximate Chi Square Value (.05)	4.156	
Adjusted Level of Significance	0.0278	
Adjusted Chi Square Value	3.539	
Anderson-Darling Test Statistic	0.561	
Anderson-Darling 5% Critical Value	0.776	
Kolmogorov-Smirnov Test Statistic	0.241	
Kolmogorov-Smirnov 5% Critical Value	0.268	
Data appear Gamma Distributed at 5% Significance Level		

Nonparametric Statistics	
95% CLT UCL	84.04
95% Jackknife UCL	88.25
95% Standard Bootstrap UCL	82.39
95% Bootstrap-t UCL	238.5
95% Hall's Bootstrap UCL	254.5
95% Percentile Bootstrap UCL	89.97
95% BCA Bootstrap UCL	115
95% Chebyshev(Mean, Sd) UCL	152.1
97.5% Chebyshev(Mean, Sd) UCL	199.5
99% Chebyshev(Mean, Sd) UCL	292.4

Assuming Gamma Distribution	
95% Approximate Gamma UCL	106.4
95% Adjusted Gamma UCL	125

Potential UCL to Use	Use 95% Approximate Gamma UCL 106.4

Naphthalene

General Statistics

Number of Valid Observations	11	Number of Distinct Observations	11

Raw Statistics		Log-transformed Statistics	
Minimum	1.3	Minimum of Log Data	0.262
Maximum	93	Maximum of Log Data	4.533
Mean	22.68	Mean of log Data	2.541
Median	13	SD of log Data	1.2
SD	26.7		
Coefficient of Variation	1.177		
Skewness	2.127		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.745	Shapiro Wilk Test Statistic	0.984
Shapiro Wilk Critical Value	0.85	Shapiro Wilk Critical Value	0.85
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	37.27	95% H-UCL	94.64
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	63.61
95% Adjusted-CLT UCL	41.44	97.5% Chebyshev (MVUE) UCL	80.89
95% Modified-t UCL	38.13	99% Chebyshev (MVUE) UCL	114.9

Gamma Distribution Test		Data Distribution
k star (bias corrected)	0.784	Data appear Gamma Distributed at 5% Significance Level
Theta Star	28.94	
MLE of Mean	22.68	
MLE of Standard Deviation	25.62	
nu star	17.24	
Approximate Chi Square Value (.05)	8.847	**Nonparametric Statistics**
Adjusted Level of Significance	0.0278	95% CLT UCL 35.92
Adjusted Chi Square Value	7.885	95% Jackknife UCL 37.27
		95% Standard Bootstrap UCL 35.14
Anderson-Darling Test Statistic	0.248	95% Bootstrap-t UCL 53.39
Anderson-Darling 5% Critical Value	0.752	95% Hall's Bootstrap UCL 84.08
Kolmogorov-Smirnov Test Statistic	0.179	95% Percentile Bootstrap UCL 36.39
Kolmogorov-Smirnov 5% Critical Value	0.262	95% BCA Bootstrap UCL 40.47
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL 57.78
		97.5% Chebyshev(Mean, Sd) UCL 72.96
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL 102.8
95% Approximate Gamma UCL	44.21	
95% Adjusted Gamma UCL	49.61	

Potential UCL to Use	Use 95% Approximate Gamma UCL 44.21

Benzene

General Statistics

Number of Valid Observations	11	Number of Distinct Observations	11

Raw Statistics		Log-transformed Statistics	
Minimum	9.5	Minimum of Log Data	2.251
Maximum	140	Maximum of Log Data	4.942
Mean	52.55	Mean of log Data	3.594
Median	41	SD of log Data	0.961
SD	42.43		
Coefficient of Variation	0.808		
Skewness	0.827		

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.896
Shapiro Wilk Critical Value	0.85

Data appear Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.914
Shapiro Wilk Critical Value	0.85

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	75.74

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL	77
95% Modified-t UCL	76.27

Assuming Lognormal Distribution

95% H-UCL	140.3
95% Chebyshev (MVUE) UCL	127.5
97.5% Chebyshev (MVUE) UCL	159
99% Chebyshev (MVUE) UCL	221

Gamma Distribution Test

k star (bias corrected)	1.156
Theta Star	45.47
MLE of Mean	52.55
MLE of Standard Deviation	48.88
nu star	25.43
Approximate Chi Square Value (.05)	14.94
Adjusted Level of Significance	0.0278
Adjusted Chi Square Value	13.64
Anderson-Darling Test Statistic	0.392
Anderson-Darling 5% Critical Value	0.742
Kolmogorov-Smirnov Test Statistic	0.18
Kolmogorov-Smirnov 5% Critical Value	0.26

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	89.44
95% Adjusted Gamma UCL	97.93

Data Distribution

Data appear Normal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	73.59
95% Jackknife UCL	75.74
95% Standard Bootstrap UCL	72.46
95% Bootstrap-t UCL	83.06
95% Hall's Bootstrap UCL	79.49
95% Percentile Bootstrap UCL	73.14
95% BCA Bootstrap UCL	75.14
95% Chebyshev(Mean, Sd) UCL	108.3
97.5% Chebyshev(Mean, Sd) UCL	132.4
99% Chebyshev(Mean, Sd) UCL	179.9

Potential UCL to Use

Use 95% Student's-t UCL 75.74

Ethylbenzene

General Statistics

Number of Valid Observations	11	Number of Distinct Observations	11

Raw Statistics		Log-transformed Statistics	
Minimum	7.45	Minimum of Log Data	2.008
Maximum	140	Maximum of Log Data	4.942
Mean	44.04	Mean of log Data	3.5
Median	39	SD of log Data	0.815
SD	36.58		
Coefficient of Variation	0.831		
Skewness	1.957		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.81	Shapiro Wilk Test Statistic	0.982
Shapiro Wilk Critical Value	0.85	Shapiro Wilk Critical Value	0.85
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	64.03	95% H-UCL	91.62
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	94.33
95% Adjusted-CLT UCL	69.14	97.5% Chebyshev (MVUE) UCL	115.9
95% Modified-t UCL	65.12	99% Chebyshev (MVUE) UCL	158.3

Gamma Distribution Test		Data Distribution
k star (bias corrected)	1.446	Data appear Gamma Distributed at 5% Significance Level
Theta Star	30.46	
MLE of Mean	44.04	
MLE of Standard Deviation	36.63	
nu star	31.81	
Approximate Chi Square Value (.05)	19.92	
Adjusted Level of Significance	0.0278	
Adjusted Chi Square Value	18.4	
Anderson-Darling Test Statistic	0.204	
Anderson-Darling 5% Critical Value	0.74	
Kolmogorov-Smirnov Test Statistic	0.147	
Kolmogorov-Smirnov 5% Critical Value	0.259	
Data appear Gamma Distributed at 5% Significance Level		

Nonparametric Statistics	
95% CLT UCL	62.18
95% Jackknife UCL	64.03
95% Standard Bootstrap UCL	60.94
95% Bootstrap-t UCL	76.28
95% Hall's Bootstrap UCL	144.7
95% Percentile Bootstrap UCL	63.17
95% BCA Bootstrap UCL	70.73
95% Chebyshev(Mean, Sd) UCL	92.12
97.5% Chebyshev(Mean, Sd) UCL	112.9
99% Chebyshev(Mean, Sd) UCL	153.8

Assuming Gamma Distribution	
95% Approximate Gamma UCL	70.33
95% Adjusted Gamma UCL	76.14

Potential UCL to Use	Use 95% Approximate Gamma UCL 70.33

Methylene Chloride

General Statistics

Number of Valid Data	11	Number of Detected Data	4
Number of Distinct Detected Data	4	Number of Non-Detect Data	7
		Percent Non-Detects	63.64%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	1.4	Minimum Detected	0.336
Maximum Detected	7.75	Maximum Detected	2.048
Mean of Detected	4.088	Mean of Detected	1.224
SD of Detected	2.732	SD of Detected	0.723
Minimum Non-Detect	0.26	Minimum Non-Detect	-1.347
Maximum Non-Detect	6.3	Maximum Non-Detect	1.841

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	10
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	90.91%

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	0.958	Shapiro Wilk Test Statistic	0.998
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	2.157	Mean	0.148
SD	2.296	SD	1.317
95% DL/2 (t) UCL	3.412	95% H-Stat (DL/2) UCL	4.742
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	0.155
		SD in Log Scale	0.967
		Mean in Original Scale	1.906
		SD in Original Scale	2.292
		95% Percentile Bootstrap UCL	3.049
		95% BCA Bootstrap UCL	3.493

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.885
Theta Star	4.62
nu star	7.077
A-D Test Statistic	0.192
5% A-D Critical Value	0.66
K-S Test Statistic	0.66
5% K-S Critical Value	0.397

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	1.4
Maximum	7.75
Mean	4.739
Median	4.4
SD	2.075
k star	3.499
Theta star	1.354
Nu star	76.99
AppChi2	57.78
95% Gamma Approximate UCL	6.314
95% Adjusted Gamma UCL	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	2.442
SD	1.928
SE of Mean	0.683
95% KM (t) UCL	3.679
95% KM (z) UCL	3.565
95% KM (jackknife) UCL	3.655
95% KM (bootstrap t) UCL	3.572
95% KM (BCA) UCL	5.314
95% KM (Percentile Bootstrap) UCL	5.009
95% KM (Chebyshev) UCL	5.418
97.5% KM (Chebyshev) UCL	6.706
99% KM (Chebyshev) UCL	9.235

Potential UCLs to Use

95% KM (t) UCL	3.679
95% KM (Percentile Bootstrap) UCL	5.009

Trichloroethene (TCE)

General Statistics

Number of Valid Data	11	Number of Detected Data	1
Number of Distinct Detected Data	1	Number of Non-Detect Data	10
		Percent Non-Detects	90.91%

Warning: Only one distinct data value was detected! ProUCL (or any other software) should not be used on such a data set!

It is suggested to use alternative site specific values determined by the Project Team to estimate environmental parameters (e.g., EPC, BTV).

The data set for variable TCE was not processed!

XYLENES, Total

General Statistics

Number of Valid Observations	11	Number of Distinct Observations	11

Raw Statistics		Log-transformed Statistics	
Minimum	140	Minimum of Log Data	4.942
Maximum	930	Maximum of Log Data	6.835
Mean	411.4	Mean of log Data	5.851
Median	450	SD of log Data	0.627
SD	242.5		
Coefficient of Variation	0.59		
Skewness	0.814		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.904	Shapiro Wilk Test Statistic	0.93
Shapiro Wilk Critical Value	0.85	Shapiro Wilk Critical Value	0.85
Data appear Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	543.9	95% H-UCL	674
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	766
95% Adjusted-CLT UCL	550.8	97.5% Chebyshev (MVUE) UCL	918.2
95% Modified-t UCL	546.9	99% Chebyshev (MVUE) UCL	1217

Gamma Distribution Test		Data Distribution
k star (bias corrected)	2.328	Data appear Normal at 5% Significance Level
Theta Star	176.7	
MLE of Mean	411.4	
MLE of Standard Deviation	269.6	
nu star	51.22	
Approximate Chi Square Value (.05)	35.78	**Nonparametric Statistics**
Adjusted Level of Significance	0.0278	95% CLT UCL 531.6
Adjusted Chi Square Value	33.69	95% Jackknife UCL 543.9
		95% Standard Bootstrap UCL 525
Anderson-Darling Test Statistic	0.403	95% Bootstrap-t UCL 571.9
Anderson-Darling 5% Critical Value	0.733	95% Hall's Bootstrap UCL 567.9
Kolmogorov-Smirnov Test Statistic	0.182	95% Percentile Bootstrap UCL 530.5
Kolmogorov-Smirnov 5% Critical Value	0.257	95% BCA Bootstrap UCL 540.9
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL 730.1
		97.5% Chebyshev(Mean, Sd) UCL 868
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL 1139
95% Approximate Gamma UCL	588.8	
95% Adjusted Gamma UCL	625.4	

Potential UCL to Use	Use 95% Student's-t UCL 543.9

APPENDIX E

RESPONSE TO COMMENTS ON THE DRAFT BASELINE HUMAN HEALTH RISK ASSESSMENT

Comments Received from Beaujon, James S LRN
7 June 2010

Subject: Internal Draft Baseline HHRA Acid Area 1, PBOW

I skimmed through Jacobs' Draft HHRA for PBOW Acid Area 1. RAs not being my forte' I only have a few comments-

Comment 1. Executive Summary and Text: A Figure 1-3 is referenced but there was no Figure 1-3 in the copy I got.

Response: The reference to Figure 1-3 has been deleted

Comment 2. Page 1-3, section 1.3.1, 3rd line: Change "Most of the building" to "Most of the buildings".

Response: The change has been made as noted.

Comment 3. Page 3-2, section 3.1.1, Geology paragraph, 4th line: The number 8 is spelled out while all the other numbers are not.

Response: The change has been per the comment.

Comment 4. Sections 3.1.3.3 and 3.1.3.4: Reference is made to "the burn area", please revise the sections to be applicable to AA1.

Response: The reference has been deleted per the comment.

Subject: Jacobs' Internal Draft Screening Level Eco Risk Assessment

I looked over the subject document and have the following 2 observations:

Comment 1. Page 1-1, end of 2nd paragraph: Change "(CERLN)" to "(CELRN)".

Response: The change has been made as noted.

Comment 2. Page 2-4, Section 2.1.5 and Table 2-1: Table 2-1's title and the text suggest it lists fauna as well as flora but only flora are listed in the Table 2-1 in my copy.

Response: The change has been made as noted.

MCHB-TS-REH

MEMORANDUM FOR District Engineer, US Army Corps of Engineers, Nashville District (CELRN-EC-R-M/Ms. Kathy McClanahan), 110 Ninth Avenue South, Room 682, US Court House Annex, Nashville, TN 37203

SUBJECT: Internal Draft Baseline Human Health Risk Assessment, Acid Area 1, Former Plum Brook Ordnance Works (PBOW), April 2010

1. The US Army Public Health Command (Provisional), formerly the US Army Center for Health Promotion and Preventive Medicine, reviewed the subject document on behalf of the Office of The Surgeon General pursuant to Army Regulation 200-1 (Environmental Protection and Enhancement). We appreciate the opportunity to review this assessment. Our comments and recommendations are enclosed.

2. Our few comments identify some minor text corrections that will make for an improved document overall. We look forward to providing further technical risk assessment support on this and other PBOW projects.

4. The scientist reviewing this document and our point of contact is Mr. Larry Tannenbaum, Environmental Health Risk Assessment Program, DSN 584-5210 or commercial (410) 436-5210.

FOR THE COMMANDER:

Encl

JEFFREY S. KIRKPATRICK
Director, Health Risk Management

CF:
HQDA (DASG-PPM-NC) (wo/encl)
USACE (CEHNC-CX-ES) (w/encl)

COMMENTS AND RECOMMENDATIONS

1. Page 1-2, Section 1.2, L. Tannenbaum
   Background
   Comment: The size of the Acid Area 1 site (i.e., the acreage) is not provided here, or in the first paragraph of Section 3.1.1 ("Physical Setting; page 3-2).
   Recommendation: Please include the site size in the document revision to assist the reader.

Response: Section 1.1 of the document indicates that Acid Area 1 is approximately 25 acres in size.

2. Page 5-4, Section 5.2, L. Tannenbaum
   Noncancer Hazards
   Comment: There is an error in the last sentence of the page's first paragraph.
   Recommendation: Please change "10.4 ug/dL" to "10 ug/dL".

Response: The change has been made as noted.

3. Page 5-7, Section 5.4, L. Tannenbaum
   Risk Characterization Results and Discussion
   Comment: The Section's third paragraph speaks of identifying chemicals of concern (COCs) when cancer risks are found to exceed 1E-4. In the page's next-to-last paragraph, the cumulative cancer risk for the construction worker is given as 2.0E-6, i.e., a figure that is less than 1E-4, i.e., less than the "trigger" for remedial considerations. The next-to-last paragraph should not therefore, identify any COCs as "drivers" of cancer risk.
   Recommendation: In the document revision, please remove the mention of arsenic and PCB-1260 as cancer risk drivers for the construction worker.

Response: The text has been revised per the comment.

Interoffice Memo

Ohio Environmental Protection Agency

To:	Paul Jayko, **NWDO-DERR**	Date: 25 May 2010
From:	Janusz Z. Byczkowski, DERR, CO	
Subject:	**"Internal Draft Baseline Human Health Risk Assessment", and "Internal Draft Screening Ecological Risk Assessment", Acid Area 1, Former Plum Brook Ordnance Works Sandusky, Ohio,** February 2010. Site: US NASA PLUM BROOK, TAYLOR & COLUMBUS Rds., SANDUSKY, OH 44870; ERIE Cnt.; OHID# 322-0552.	

The following comments and suggestions are regarding two documents: ***"Internal Draft Baseline Human Health Risk Assessment", and "Internal Draft Screening Ecological Risk Assessment", Acid Area 1, Former Plum Brook Ordnance Works Sandusky, Ohio,*** dated April 2010.

.

If you have any questions or need further technical support, please give me a call at: 614-644-3070 or e-mail at jbyczkowski@epa.state.oh.us.

50 West Town Street, Suite 700
P.O. Box 1049
Columbus, OH 43216-1049

614 | 644 3020
614 | 644 3184 (fax)
www.epa.ohio.gov

DOCUMENT TITLE: Internal Drafts: "Baseline Human Health Risk Assessment", and "Screening Level Ecological Risk Assessment"

SITE: Acid Area 1, Former Plum Brook Ordnance Works Sandusky, Ohio 44870 **DOCUMENT/DATE**: April 2010

Ohio EPA – Division of Emergency and Remedial Response COMMENTS

REVIEWER: Dr. Janusz Z. Byczkowski, DERR, CO; Tel: 614-644-3070; e-mail: jbyczkowski@epa.state.oh.us.

Review/DATE: 05/25/2010

Comment Number	Sect. Page/ Line#	Cross Ref.	Comment	Recommendation	Response
1.	HHRA S. 1.0 P. 1-1 L# 14 S. 2.1.3 P. 2-3 L# 24 S. 8.0 P. 8-3 L# 25		If you have any questions or need further technical support, please give me a call at: 614-644-3070 or e-mail at jbyczkowski@epa.state.oh.us . This document states that: "…*It is consistent with U.S. Environmental Protection Agency (EPA) and Ohio EPA (OEPA) guidance*…" then it says: "…*RBSCs used in this BHHRA were derived from the U.S. EPA Region 3 RBC tables (U.S. EPA, 2004a)*…" but in References Section it lists: "…*U.S. EPA, 2004a, Region 9 Preliminary Remediation Goals*…" and provides the URL: " http://www.epa.gov/region09/waste/sfund/prg/files/prgtable.pdf " Comment: Text, tables, guidelines and references should be reconciled (*e.g.,* Region 3 *vs*. Region 9). In addition the URL, as written in the example above, does not work anymore. Please note, that according to OEPA-DERR (2009) guidance for toxicity based screen, either a current (as of December 2009) RSL table, or the archived 2004 Region 9 PRG table should be used instead of "*Region 3 RBC tables*".	This document requires quality reading/typo corrections. A few additional specific editorial corrections are recommended before finalizing these documents and releasing to the public: Please reconcile text, tables, references and Internet addresses (URLs). Please apply and refer to current OEPA-DERR guidelines available on Internet at: http://www.epa.ohio.gov/derr/rules/guidance.aspx.	The document will be reviewed for typos and corrections in text and tables. The internet address identified as incorrect will be revised per the comment. In Table 4-1, toxicity values listed as reference doses are based on noncancer endpoints. Toxicity values listed as cancer slope factors are based on cancer endpoints. The text will be revised to indicate that the current RSL tables were used for completion of the risk assessment. The text will be reviewed and revised for consistency throughout. Figure 3-1 has been revised for consistency

Comment Number	Sect. Page/ Line#	Cross Ref.	Comment	Recommendation	Response
			Moreover, despite the claim in the Section 2.1.3 that "…*the noncancer values listed in RBC tables were multiplied by a factor of 0.1 to provide additional protection*…", the values, listed in Table 2-1 as "*Toxicity Screening Level*", are not adjusted. In the Table 4-1, there is no indication which toxicity values are based on cancer and which on noncancer endpoints. While the Section 3.2.2 states that "…*The simple whole-house tap water-to-air model* […] *was used in BHHRA*…", the caption to Figure 3-1 says "…*Although theoretically complete, this pathway in* (sic!) *not quantified as explained in text*…" Also, despite the statement in Section 3.1.3.1 that "…*the BHHRA will qualitatively evaluate potential exposure to perched groundwater*…", there is no such an evaluation described in this document. There are multiple typos throughout this document that should be corrected (e.g., Table 5-1 "*rdnance*"). **Reference:** **OEPA-DERR (2009)** Use of U.S. EPA's Regional Screening Levels as Screening Values in Human Health Risk Assessments. 21 August 2009. On line: http://www.epa.ohio.gov/portals/30/rules/screening.pdf		

Comment Number	Sect. Page/ Line#	Cross Ref.	Comment	Recommendation	Response
2.	S. 2.1.5 P. 2-4 L# 10		This document states: "…*groundwater BSC is either the MDC or the calculated 95 percent upper tolerance limit of the background groundwater data set*…" and then: "…*Background screening was not used to eliminate COPCs*…" <u>Comment:</u> The use of "*MDC*" or the "*95 percent" UTL* as BSCs, is currently not recommended by OEPA-DERR for background screening. If background levels (BSCs) cannot be recalculated from the original data in accordance with OEPA-DERR (2009a) guidance, then either no chemicals detected in Acid Area 1 should be screened based on background level or a detailed explanation should be provided as to why OEPA-DERR (2009a) was not applied. The discussion provided in Section 6.0 does not explain deviation from U.S. EPA and/or OEPA-DERR methodology, and thus, it is insufficient. **Reference:** **OEPA-DERR (2009a)** Use of Background for Remedial Response Sites. 21 August 2009. On line: http://www.epa.ohio.gov/portals/30/rules/bground%20guidance.pdf	Please recalculate BSCs according to OEPA-DERR (2009a) guidance, or explain why the guidance was not used.	It is true, there is no recent background data taken specifically for 2BG. However, there is a metals background data set from 2001, from background locations as agreed upon by the PBOW Team, including USACE and OEPA, that would suffice as the background data set for all PBOW FUDS AOCs to be investigated, including Acid Area 1. During the development of the appropriate background statistic to compare to for PBOW FUDS AOCs, the PBOW Team reviewed many statistics, including arithmetic mean, median, UCLs and UTLs. The OEPA risk assessors Bonnie Buthker, Laurie Moore with the rest of the PBOW team deemed the 95% UTL or the maximum detected background metal concentration, which ever is less, as the appropriate statistic to use during background screening of AOCs' metals, and as documented in the May 2000 PBOW Team Meeting Minutes as consensus for using this method.

Comment Number	Sect. Page/ Line#	Cross Ref.	Comment	Recommendation	Response
3.	SLERA ES P. ES-3 L# 21 also S. 6.0 P. 6-1 L# 22 and L# 28		This document states: "…*Estimated HQs for the terrestrial receptors […] are less than 10 indicating a low potential for adverse effect*…" and then: "…*Estimated HQs for the raccoon are less than 10 indicating a low potential for adverse effect*…" <u>Comment:</u> The OEPA goal for hazard quotient is ≤1. Therefore, HQ ≤ 10 is an order of magnitude above this goal, so it should not be described as "*a low potential*". The potential is ten times too high.	Please delete from these phrases the adjective "*low*".	The following text describing HQs and associated interpretation is provided in Section 5.3 of the SLERA. "The HQs were compared according to HQ guidelines for assessing the risk posed from contaminants. HQs less than or equal to 1 represent no probable risk. HQs from 1 up to but less than 10 represent a low potential for adverse ecological effects. HQs from 10 up to but less than 100 represent a significant potential that effects could result from greater exposure. HQs greater than 100 represent the highest potential for expected effects (Wentsel, et al., 1996). OEPA considers HQs greater than 1.0 to be potentially significant. It should also be noted that HQs are not measures of risk, are not population-based statistics, nor are they linearly scaled statistics. Accordingly, an HQ above 1, even exceedingly so, does not necessarily mean that there is even one individual expressing the toxicological effect associated with a given chemical to which it was exposed (Tannenbaum, 2001; Bartell, 1996)". No change was made to the text.

Comment Number	Sect. Page/ Line#	Cross Ref.	Comment	Recommendation	Response
4.	S. 2.0 P. 2-1 L# 9		This document states: "…*The potential for adverse ecological effects to ecological receptors at the site is minimal or nonexistent due to the lack of potential chemical stressors*…" <u>Comment:</u> Since in ecological risk assessment, the goal of HQ ≤ 1.0 is based on concentration and it represents a threshold below which no significant adverse effect is expected, this is not necessarily the "*lack*" of a chemical stressor which determines "*minimal or nonexistent*" potential for adverse effect. Rather this is their low concentration, This null hypothesis should be rephrased.	Please substitute in this null hypothesis the word "*lack*" with "**low concentration**"	The change has been made as noted.
5.	S. 4.2 P. 4-1 L# 29 Table 4-1		This document states: "…*These factors were used together to derive a final adjusted TRV, also presented in Table 4-1*…" <u>Comment</u>: In the Table 4-1, two columns of values are listed: "*NOAEL*" and "*Body Wt*." For those not familiar with the methodology, there is no way to understand which column actually represents "*final adjusted*" TRVs.	Please indicate (in the table head or footnote) which column represents **TRV**.	Table 4-1 presents all identified TRVs available in the literature. Appendix B presents the selected TRV used for the risk assessment. The text has been revised accordingly.
6.	S. 5.3 P. 5-2 and 5-3 Tables		The tables provide a column of numbers without explanation of their meaning or dimension.	Please add a table head that saying "**Hazard Quotients**"	Hazard Quotient has been added to the title block per the comment.