

WILKINS AIR FORCE STATION
SHELBY, OHIO

DERP FUDS PROPERTY NUMBER G05OH0972

PIONEER AREA OF CONCERN

REMEDIAL INVESTIGATION/FOCUSED FEASIBILITY STUDY

REMEDIAL INVESTIGATION REPORT

Final

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CONTRACTOR STATEMENT OF TECHNICAL REVIEW

Plexus Scientific Corporation has completed this Remedial Investigation Report for the Wilkins Air Force Station, Pioneer Area of Concern, Remedial Investigation/Focused Feasibility Study project. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project, as defined in the Quality Control Plan. During the independent technical review it was established that policy principles and procedures, utilizing justified and valid assumptions were complied with in preparation of this Remedial Investigation Report. This included review of assumptions; methods, procedures, and material used in analyses; alternatives evaluated; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing U.S. Army Corps of Engineers' policy.

Review documentation identifying any specific concerns identified during the technical review and their resolution is maintained in the project file.

Bill Millar, Project Manager

Date

John Kearns, QA/QC Manager or his designee

Date

EXECUTIVE SUMMARY

The Remedial Investigation (RI) presented in this report is a continuation of the effort begun in the Site Investigation (SI) to characterize the nature and extent of contamination associated with the fill material and, in addition, to establish background levels of chemicals in soil and groundwater in the area of the Wilkins Air Force Station (AFS). A risk assessment has also been conducted to evaluate risk to human health and the environment associated with the contamination. Surface soil samples were collected in and around the fill area, between the fill area and the Pioneer Career and Technology Center (PCTC) buildings and in background areas 2000 feet south of the Pioneer area of concern (AOC). Two background groundwater monitoring wells were installed in the same areas. The on-site wells and background wells were developed or redeveloped as appropriate, purged, and sampled. The soil and groundwater samples were submitted to an analytical laboratory for chemical analyses. A landfill gas survey was conducted.

The Wilkins AFS is located at the north end of the town of Shelby, Ohio in Richland County. It was formerly utilized primarily as a storage and shipping facility for aircraft parts. Wilkins AFS was built from 1943 to 1944 on 344 acres, later expanded to 486 acres and included 77 acres of warehouse space and 29 acres used for outdoor storage. In the early 1960's the facility was identified as excess property by the Department of Defense and transferred to the General Services Administration (GSA). The GSA began the transfer of portions of the property to private businesses and public organizations. GSA sold the last building at Wilkins AFS in 1984. A 43-acre parcel of the property was sold to the Pioneer Joint Vocational School District, which was developed as the PCTC.

A Preliminary Assessment (PA) of the Wilkins AFS was conducted in 2000, which identified the Pioneer AOC, a fill area at the west end of the PCTC property. A SI at the Pioneer AOC was completed in 2001. A review of historical aerial photographs shows that dumping in the area began around 1950 and appears to have ended sometime after 1971. The fill at the site contained concrete demolition debris and medical/laboratory glassware. Some of the glass shows signs of melting and anecdotal evidence indicates that the material in the fill area was periodically burned. This was a common practice. The area was also known to receive concrete and demolition debris. Concerns identified during the PA and SI included the unknown nature of the contents of the fill, and possible environmental risks associated with the fill material.

During the SI surface and subsurface soil samples were collected in and around the fill area. Polynuclear aromatic hydrocarbons (PNAs or PAHs) and metals were detected in the soil samples at levels exceeding the U.S. Environmental Protection Agency (EPA) Region 9 preliminary remediation goals (PRGs) for residential soil. The metals above the residential soil PRGs were iron and arsenic. Dioxin was detected in one of the subsurface soil samples above the residential soil PRG.

Three groundwater monitoring wells were installed at the fill area and samples were collected from the wells. The analytical results of the groundwater samples showed elevated levels of total and dissolved metals in groundwater. Manganese, both total and dissolved, exceeded the tap water PRG in one well. Arsenic and iron exceeded the PRG in a second well. Organics detected in groundwater did not exceed their tap water PRGs.

The sources of the PNAs in the fill material may be tar or asphalt observed in the area. PNAs are also associated with chemically-treated wood, and with combustion, and can be airborne. Dioxin and related compounds are also byproducts of combustion. It was unclear during the SI if the metals detected could be naturally occurring or if they were associated with the fill materials. Areas of Ohio are known to have elevated arsenic levels in soil.

A similar analysis was performed on the soil samples during the RI as was performed during the SI. The RI analysis for semi-volatile organic compounds (SVOCs) detected the same compounds as the analysis for PNA's done in the SI. The SVOC analysis was used to detect a wider range of compounds than the PNA analysis, but the compounds detected during the SI and RI were the same.

SVOCs were detected in all of the soil samples collected at various levels. When comparing total SVOC concentration in the soil samples collected, the data show that the surface soils in the mound area have higher concentrations of SVOCs than the subsurface soils samples from the mound area. The mound area surface soil samples also had higher concentrations of SVOCs than the surface soils surrounding the mound, between the mound and the PCTC buildings, and in the background area.

The target analyte list metals analytical results from the SI and RI were reviewed and the highest concentration of each metal was compared to the sample location. The highest concentrations of lead, silver, chromium, copper, antimony, mercury, thallium, calcium and sodium were reported for samples collected in the fill area. These maximum concentrations in the fill area were mostly in one sample collected from the bottom of the drainage swale. Many of the remaining metals maximum concentrations were detected in the sample collected within the drainage, near the pipe outfall at the southwest corner of the PCTC property, well removed from the fill area. Arsenic was detected in every soil sample collected including the background samples. The arsenic levels in the fill material were similar to the results from the surface soil samples outside the AOC and the background samples. Arsenic was above its maximum contaminant level (MCL) in samples from one well. Thallium was detected above its MCL, but is thought to be naturally occurring.

No substantive levels of volatile organic compounds (VOCs), SVOCs, pesticides, polychlorinated biphenyls (PCBs), or dioxin were detected in the RI groundwater samples.

Soil gas testing was performed between 2 and 4 feet bgs. Soil gas was brought to the surface and tested in the field using a landfill gas meter to detect hydrogen sulfide, carbon dioxide, methane, and oxygen at 20 points on a grid around the fill area and between the fill area and the PCTC buildings. No concentrations that would be indicative of landfill gas generation were detected at any of the points.

A licensed surveyor established the location and elevation of all sampling points and created a topographic map of the area at the west end of the PCTC property, including the Pioneer AOC.

The data from the SI and the RI investigations have been combined and analyzed in a baseline risk assessment to evaluate the risk to human health and the environment from the contamination detected at the site. The Human Health Risk Assessment evaluated four exposure scenarios a worker, who performs grounds maintenance at the site, a trespasser on the landfill mound who may come in contact with the surface soil via ingestion, dermal, contact or inhalation exposure routes, a construction worker being exposed to contaminants in aggregate soils (0 to 10 feet

below ground surface), and a future resident being exposed to aggregate soils. The conclusions of the analysis are that there is no unacceptable risk to either a site worker or trespasser from the contaminants in the landfill surface soil. There were no risks to the construction work from carcinogens, but there was a slight risk in this scenario to exposure to non-carcinogens (manganese). Residential use of the site seems unlikely, but a resident scenario was included to determine an upper bound on the level of risk posed by the site. The scenario used indicated that an unacceptable risk would exist for resident exposed to aggregate soils (0-10 feet). The cancer risk was from exposure to arsenic, SVOCs and dioxin. The total risk from arsenic contributed over 70% of the total. As discussed above, arsenic was detected in every soil sample collected including the background samples. The arsenic levels in the fill material were similar to the results from the surface soil samples outside the AOC and the background samples. The arsenic detected in groundwater at the site is similar in concentration, and comparable to, arsenic detected in background wells. All the SVOCs detected in samples collected from the AOC soil mound during the SI and RI were also detected in samples collected in surface soils from areas around the site, between the AOC and the PCTC building, and in background samples. Only one soil sample contained dioxin above PRGs, specifically 2,3,7,8-TCDD. The sample was collected from 2 to 3 feet below the surface of the mound. The non-cancer risk for residential use was from manganese. The groundwater pathway is not considered complete. A screening level ecological risk assessment found that the site does not impact any ecologically important resources.

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List of Acronyms

AAF	Army Air Force
ABS _d	Dermal absorption factor
ABS _{GI}	Absorbed in the gastrointestinal tract
ADD	Average daily dose
AF	Adherence factor
AFS	Air Force Station
AOC	Area of Concern
ARAR	Applicable, relevant and appropriate requirement
ASTM	American Society for Testing and Materials
AT	Averaging Time
bgs	Below ground surface
BW	Body weight
CAA	Clean Air Act
CDI	Chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CLP	Contract Laboratory Program
COIP	Central Ohio Industrial Park
COPC	Compounds of Potential Constituents
CSF	Cancer slope factor
CSF _d	Cancer slope factor dermal
CSF _i	Cancer slope factor inhalation
CSF _o	Cancer slope factor oral
CSM	Conceptual site model
CWA	Clean Water Act
DERP	Defense Environmental Restoration Program
DL	Detection Limit
DO	Dissolved oxygen
DQI	Data quality indicators
DQO	Data quality objective
DWHA	Drinking water health advisory
ED	Exposure duration
EF	Exposure frequency
EPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
ERA	Ecological risk assessment
FFS	Focused Feasibility Study
FI	Fraction ingested
FR	Federal Register
FSP	Field Sampling Plan
FUDS	Formerly used defense site
GSA	General Services Administration
HASP	Health and Safety Plan
HEAST	Health Effects Assessment Summary Tables

HHRA	Human Health Risk Assessment
HI	Hazard index
HPLC	high performance liquid chromatography
HQ	Hazard quotient
IRA	Inhalation rate
IRIS	Integrated Risk Information System
IRS	Soil ingestion rate
LADD	Lifetime average daily dose
LCG	Louisville Chemistry Guidelines
MCL	Maximum contaminant level
MCLG	Maximum contaminant level goals
MDL	Method detection limit
mg/kg	Milligrams per kilogram
mg/kg-day	Milligram COPC per kilogram of body weight per day
ug/kg	Micrograms per kilogram
ug/L	Micrograms per liter
MRL	Method reporting limit
MSL	Mean sea level
NCEA	National Center for Environmental Assessment
ND	None detected
ng/kg	Nanograms per kilogram
ODGS	Ohio Division of Geological Survey
OEPA	Ohio Environmental Protection Agency
ORP	Oxidation-reduction potential
OSHA	Occupational Safety and Health Administration
PA	Preliminary Assessment
PAH	Polynuclear aromatic hydrocarbons
PCB	Polychlorinated biphenyl
PCTC	Pioneer Career and Technology Center
PEF	Particulate emission factor
%R	Percent recovery
Plexus	Plexus Scientific Corporation
PNA	Polynuclear aromatic hydrocarbons
PRG	Preliminary remediation goal
PVC	Polyvinyl chloride
QAPP	Quality Assurance Project Plan
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
redox	Oxidation-reduction
RfD	Reference dose
RfD _d	Reference dose dermal
RfD _i	Reference dose inhalation
RfD _o	Reference dose oral
RI	Remedial Investigation
RI/FFS	Remedial Investigation/Focused Feasibility Study
RL	Reporting limit

RME	Reasonable maximum exposure
RPD	Relative percent difference
SA	Skin surface area
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SI	Site Investigation
SIM	Selective ion monitoring
SLERA	Screening level ecological risk assessment
SQL	Sample quantitation limit
SVOC	Semi-volatile organic compounds
TAL	Target analyte list
2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo[b,e][1,4]dioxin
TCL	Target compound list
TEF	Toxicity equivalence factor
TEQ	Toxic equivalence
THQ	Target hazard quotient
TR	Target risk
UCL	Upper confidence limit
USACE	U.S. Army Corps of Engineers
USCS	Unified Soil Classification System
USGS	U.S. Geological Survey
VOC	Volatile Organic Compound
WP	Work Plan

1.0 INTRODUCTION

The Remedial Investigation (RI) summarized in this report is part of the Wilkins Air Force Station (AFS), Pioneer Area of Concern (AOC) Remedial Investigation/Focused Feasibility Study (RI/FFS) project. The project is a part of a continuing effort to assess the nature and extent of impacts to environmental media at the Pioneer AOC (site) resulting from activities at the former Wilkins AFS. The Site Investigation (SI) of the Pioneer AOC found levels of polynuclear aromatics hydrocarbons (PNAs or PAHs), dioxins, iron, and arsenic above the U.S. Environmental Protection Agency (EPA) Region 9 preliminary remediation goals (PRGs) for residential soil in surface and subsurface soil samples. Manganese, iron and arsenic exceeded the tap water PRGs in groundwater samples collected from monitoring wells at the site.

Plexus Scientific Corporation (Plexus) has been contracted by the United States Army Corps of Engineers (USACE), Louisville District under contract number DACA27-98-D-0031, delivery order 0007, in part to review available information, and complete the RI.

1.1 PURPOSE OF REPORT

This RI Report summarizes previous contamination assessment activities. The report also presents the methods and results of the current field investigation, sample analyses, and data verification. Potential impacts associated with the Pioneer AOC are evaluated and summarized, fate and transport of the compounds of potential concern (COPCs) are discussed, and recommendations are made. A Baseline Risk Assessment of the relative risk to potential receptors of COPCs from the Pioneer AOC has been conducted and results of this assessment are presented in this report. The Risk Assessment is an evaluation of human health risk to students and staff at the Pioneer Career and Technical Center (PCTC) from COPCs originating at the Pioneer AOC and ecological risks associated with the site. In addition, two background wells have been installed and sampled on the former Wilkins AFS property south of the Pioneer AOC. Background soil samples were also collected from locations near the background wells and analyzed. Results of background groundwater and soil analyses are presented.

1.2 SITE BACKGROUND

1.2.1 Site Description

The former Wilkins AFS is located in north central Ohio just within the northern city limits of the town of Shelby, in Richland County, Ohio (Figure 1-1). The Wilkins AFS is located in Plymouth Township (Township 23 N, Range 19 W), north side and Sharon Township (Township 22 N, Range 19 W) south side. The Pioneer AOC is in the southeast quarter of section 31 of the Plymouth Township. The geographic coordinates of Wilkins AFS are 40° 54' 06" north latitude and 82° 40' 10" west longitude (U.S. Geological Survey (USGS), 1960; Totten, 1973).

The Wilkins AFS is northeast of the intersection of State Street and Route 61 (North Gamble Street). The Pioneer AOC is located at the west end of the PCTC property (the northwest portion of the former AFS), which is located between the Shelby Horizons property and the Central Ohio Industrial Park (COIP) property. Figure 1-2 is a map of the former Wilkins AFS showing the location of the Pioneer AOC. The site is accessed from Shelby by traveling north on Route 61, turning west on State Street, then north on Curtis Drive, and west on Ryan Road. Figure 1-3 is a portion of the USGS 7.5 minute quadrangle map, Shelby, Ohio and shows some of the natural and cultural features surrounding the site.

The Wilkins AFS is a formerly used defense site (FUDS) that was operated by the military for storage and distribution. The site encompasses 486 acres, much of which (344.4 acres) was acquired in 1943 to construct an Army Air Force (AAF) Depot. In 1952, 141.7 additional acres were acquired for construction of a warehouse north of the existing acreage. Approximately 77 acres of the property was indoor storage, with an additional 29 acres used for outdoor storage (Plexus, 2000; 2001).

As part of the field work for the RI a topographic survey of the area of the Pioneer AOC was completed. A topographic map of the area with a one-foot contour interval has been prepared and is discussed in Section 3. The topographic map shows the landfill mound, covering approximately two acres, as the most prominent feature in the AOC. The mound area is overgrown with high grass, brush and trees. According to the Preliminary Assessment (PA), the PCTC staff excavated a ditch through the landfill mound to facilitate drainage of an adjacent property.

During the field activities in April 2003 it was observed that a temporary fence around the landfill mound restricts access to most of the landfill mound and limits exposure to surface soil. During heavy precipitation events, storm water runoff passes through the ditch that bisects the landfill mound. The natural vegetative cover at the site is being maintained and helps to limit the movement of fill material via storm water and air-borne dust.

1.2.2 Site History

1.2.2.1 Wilkins AFS

In late December 1942, the USACE established an office in the basement of the Shelby post office for the purpose of construction of the AAF Storage Depot. Construction began in early January 1943. The original installation included 12 warehouses, three open storage sheds, an administration building, two cafeterias, two firehouses, a dispensary, a paint and dope shop, a garage, an engineer's office, equipment building, a reservoir for fire control, and a heating plant (Plexus, 2001).

The first warehouses were turned over for occupancy on June 30, 1943; the next warehouses were opened in July, and the first shipments were received on August 1. The original plans for one million square feet of covered storage were expanded to 2.5 million square feet in August 1943 and construction continued until the spring of 1944. In 1943, over five million pounds of B-29 aircraft tires were shipped from the depot monthly (Plexus, 2001).

The facility was established in 1943 for the primary purpose of concentrating bulk storage and issue facilities for certain classes of property. When the Air Material Command decentralized its program, the facility added administration and procurement of certain items to its responsibilities (Plexus, 2001).

Activities conducted at the former Wilkins AFS included maintenance, corrosion control, strategic storage of crude rubber, salvage of materials, reproduction, and disposal of excess property. Maintenance activities included aircraft parts repair, aircraft metal parts surface repair, box repair, auto equipment repair, auto battery service, vehicle washing and inspection, auto painting, and auto repair (Plexus, 2001).

The facility was activated as the 27th AAF Supply Depot, Shelby, Ohio on May 8, 1943. The facility operated under a number of designations until the planned closure of the Wilkins AFS was announced on October 2, 1957. In February 1961, the last inbound shipment was received

at the site. On June 30, 1961 the site was transferred to the General Services Administration (GSA) for sale. The entire facility was reported excess, and tracts of land and buildings were transferred to various organizations and businesses. GSA continued to operate Building 31 as a warehouse until June 1982 and the building was sold in 1984. Much of the property is now occupied by the COIP.

At the time the facility closed there were approximately sixty buildings on-site. Since closure of Wilkins AFS, a number of smaller buildings have been removed and several other buildings have been built. Although portions of the site are fenced, access to the site is generally unrestricted (Plexus, 2001).

A more detailed discussion of the facility history can be found in the PA (Plexus, 2000) and SI (Plexus, 2001) documents for the site.

1.2.2.2 Pioneer AOC

A former depot/GSA employee reported that the Pioneer AOC was formerly a swampy area. The waste deposited consisted of general rubbish and concrete from GSA operations. He did not believe that any trenching was done in the area. Waste was burned in this location for several years. He knew of no hazardous materials that were disposed of in the areas (Plexus, 2001).

PCTC staff trenched through the landfill mound to improve site drainage. During excavation wheels from forklifts and glassware including flasks, beakers, graduated bottles, and test tubes were found. The surface of the mound was graded smooth during the excavation of the trench. Prior to this grading, individual piles of debris were still visible in the mound. PCTC has added some concrete and landscaping debris to the east side of the mound (Plexus, 2001).

While the military owned the area that is now the PCTC two activities of potential concern occurred on the western half of the property. An open storage yard (Open Storage Yard 2) was located in the area that is now the student parking lot. A disposal area (Area D) was present that corresponds to the landfill mound in the AOC.

A description of the activities at Open Storage Yard 2 was developed through review of historic aerial photographs conducted for the PA. In 1950, many materials stored were stacked in rectangular-shaped piles similar to that of lumber or other angular, linear materials. A large number of crates or truck trailers were also observed in this storage yard. No evidence of disposal activity is associated with this storage site. The 1958 aerial photo shows that the storage yard is empty. The buildings of the PCTC were built sometime in 1971. In an aerial photo from 1979 the former yard was being used as a parking lot by the PCTC (Plexus, 2000).

The disposal area, Area D lies west of the former storage yard. The majority of the area lies on the PCTC property and a small portion extends south onto the COIP property. Aerial photo evidence indicates that disposal of debris occurred at the site between 1950 and 1964. Between 1950 and 1958 significant fill activity occurred, raising the surface of this area several feet. The depth of fill is particularly pronounced on the west side of this area where an established drainage ditch was visible. By 1971, disposal in the area appears to have stopped (Plexus, 2000).

1.2.3 Previous Investigations

Work completed to date at the Pioneer AOC includes a PA (Plexus, 2000) at the former Wilkins AFS and a SI of the Pioneer and Shelby AOCs (Plexus, 2001). Field activities completed at the

Pioneer AOC during the SI included surface soil sampling, subsurface soil sampling, monitoring well installation, groundwater sampling, a passive soil gas survey, and a geophysical survey.

Soil sampling identified several compounds above EPA Region 9 residential soil PRGs, making them COPCs. These compounds include: arsenic, iron, PNAs, and dioxin. PNAs present above residential soil PRGs include benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd) pyrene. A dioxin was detected in one soil sample at a depth of 2-3 feet slightly above the soil PRG for 2,3,7,8-tetrachlorodibenzo[b,e][1,4]dioxin (2,3,7,8-TCDD).

EPA Method 8270 is used to analyze soil samples for a list of semi-volatile organic compounds (SVOCs). EPA method 8310 was used to analyze soil sample for PNAs. All of the compounds on the PNA list are also on the SVOC list. Method 8310 is more specific to a smaller list of compounds and used to achieve a lower reporting limit (RL). During the RI soil samples were analyzed for SVOCs using EPA Method 8270C and a subset of these compounds was also analyzed using EPA 8270C selective ion monitoring (SIM), which provided a lower RL. Compounds detected were referred to generically in the SI as PNAs; these will be referred to in the RI as SVOCs.

Three shallow groundwater monitoring wells were installed and sampled during the SI. Three metals (arsenic, manganese, and iron) were identified in groundwater above PRGs for tap water making them COPCs.

The SI did not determine if the COPCs identified for the soil or groundwater media were the result of past disposal activities associated with the Pioneer AOC or if they are naturally occurring. The records review and site screening surveys (soil gas survey and geophysical surveys) summarized in the SI Report did not indicate the presence of hot spots in the former disposal area.

During the SI geophysical survey two anomalies were identified. The major anomaly is approximately 3¹/₄-acres and includes the 2-acre landfill mound. A small secondary anomaly was identified northeast of the major anomaly. Soil gas collectors were distributed over both of the anomalies and concentrated over the strongest portions of the anomalies. A number of compounds were detected in the soil gas, but most were found only sporadically and near the detection limit. Chloroform and three diesel alkanes were detected at low to moderate concentrations in the soil vapor of the major anomaly, the landfill mound. Chloroform was detected in the central portion of the landfill mound and diesel alkanes were found at several locations around the perimeter of the mound. No contaminants were detected during the soil gas survey in the second geophysical anomaly.

Seven surface soil and eleven subsurface soil samples were collected and sent for off-site analysis. The sampling locations were identified sequentially during the SI, i.e., surface soil sample WI-SS-05 was collected at the same location as soil boring SB-05 where subsurface soil samples WI-SB-05A and WI-SB-05B were collected, which is the same location as monitoring well MW-05. PNAs are associated with petroleum products and tars, and were detected above PRGs for residential soil in three surface soil samples. The Pioneer AOC was reportedly used for the open burning of rubbish during its operation and dioxins, which are often related to incomplete combustion, were above PRGs in a subsurface soil sample. Iron exceeded PRGs at a subsurface soil location and could be related to disposal activities or may be naturally occurring. Arsenic exceeded PRGs in every soil sample. Arsenic is found at naturally high levels in soils in

portions of Ohio; it is, therefore, unclear if the arsenic detected is related to waste disposal activities or is naturally occurring.

The three monitoring wells at the site were completed primarily in sandy materials encountered at a depth of approximately 10-feet below ground surface (bgs). The sands at all locations were thin-bedded and interbedded with clays. Therefore, well completions were in mixed, non-heterogeneous materials. The groundwater at the site contained manganese (both total and dissolved) that exceeded PRGs at one well. Arsenic (both total and dissolved) and iron (total) were found in excess of the PRGs in another well. The presence of metals in the groundwater may be natural or could be related to waste disposal activities. No organics were detected in excess of PRGs in groundwater. Note that all volatile organic compound (VOC) results for MW-05 were rejected.

It is uncertain if the three metals detected in groundwater above the tap water PRGs are naturally occurring or are related to disposal activities. As contaminant levels were found to be relatively low and the nearest potentially down gradient well user was approximately ½ mile northwest of the AOC, it was concluded in the SI that it is unlikely that groundwater poses a significant threat to human health.

1.3 REPORT ORGANIZATION

Section 2.0 presents general information on the site and the surrounding area. This section focuses on the soils, surface water hydrology, geology and hydrogeology of the site and information from the current and previous investigations and studies of the subsurface at the site.

Section 3.0 discusses the current site investigation methods, results, analytical data, and data verification.

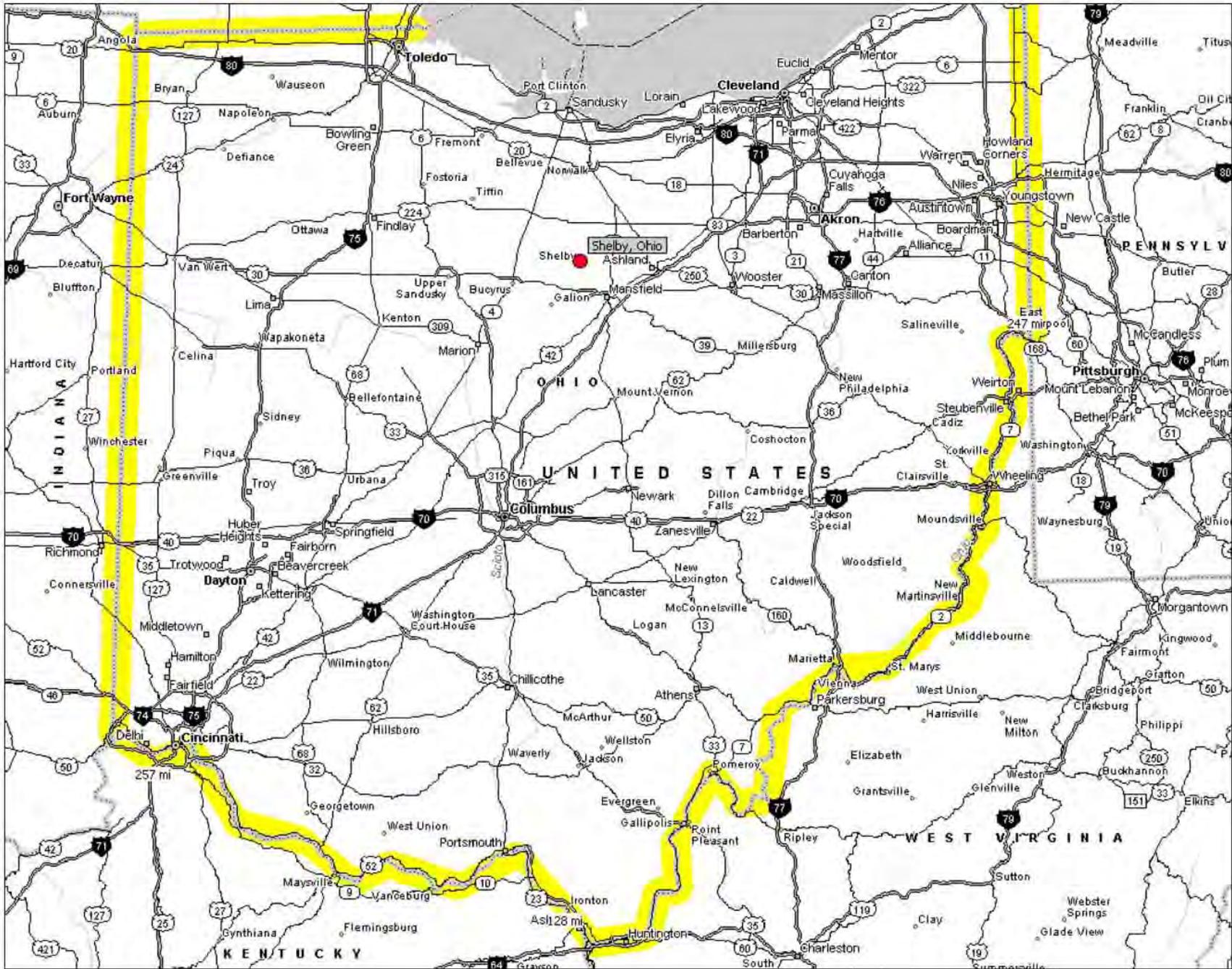
Section 4.0 presents the nature and extent of the COPCs detected. This section discusses groundwater data resulting from the current investigation and the data from the SI. This data is used to identify the COPCs for soil, sediments, and groundwater at the site, and discuss their distribution.

Section 5.0 is a discussion of the fate and transport of the COPCs in the soil, sediments, and groundwater.

Section 6.0 discusses the Risk Assessment, and the potential risk to on and off site personnel and students from the COPCs found in media of concern at the site.

Section 7.0 is a summary of the RI Report and presents conclusions based on the RI effort.

Section 8.0 is a list of references used in preparing the RI Report.



SITE LOCATION



**FIGURE 1-1
REGIONAL MAP**

**PIONEER ACC
REMEDIAL INVESTIGATION/
FOCUSED FEASIBILITY STUDY**

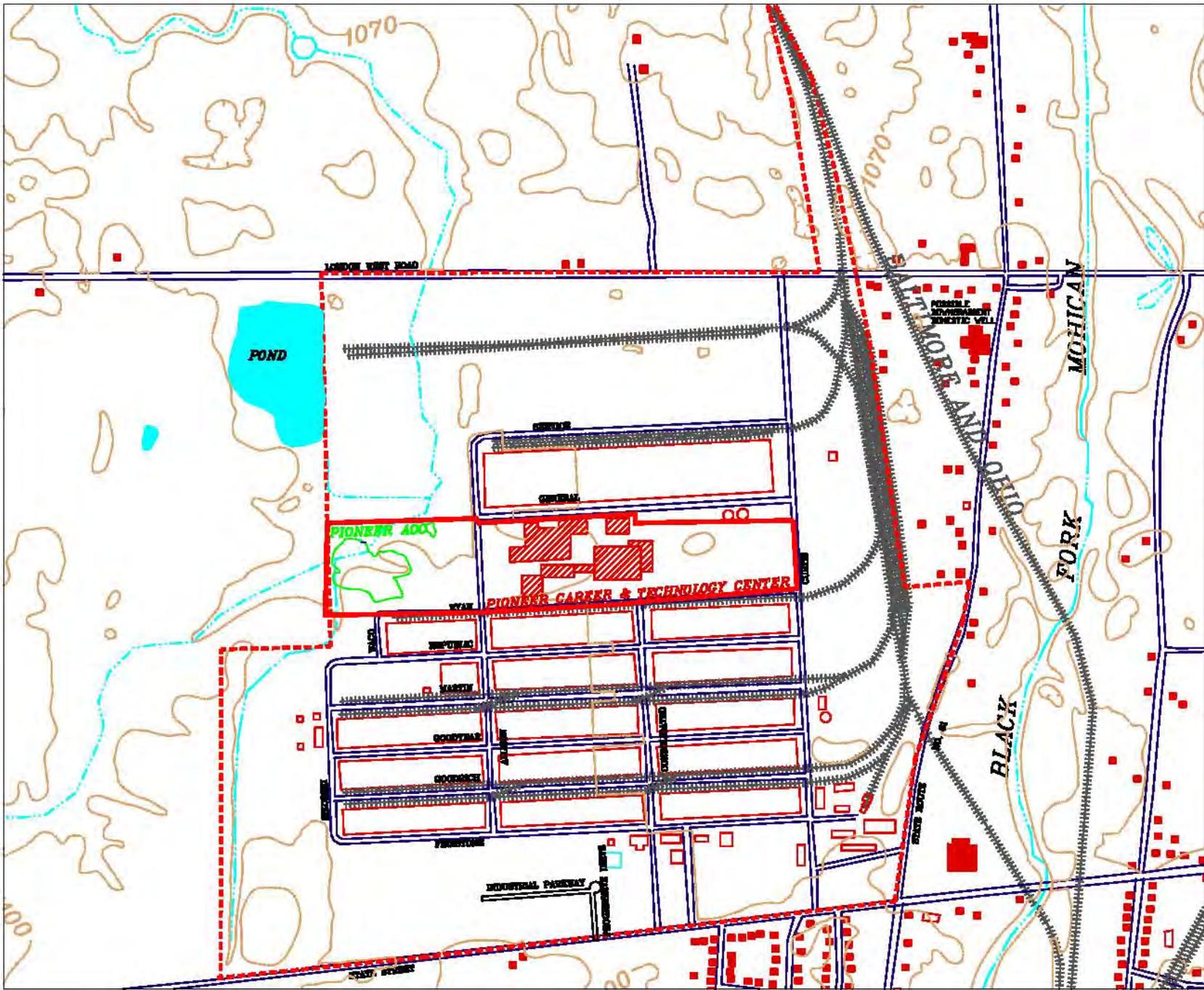
SHELBY OHIO CH2D

**U.S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY**



**PROJECT NO. FILE NO.
W82-07 P1002 0-1**

SOURCE: MICROSOFT STREETS & TRIPS 2002



SITE LOCATION

LEGEND

- FORMER WILKINS AFS APPROXIMATE PROPERTY BOUNDARY
- PIONEER CAREER & TECHNOLOGY CENTER PROPERTY BOUNDARY
- PIONEER AOC AREA OF INVESTIGATION CONTOURS
- STREAMS
- RAILROAD
- EXISTING BUILDINGS
- PIONEER CAREER & TECHNOLOGY CENTER BUILDINGS



**FIGURE 1-2
SITE LAYOUT
FORMER WILKINS
AIR FORCE STATION**

PIONEER AOC
REMEDIAL INVESTIGATION/
FOCUSED FEASIBILITY STUDY

SHELBY OHIO

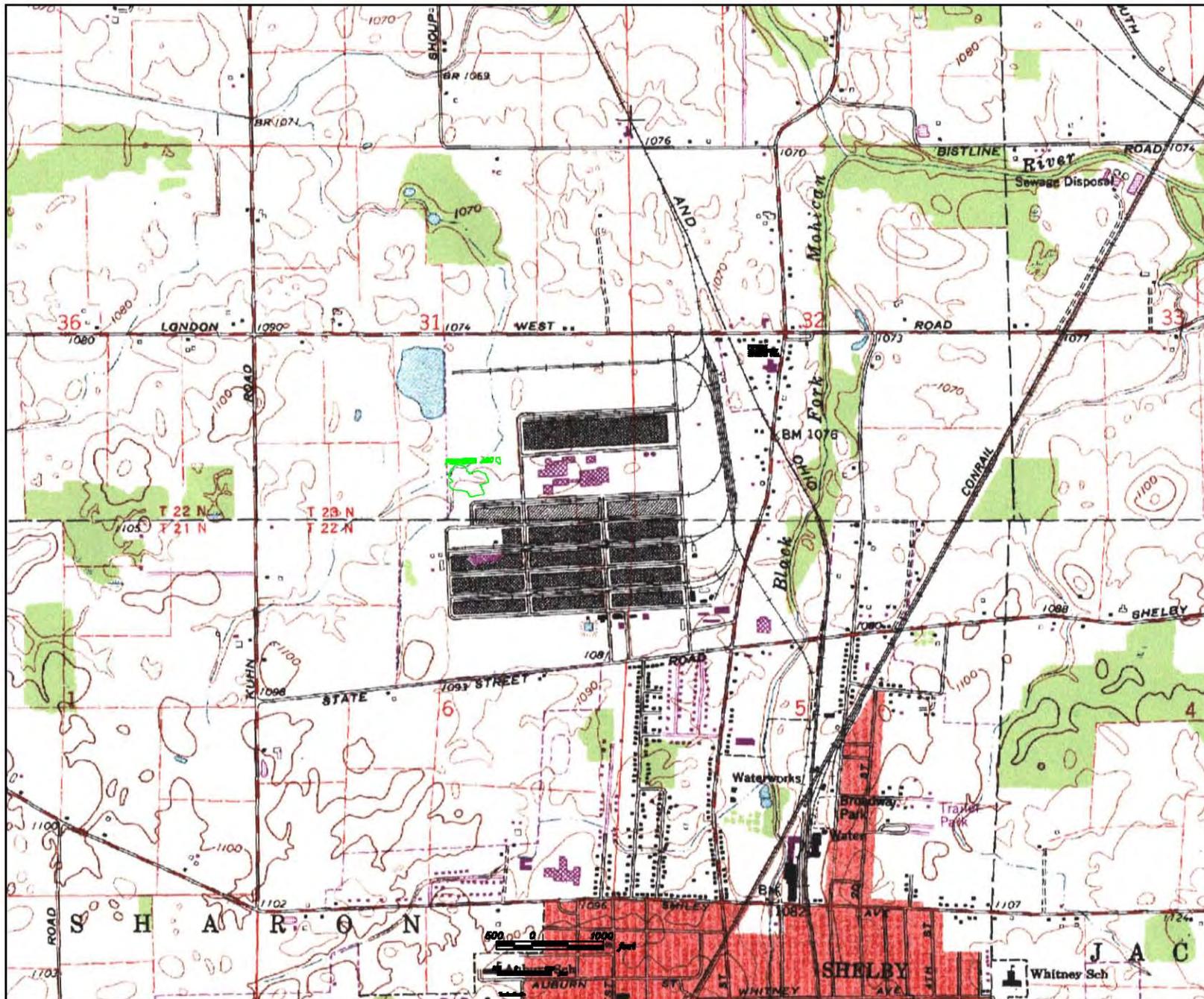
U.S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY



PROJECT NO. FILE NO.
9808-007 9808-007
FIGURE 1-1

SOURCE: 7.5 MINUTE QUADRANGLE SHELBY, OHIO, 1960 (PHOTO REVISED 1982)
BASIC LAYOUT, DRAINAGE SYSTEM, WILKINS AF SPECIALIZED DEPOT, FEBRUARY 13, 1963
BASIC LAYOUT PLAN, SHELBY AIR FORCE DEPOT, WILKINS AIR FORCE STATION
SEE TABLE 1-1: BUILDING USES, CONSTRUCTION DATA AND SIZE.





LEGEND

 PIONEER AOC



**FIGURE 1-3
AREA MAP
FORMER WILKINS
AIR FORCE STATION**

**PIONEER AOC
REMEDIAL INVESTIGATION/
FOCUSED FEASIBILITY STUDY**

SHELBY OHIO

 U.S. ARMY ENGINEER DISTRICT, LOUISVILLE
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LOUISVILLE, KENTUCKY



PROJECT NO. 8888-007 FILE NO. FIGURE 1-8

2.0 GENERAL INFORMATION

2.1 SURFACE FEATURES

The former Wilkins AFS site is relatively flat with ditches cut into the property to facilitate drainage. The highest point on the property is on the southeast corner at approximately 1090 feet above mean sea level (MSL). The property slopes gently to the northeast (Plexus, 2000) (Figure 1-3). The property is roughly square (Figure 1-2).

The Pioneer AOC is located at the western end of the PCTC property (Figure 1-2). The landfill mound is slightly elevated relative to the surrounding area and overgrown with vegetation; temporary fencing has been used to surround a portion of the landfill mound.

The area between the landfill mound and the PCTC buildings is flat and landscaped with mature trees and a well maintained lawn that was saturated at the surface during the field activities in April 2003. Vehicles were stuck in the saturated soil during the field activities and a PCTC lawn mower was observed stuck in the mud as well.

2.2 CONTAMINANT SOURCES

The suspected contaminant source at the site is the fill material in the landfill mound.

2.3 METEOROLOGY

Historical climate data (1971 to 2001) was reviewed for Mansfield, Ohio that is roughly ten miles southeast of Shelby. January is the coldest month with a mean temperature of 23.6° F (maximum 31.8° F and minimum 15.4° F) and July is the hottest month with a mean temperature of 70.6° F (maximum 81.7° F and minimum 59.5° F). The mean annual precipitation is 37.60 inches, the wettest months are May and June, with 4.16 and 4.27 inches respectively, and the driest is February, with 1.75 inches. The mean annual lake evaporation is 31 inches. Snow falls in the months of November thru March. The average annual snowfall is 18.7 inches most of which falls in December, January, and February (Midwest Regional Climate Center at <http://mcc.sws.uiuc.edu/>).

Wind direction data was not readily available for the site area, but the average wind speed for Mansfield, Ohio was found. Data collected and summarized by month over 18 years shows that the annual wind speed in Mansfield, Ohio is 10.3 miles/hour with higher winds in the winter months and lower during the late summer and fall (National Climate Data Center <http://lwf.ncdc.noaa.gov/oa/climate/online/ccd/avgwind.html>). Windrose diagrams were available for Cleveland, Ohio (90 miles to the northeast) and Columbus, Ohio (80 miles to the south). The windroses were specifically for “violation days” and “ozone season,” from 7 AM to 6 PM, meaning the windroses would reflect summer daytime wind conditions, in general. The windroses are presented in Appendix A and generally show the winds are typically from the southwest and west with some winds in Cleveland from the northeast. Top winds are up to 17 knots (Pacific Environmental Services (MACTEC), 2003 at <http://home.pes.com/windroses/default.htm>). Windroses for winter conditions were not readily available.

The following is a summary of Ohio’s climate taken from the Ohio Agronomy Guide (Ohio State University at <http://ohioline.osu.edu/b472/climate.html>): Ohio’s climate changes significantly throughout the State. Mean annual air temperatures range from 49 degrees F in the northeast to

57 degrees F in the extreme south. Ohio's climate is continental, with a wide range of air temperatures, higher precipitation in the spring and summer and lower in the fall and winter.

Because no mountain ranges exist between Ohio and the Polar Regions, no effective barrier prevents the southward spread of Arctic air from Northern Canada. Similarly, warm tropical air masses move freely northward in the summer. Storm systems form along the boundary between major cold and warm air masses, and storm paths frequently cross the Ohio Valley and the Lower Great Lakes.

Average length of the freeze-free period (number of growing season days) ranges from a high of 200 days along the Lake Erie shore to a low of 140 in east central Ohio. The earliest dates with a 50 percent or less chance of frost range from April 20 for areas immediately adjacent to Lake Erie to May 15 in east central Ohio. The earliest freezing temperatures generally occur around September 30 in east central Ohio and October 20 along the Lake and in southern Ohio.

Most soils in Ohio are saturated during March and early April. Soil moisture declines during June, July and August; by the end of August available soil moisture is usually reduced by 80 percent or more.

2.4 SURFACE WATER AND SEDIMENT

Surface water from the Pioneer AOC either infiltrates into the ground or is carried with surface drainage to the north and off site to Marsh Run. Only during substantial precipitation events does water move to the north and off site (Plexus, 2000; 2001).

Surface water runoff leaving the Pioneer AOC enters a drainage ditch and flows along the north side of the PCTC property to the east towards a small retention pond at the west end of the Shelby Horizons Building, that is to the north of the PCTC. This retention pond drains to a 16-inch drain tile that was in place when the pond was constructed. Shelby Horizons indicates that they do not know where the drain tile discharges. It is likely that the drain tile continues in a northerly direction and discharges to Marsh Run (Plexus 2000).

At the west end of the PCTC property is a prominent drainage that begins at what appears to be a pipe outfall near the southwest corner of the property and flows north to a drain tile near the west edge of the landfill mound. Immediately west of the Pioneer AOC is a manhole allowing access to the drain tile. Water was observed flowing through the pipe in a northeasterly direction. Several years ago PCTC personnel trenched through the debris on their property to facilitate the drainage of the property. It is unclear if water is entering or exiting the manhole/tile drain during heavy rains. However, it is apparent from the vegetation collected against the temporary fencing around the Pioneer AOC that there is a significant flow through the trench from the southwest to the northeast of the AOC. Surface water from this specific area flows north overland and is intercepted by the drainage ditch that carries it to the retention pond (Plexus 2000). North of the landfill mound is a second ditch that is overgrown and filled with stagnant water.

Following heavy rains in late August 2000, Plexus observed that the area surrounding the Pioneer AOC was flooded to a depth of between a few inches to approximately two feet of water (Plexus, 2001).

Surface water entering the Marsh Run flows generally easterly for 1.9 miles where it joins the Black Fork Mohican River that continues in an easterly direction for 11.3 miles and enters Charles Mill Lake (USGS, 1960).

2.5 GEOLOGY

The Wilkins AFS lies in the Central Lowlands physiographic province. Within this province, the site lies in the Till Plains section and within this section, in the Galion Glaciated Low Plateau region or district. The Galion Glaciated Low Plateau region is described as rolling upland transitional between the gently rolling Till Plain and the hilly Glaciated Allegheny Plateau mantled with thin to thick drift, elevation 800 to 1400 feet above MSL with moderate relief (Brockman, 1998).

A generalized soil map of the County shows the site soils are designated as Pewamo-Bennington and Fitchville-Luray-Bennington (Totten, 1973). Totten mapped the surface deposits at the site as being lacustrine, deposited in Lake Shelby. Lake Shelby refers to a lakebed in northwestern Richland County that was once the site of a proglacial lake. Lake Shelby was not a deep lake at any point during its history. The general absence of lacustrine deposits on the crests of the low end moraines within its confines suggest that these moraines were islands. Sediments within the remainder of the basin are considerably different from place to place, but consist chiefly of silts and clays. However, sand and even some pebbles may be included in places, and the sediments may be mistaken for till. The absence of beaches and other shoreline features indicate that the lake had a short life. Lake Shelby was an ice dammed lake that drained as soon as the ice dam melted (Totten, 1973).

Nearly everywhere, except for the lake margin, thicknesses of lacustrine silt and clay exceed five feet. The lake deposits become coarser northward to a point just south of the prominent moraine front, where gravel outwash lenses interfinger with silt. Several small deltas were built out into the lake south of the sharp morainic front which formed the north boundary of the lake. In many areas the lake deposits overlie a gravel layer that is underlain by a till. Several different till deposits were encountered under the lake sediments (Totten, 1973).

Moraines are mapped north of, south of and within the Lake Shelby deposits. The moraines in the area were deposited by the Buckskill lobe of the glacier that moved through the area during the Woodsfordian substage of the Wisconsinian glaciation (Totten, 1973).

Several well boring logs from the area indicate the surficial deposits consist mostly of clays with some sand and sandy clay deposits. Bedrock was reported to be greater than 50 feet below ground surface (ODNR 1963; 1964; 2000a,b,c). Soil borings completed during the SI encountered mostly silty clay with minor amounts of sand and gravel. In several borings thin sand lenses were present at 8 to 10 feet bgs (Plexus, 2001). The sediments encountered in the background well borings advanced south of the Pioneer AOC consisted of silts and clays with traces of sand and gravel near the surface and layers or lenses of sand, gravel and mixtures of clay, silt, sand and gravel between 10 and 20 feet bgs (Appendix B).

The bedrock surface in the area of the site is mapped at roughly 1000 feet above MSL (ODGS, 1984a). The drift thickness in the site area is between 50 and 100 feet. The site elevation in between 1075 and 1085 feet so based on the bedrock surface elevation the drift would be expected to be between 75 and 85 feet thick (ODGS, 1984b).

Bedrock in the area is Mississippian in age and is mapped as the Logan and Cuyahoga Formations undivided. The Logan Formation consists of brown to reddish brown, thin to thick-bedded sandstone, siltstone and minor shale ranging in thickness from 0 to 400 feet. The Cuyahoga Formation consists of gray to brown thin to thick-bedded shale with minor sandstone

and siltstone ranging in thickness from 50 to 650 feet (ODGS, 1995). Totten (1973) in a preliminary bedrock map showed the bedrock in the area of the site to be the Pleasant Valley Member of the Cuyahoga Formation. The Pleasant Valley Member is a thin-bedded gray siltstone and shale that is exposed beneath the Black Hand Sandstone along valleys in widely scattered localities. Even though the Pleasant Valley Member is the surface rock over most of the northern half of Richland County, exposures are rare due to the covering of drift.

During drilling groundwater was observed at about ten feet bgs coinciding with the sandy deposits. After well completion static water levels were higher in elevation and ranged from 2.09 to 3.35 feet bgs (Plexus, 2001). All wells were completed in sands and interbedded clays that represent the first water bearing zone beneath the site. The Pioneer AOC wells were sounded in September 2001 during a visit to the PCTC; the data are presented in Table 2-1. The data were plotted on a site map and a flow direction and gradient were calculated. The sediments beneath the site are glacial in origin, and water producing units may not be continuous across the site. The flow direction and gradient were estimated utilizing the limited available data. The groundwater at the site was calculated to flow to the north at a gradient of 0.02 feet/foot.

2.6 SOIL AND VADOSE ZONE

Native soils encountered beneath the site consist of silts and clays from the lacustrine deposits laid down in Lake Shelby (see Section 2.5). A shallow soil profile has developed. Non-native fill materials underlie large areas of the Pioneer AOC. The vadose zone at the site is shallow; groundwater was detected at less than two feet bgs in each of the three on-site wells. A passive soil gas study was completed as part of the SI and is discussed briefly above in Section 1.2.3. An active landfill gas survey was completed during the RI and is discussed later in this report. Extensive surface soil samples were also collected and analyzed as part of this investigation and are discussed below.

2.7 GROUNDWATER

Groundwater at the site is very shallow, ranging from less than a foot to approximately two feet bgs during the site visit in April 2003. Depth to groundwater was determined for the three on-site wells and the two background wells installed south of the site, which are discussed in more detail later. The groundwater flow direction on the Pioneer AOC site appeared to be to the north, based on the September 2001 groundwater elevation data for the three on-site wells. The gradient was calculated to be 0.02 feet/foot. The April 2003 data for the three on-site wells shows a northwesterly flow direction and a gradient similar to that calculated in 2001, 0.027 feet/foot. An attempt was made to determine a flow direction and gradient between the background wells and the on-site wells. When the background monitoring well's groundwater elevations were included, the potentiometric surface became more complex, with groundwater moving to the northeast and northwest. The gradient between the three wells on-site was much steeper than that between the site wells and the background wells. This may be a function of the proximity of the on-site wells and the relatively large differences in surface elevation over the short distance between the on-site wells versus the large distances and relatively small change in surface elevation between the background wells and the site wells. In addition, there are a variety of ditches, buildings, etc., that may affect the potentiometric surface between the background wells and the site.

Slug tests were performed on wells MW-06 and MW-08 during the April 2003 field event. The hydraulic conductivities for the aquifer at these two wells, determined using the slug-out test

calculated using the Bouwer-Rice solution for an unconfined aquifer, were 9.12×10^{-3} centimeters/second (cm/sec) and 6.00×10^{-3} cm/sec, respectively. These hydraulic conductivities are similar to those found in silty sands to clean sands (Freeze and Cherry, 1979).

2.8 DEMOGRAPHICS

There are numerous active businesses at the former Wilkins AFS, including the PCTC (a vocational school for adolescents and adults). PCTC is a school serving 823 high school students, approximately 200 adults, and has a staff of 150. There are approximately 100 full and part time employees on the Shelby Horizons property and approximately 900 on the COIP property (Plexus, 2000).

The nearest residences are located 400 feet north of the Pioneer AOC. The population within 0.25 mile is approximately 16, between 0.25 and 0.5 mile is 47, 0.5 and 1 mile is 239, between 1 and 2 miles is 2279, 2 and 3 miles is 2322, and between 3 and 4 miles is 2936 (Plexus, 2001).

The majority of the population within a 4-mile radius relies on municipal water provided by the Shelby Water Department. This includes businesses operating within the Former Wilkins AFS. The Water Department provides service to all areas within the City limits and also along Broadway north of the City to London West Road east to the sewage treatment plant. There are no other public water systems in the area. The system serves 4,300 connections (between 9,800 and 10,000 people). The system obtains its water from two surface water intakes and has two wells for backup. Surface water currently supplies 40 percent of their water needs. Surface water and groundwater mixing occurs within the system. The surface water is preferred, as it is not as hard. The wells are approximately 30 feet in diameter and are about 30 feet deep and are located behind the water plant at 110 North Gamble. The surface water intakes are located on Marsh Run (primary intake) just upstream from the confluence with the Black Fork of the Mohican River and at the dam at the south end of Park Avenue in Shelby. The Marsh Run intake is downstream of the probable entry point of the surface water runoff from the northern portion of the Pioneer AOC. The Shelby wells are located approximately 0.6 miles southeast of Wilkins AFS (refer to Figure 1-3)(Plexus, 2001).

Areas outside of the City limits obtain their drinking water from domestic wells. There are approximately 1,128 homes within four miles that lie outside of the City limits and are assumed to use private wells for drinking water. The nearest private well is approximately ½ mile northwest of the Pioneer AOC. The residences with wells are distributed as follows: 45 residences 0- 0.25 mile, 14 residences 0.25 to 0.5 mile, 53 residences 0.5 to 1 mile, 189 residences 1 to 2 miles, 305 residences 2 to 3 miles, and 522 residences 3 to 4 miles (Plexus 2001).

The only other surface water withdrawal identified was one from the Black Fork Mohican River for the Spring Hill Fruit Farm (N40° 54' 35" W82° 33' 45"). This intake is located approximately seven stream miles from the confluence with Marsh Run just north of the town of Ganges (Plexus, 2000).

Fishing was noted in the pond adjacent to the northwest corner of the former AFS property. Marsh Run and the Black Fork Mohican River are used for recreational fishing. USGS quadrangles do not show wetlands within 15 downstream miles of the site (Plexus 2000; 2001).

2.9 ECOLOGY

There are no known State or Federal threatened or endangered species within a 4-mile radius of the site. There are approximately 130 acres of scattered wetlands within a 4-mile radius of the site. The nearest, about seven acres in size, lies approximately 0.65 miles west of the Pioneer AOC. The distribution of wetlands is approximately as follows: 15 acres between 0.5 and 1 mile; 15 acres between 1 and 2 miles; 70 acres between 2 and 3 miles; and 30 acres between 3 and 4 miles (Plexus, 2000).

There are three State-protected and one State-endangered plants that potentially inhabit the Black Fork Mohican River approximately 15 stream miles from the Wilkins Site. The Marsh Fivefinger (*Potentilla palustris*), Large Cranberry (*Vaccinium macrocarpon*), and Swamp Cottonwood (*Populus heterophylla*) are identified as potentially threatened by the State and the Sharp-Glumed Manna-Grass (*Glyceria acutiflora*) is a State endangered species (Plexus, 2000).

Table 2-1
 Groundwater Monitoring Well Elevations and Groundwater Elevation
 Wilkins AFS, Pioneer AOC
 September-01

	Elevation Ground Surface (feet MSL)	Elevation Top of Casing (feet MSL)	Total Depth (feet)	Elevation Bottom of Well (feet MSL)	Screen Length (feet)	Blank Length (feet)	Date	Time	Depth to Groundwater (feet)	Groundwater Elevation (feet MSL)	Northing (feet)	Easting (feet)
MW-05	1076.32	1078.89	20.12	1058.77	10	10.12	9/24/2001	16:00	6.92	1071.97	450593.95	1920085.787
MW-06	1079.76	1082.26	21.70	1060.56	10	11.70	9/24/2001	16:20	8.62	1073.64	450515.49	1920247.727
MW-08	1082.69	1085.07	22.08	1062.99	10	12.08	9/24/2001	16:25	7.94	1077.13	450342.832	1920207.246

3.0 FIELD INVESTIGATION

The current investigation included the collection and analysis of surface soil samples at the Pioneer AOC, between the Pioneer AOC and the PCTC, and at background locations south of the Pioneer AOC on the former Wilkins AFS property. Sampling locations are presented on Figure 3-1. Background groundwater monitoring wells were installed at two locations south of the Pioneer AOC on property that was formerly part of the Wilkins AFS (Figure 3-2). The three on-site wells and the two background wells were developed (or redeveloped as appropriate), purged, and sampled. A landfill gas survey was conducted around the Pioneer AOC and between the Pioneer AOC and the PCTC on soil vapor collected from two to four feet bgs. Slug tests were completed on two of the on-site wells. All wells and sampling points were surveyed and a topographic map of the west end of the PCTC property was prepared.

3.1 FIELD ACTIVITIES

RI fieldwork at the site took place April 10-17, 2003. The current investigation activities include the installation of two background groundwater monitoring wells on April 10th. The wells were installed near the southwest corner of the former Wilkins AFS, roughly 2000 feet south of the Pioneer AOC. The three on-site wells were redeveloped on April 11th. The two background wells were developed on April 12th. Slug tests were completed on MW-08 and MW-06 on April 12th and 13th. The landfill gas survey was completed on April 14th. A surveyor licensed in Ohio surveyed the elevation and location of the existing wells, new wells and sample points on April 14th. In addition, the survey team completed a topographic survey of the west end of the PCTC property. Surface soil samples were collected on April 14th and 15th. The on-site wells were purged and sampled on April 16th and 17th. The background wells were purged and sampled on April 17th. All field activities were completed in accordance with the approved work plans.

3.1.1 Well Installation

The background groundwater monitoring wells were installed using an Acker truck-mounted drill rig. The soil borings were advanced using 8-inch diameter augers. The boring was continuously sampled using a 2.5-inch split spoon sampled to a total depth of 20 feet bgs. Each boring was logged in the field; the boring logs are presented in Appendix B. The boring logs for the wells and soil borings installed during the SI are also included in Appendix B. The wells were constructed inside the augers, as they were withdrawn for the boring. Each well was screened from 20 to 10 feet bgs. The screen was 2-inch diameter polyvinyl chloride (PVC) with 0.01-inch factory cut slots. The blank casing from ten feet bgs to the surface was also PVC. The filter pack in each well consisted of eight 40-lb bags of #4 sand. The filter pack filled the annulus to one foot above the top of the screen. The seal was hydrated bentonite chips, and the annulus around the casing was also filled with hydrated bentonite chips. The surface completions at both background wells were flush mount street boxes to facilitate grass mowing in the area. Well construction logs are presented on the boring logs in Appendix B. The monitoring well locations are presented on Figure 3-1 and 3-2.

A soil sample was collected between 10 and 12 feet bgs in the BG-1 boring and between 8 and 10 feet bgs in BG-2. The samples were collected in glass jars and submitted for grain size and Atterberg limit analysis. The laboratory report for these analyses is presented in Appendix C.

3.1.2 Well Development

The new background wells were developed and existing wells were redeveloped using Whale® submersible pumps. Per the approved Sampling and Analysis Plan (Plexus 2002), at least five volumes of water were removed from each well. The wells were surged in an effort to set the filter pack and suspend fines in the water column to be pumped out of the well. Most of the wells were pumped dry at least once during development and were allowed to recharge and pumped again until a total of five volumes of water was removed. During development the date, time, pH, conductivity, turbidity, temperature, oxidation-reduction potential (ORP), dissolved oxygen (DO), volume removed, and depth to water were recorded several times. Well development logs are presented in Appendix D.

3.1.3 Groundwater Sampling

Following development the wells were allowed to recover for two days prior to purging and sampling. The wells were purged of three well volumes using low flow purge techniques. A peristaltic pump operated with a car battery was used to remove a minimum of three well volumes from each of the wells. A length of Teflon® lined tubing was lowered into the well and water was drawn out. An inline water meter was used to record the pH, conductivity, turbidity, temperature, ORP, and DO during purging. Samples for dissolved metals analysis were field filtered using 0.45-micron filters. The filtered was attached to the end of the peristaltic pump tubing and the filtered water was collected in a laboratory supplied 1-liter bottle. Well purging and sampling logs are presented in Appendix E. Well MW05 was pumped dry during purging, and three well volumes were removed; but the well produced water so slowly that low flow techniques could not be followed. Well MW05 was also very slow to recover following pumping.

3.1.4 Slug Tests

Slug tests were performed on groundwater monitoring wells MW06, and MW08. The slug tests were performed in keeping with the American Society for Testing and Materials (ASTM) Standard Test Method D 4004 (re-approved 2002)(ASTM, 1996). The tests began by lowering a transducer into the well to a depth where it would not interfere with slug insertion and removal. A computer at the surface was used to activate the transducer and the slug was lowered into the well on a rope (“slug in”). The slug consisted of a length of 1-inch PVC pipe filled with sand and sealed at both ends. The transducer recorded the “instantaneous” change in water level caused by the slug going into the water and the gradual drop in water level as the groundwater returned to its original level. A water level meter was used to hand sound the well during the test as a backup to the transducer data. Hand soundings were recorded on a data sheet. When the water had returned to its pre-slug in level, the transducer was turned off and the “slug out” part of the test started. The computer was used to start a new test on the transducer. Then the slug was removed from the well. As in the slug in test the transducer recorded the initial drop in water level and gradual recovery. Hand soundings were once again used to backup the transducer data. When the water returned to the pre-test level the transducer was turned off and the test ended.

The AQTESOLV® for Windows® software package was used to reduce the slug test data and calculate the hydraulic conductivity of the aquifer material penetrated by the well. The Bouwer-Rice solution for a slug test in an unconfined aquifer was used (Bouwer and Rice, 1976). The

hydraulic conductivity for MW06 was 9.12×10^{-3} cm/sec and for MW08 was 6.00×10^{-3} cm/sec. The data packages, graphs, and results of the aquifer tests are presented in Appendix F.

3.1.5 Landfill Gas Survey

A landfill gas survey was completed around the Pioneer AOC and between the AOC and the PCTC buildings. A truck-mounted Geoprobe® rig was used to advance the direct push soil point to 4-feet bgs. The 2-inch soil point was pulled up two feet to expose the retractable screened interval within the pipe. A Teflon® lined tube was advanced to the bottom of the pipe. The gas in the tube was purged with a pump. The tube was attached to the inlet on the portable landfill gas meter, a GEM 2000 Gas Analyzer and Extraction Monitor with a Geotechnical Instruments H₂S pod. The meter was calibrated with methane and hydrogen sulfide standards the morning of the testing. The landfill gas meter was used to test the soil vapor for methane (CH₄), carbon dioxide (CO₂), hydrogen sulfide (H₂S), and oxygen (O₂). The gas meter pump drew soil gas through the meter and results were displayed. Results were recorded on field sheets. The landfill gas survey points were laid out in a grid of 20 points starting near the west end of the PCTC property and covering the area up to the PCTC buildings. No soil gas points were driven in the landfill mound, or through the asphalt covered parking areas. The soil gas sampling point locations are presented on Figure 3-1. The results of the landfill gas survey are presented on Table 3-1.

3.1.6 Surface & Subsurface Soil Sampling

A total of 22 surface soil samples (0 to 0.5 feet bgs) were collected at the Pioneer AOC and between the AOC and the PCTC buildings during the RI. Background surface soil samples (0 to 0.5 feet bgs) were collected from seven locations near the background monitoring wells, roughly 2000 feet south of the Pioneer AOC. The sample locations and designations are presented on Figure 3-1 and 3-2. The results of the analysis of the surface soil samples are discussed in Section 3.3. A summary table of data from the Field Data Sheets with sampling information and soil descriptions is presented in Appendix G.

Eleven subsurface soil samples were collected and analyzed as part of the SI to determine if contamination was present at depth. No additional subsurface soil samples were collected as part of the RI field effort. Section 4.4.2 includes a discussion of the soil sample results.

Surface soil samples were collected from 0 to 0.5 feet bgs, the OEPA considers surface soils to be from 0 to 1 foot bgs for the purposes of risk assessments.

3.2 GEOLOGICAL INVESTIGATION

The general geology of the site and some of the SI findings are discussed in Section 2.5. The boring logs for BG-1 and BG-2 (Appendix B) show several feet of clay, silty clay and clayey silt near the surface. The BG-1 boring penetrated layers of silty sand, silty clay, clay, sandy silt and sandy clay between 6 and 20 feet bgs. BG-2 was logged as silty clay to clayey silt from the surface to 20 feet bgs. Lenses of sand and gravel were detected between 10 and 14 feet bgs and fine sand lenses were detected between 18 and 20 feet. The shallow layers may represent the lacustrine deposits and the deeper layers may result from lacustrine or glacial till deposition.

The surface soils at the site were predominantly fine-grained, silts and clays with minor amounts of gravel and sand. Some of the material appeared to be fill or base that was set down for drainage and/or the construction of the parking areas.

During the field investigation, duplicates of six soil samples were collected and submitted to the laboratory for grain size and Atterberg Limit analysis. Results of the grain size and Atterberg Limit analyses are presented in Appendix C. The grain size analyses and field descriptions for the six samples are presented for comparison in Table 3-2. The field descriptions and the classifications applied based on the laboratory analyses generally correspond.

The Atterberg Limit analytical results showed that the clays in the soil samples have low to medium plasticity, or are “lean” clays (McCarthy, 1988).

3.3 GROUNDWATER INVESTIGATION

As discussed in Section 2.7 and Section 3.1, background wells were installed roughly 2000 feet south of Pioneer AOC during the field event. Three groundwater monitoring wells were installed at Pioneer AOC during the SI. Depth to groundwater readings were recorded for the three on-site wells on the morning of April 11, 2003 and the two background wells on the morning of April 12, 2003. Table 3-3 presents a summary of the survey data and depth to groundwater readings. A potentiometric surface map was prepared based on groundwater elevations at the site. The elevations of the background wells are presented, but not included in the potentiometric surface since all wells may not have been completed in a continuous water bearing unit (Figure 3-3). The groundwater flow direction at the site is generally to the northwest. When a potentiometric surface map was prepared using the groundwater elevations for all five wells the flow directions varied from northwest to north to northeast. The variability appears to be a function of the proximity of the on-site wells and the relatively large differences in surface elevation over the short distance between these wells. In addition, on-site groundwater monitoring well MW05 does not appear to respond quickly to changes in shallow groundwater elevation, i.e., the well recharges very slowly after pumping. Using the high and low water elevations reported the groundwater gradient at the site was estimated at 0.027 feet/foot.

Slug tests were completed in wells MW06 and MW08 during the field event. As discussed in Section 3.1, the hydraulic conductivity for MW06 was 9.12×10^{-3} cm/sec and for MW08 was 6.00×10^{-3} cm/sec. The data packages, graphs, and results of the aquifer tests are presented in Appendix C. These hydraulic conductivities are similar to those found in silty sands to clean sands (Freeze and Cherry, 1979). Based on field observations it is likely that the hydraulic conductivity of the material screened in MW05 is lower than the wells tested. Water may not move as easily through the material screened in MW05 as it does through MW06 or MW08.

Purge and development water for monitoring well locations with the potential for contamination were containerized and disposed of off site. These locations included monitoring wells MW-05, MW-06, and MW-08 present near the fill area. The locations for the two background wells BG-1 and BG-2 were specifically selected because there was no reason to suspect they were impacted with contaminants. Because no evidence of contamination was observed during IDW generation, the water and soil cuttings associated with the installation, development and purging of the background wells BG-1 and BG-2 was allowed to run off and/or placed on the ground surface near the well head.

3.4 SUMMARY OF FIELD ACTIVITY TECHNICAL MEMORANDA

There were no Technical Memoranda generated during the fieldwork.

Movement of vehicles during the field effort resulted in creation of tire ruts. Tire tracks created on COIP property were filled with topsoil and grass seed planted. At the PCTC, maintenance personnel were informed and the areas were rolled smooth using tractor mounted rollers.

3.5 ANALYTICAL INVESTIGATION

Surface soil samples were collected from a total of 29 locations during the RI, 22 at the Pioneer AOC, WI-SS-09 through WI-SS-30 and seven from background locations, WI-SS-31 to WI-SS-37. Appendix G presents a tabulated summary of the soil sampling field data sheets. Figures 3-1 and 3-2 illustrate the sample locations. All of the surface soil samples were analyzed for SVOCs and target analyte list (TAL) metals. Selected surface soil samples were analyzed for grain size and Atterberg Limits, see Section 3.1.1 for a discussion of these results. A background surface soil sample, WI-SS-31, was analyzed for dioxins. Results of the chemical analyses for soil samples are tabulated in Appendix H; only compounds detected are included on Tables H-1 and H-2. Where applicable the EPA Region 9 PRG for residential soil and industrial soil are included in the tables for reference.

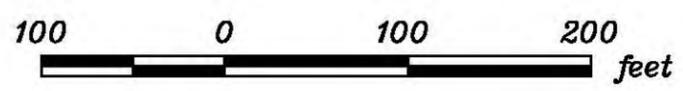
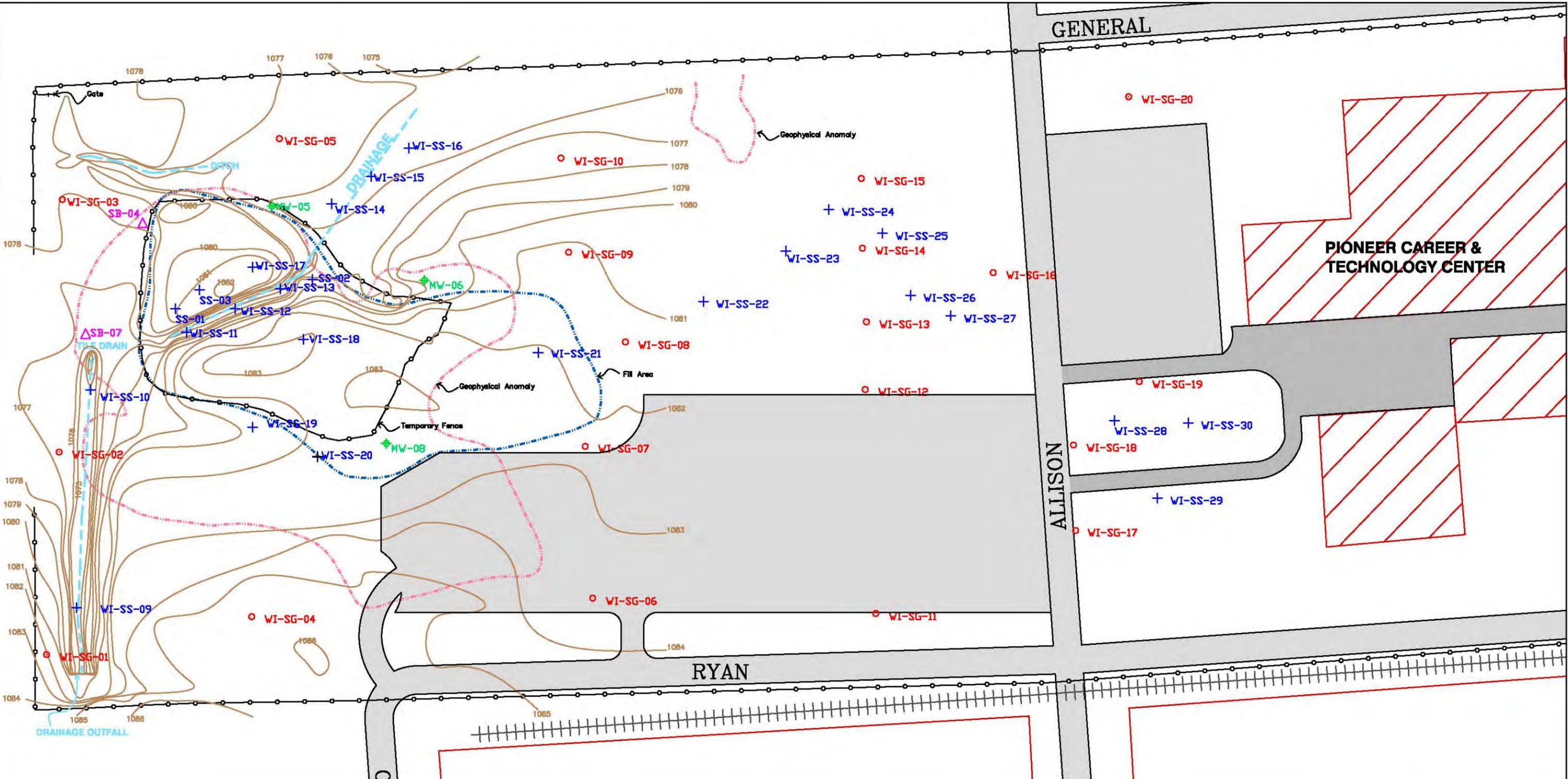
The active landfill gas survey at the site was completed using a calibrated field meter and the results are presented in Table 3-1. Sampling locations are illustrated on Figure 3-1.

Two soil samples were collected at depth from soil borings for the background wells and analyzed for grain size and Atterberg Limits, see Section 3.1.1 for the discussion of these results.

The three on-site groundwater monitoring wells installed during the SI were purged and sampled during the April 2003 field event. The newly installed background groundwater monitoring wells were also purged and sampled. The samples collected from on-site wells were analyzed for volatile organic compounds (VOCs), SVOCs, total TAL metals, dissolved TAL metals, and cyanide. The samples collected from the background wells were analyzed for the same compounds as the site samples; and pesticides, polychlorinated biphenyls (PCBs), and dioxin. The results of the groundwater analyses are presented in Appendix I, only compounds detected are included in Table I-1 and I-2. The locations of the wells are illustrated in Figures 3-1 and 3-2.

3.6 DATA VERIFICATION

Plexus was in contact with the laboratory prior to the field investigation and had frequent conference calls with the lab prior to, and during sample collection and analysis. No problems with the sample collection, shipment, or chain-of-custody were noted. Methylene chloride was detected in the trip blank and in the field blanks, but not in any of the groundwater samples. The laboratory data package for the chemical analyses was reviewed and the data verification reports are in Appendix J. All data anomalies are discussed and addressed in the verification reports. Verified analytical results are tabulated and presented in Appendix H and Appendix I.



- TOPOGRAPHIC CONTOURS
- DRAINAGE
- FENCELINES
- RAILROAD
- ROAD
- INTERPRETED DISPOSAL AREA
- LANDFILL MOUND
- SS-09 SOIL BORING SAMPLING LOCATION
- WI-SS-09 SURFACE SOIL SAMPLING LOCATION
- WI-SG-04 SOIL GAS SAMPLING LOCATION
- MW-08 GROUNDWATER MONITORING WELL LOCATION
- BUILDINGS
- ASPHALT
- CONCRETE WALKWAY



SOURCE: 7.5 MINUTE QUADRANGLE SHELBY, OHIO, 1960 (PHOPO REVISED 1962)
 BASIC LAYOUT, DRAINAGE SYSTEM, WILKINS AF SPECIALIZED DEPOT, FEBRUARY 13, 1962
 BASIC LAYOUT PLAN, SHELBY AIR FORCE DEPOT, WILKINS AIR FORCE STATION
 GEOPHYSICAL SURVEY CONDUCTED BY NAEVA GEOPHYSICS INC., CHARLOTTESVILLE, VA, AUGUST 2-3, 2000

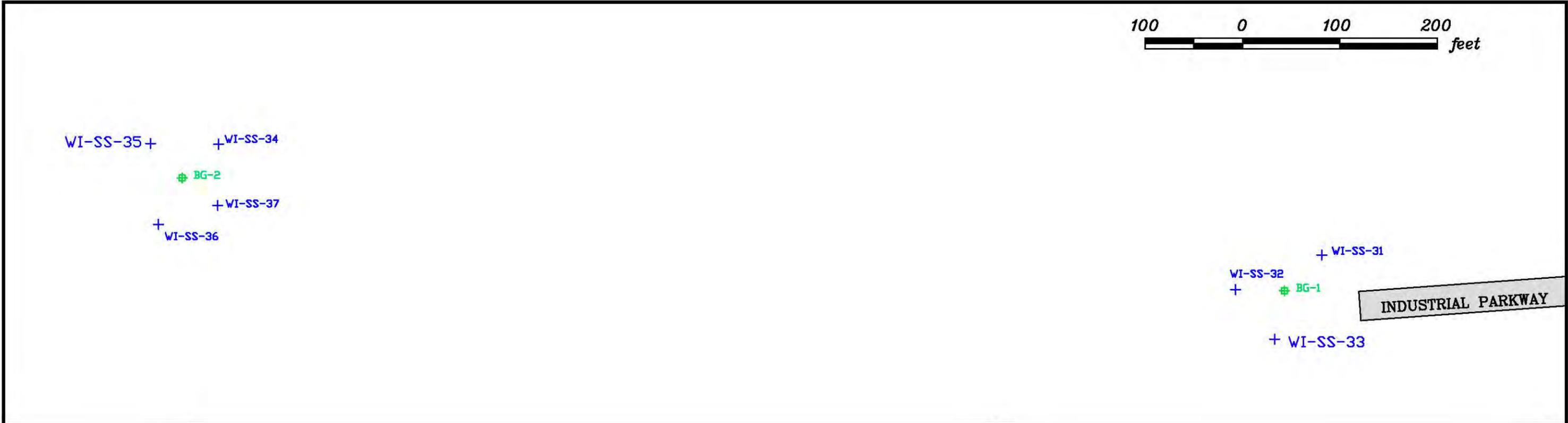
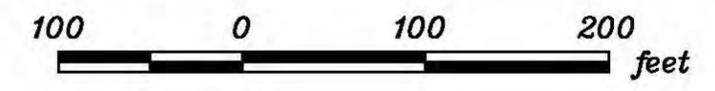
**FIGURE 3-1
 PIONEER AOC
 SAMPLING LOCATIONS &
 TOPOGRAPHIC MAP**

WILKINS AIR FORCE STATION
 PIONEER AOC
 REMEDIAL INVESTIGATION/
 FOCUSED FEASIBILITY STUDY

SHELBY OHIO

U.S. ARMY ENGINEER DISTRICT, LOUISVILLE
 CORPS OF ENGINEERS
 LOUISVILLE, KENTUCKY

PROJECT NO. DATE
 062E-07 JULY 2003



- | | | | |
|--|---|--|------------------|
| | FENCELINES | | BUILDINGS |
| | WILKINS BOUNDARY | | ASPHALT |
| | ROAD | | CONCRETE WALKWAY |
| | INTERPRETED DISPOSAL AREA | | |
| | LANDFILL MOUND | | |
| | SS-09 SOIL BORING SAMPLING LOCATION | | |
| | WI-SS-09 SURFACE SOIL SAMPLING LOCATION | | |
| | WI-SG-04 SOIL GAS SAMPLING LOCATION | | |
| | MW-08 GROUNDWATER MONITORING WELL LOCATION | | |
| | BG-02 BACKGROUND GROUNDWATER MONITORING WELL LOCATION | | |

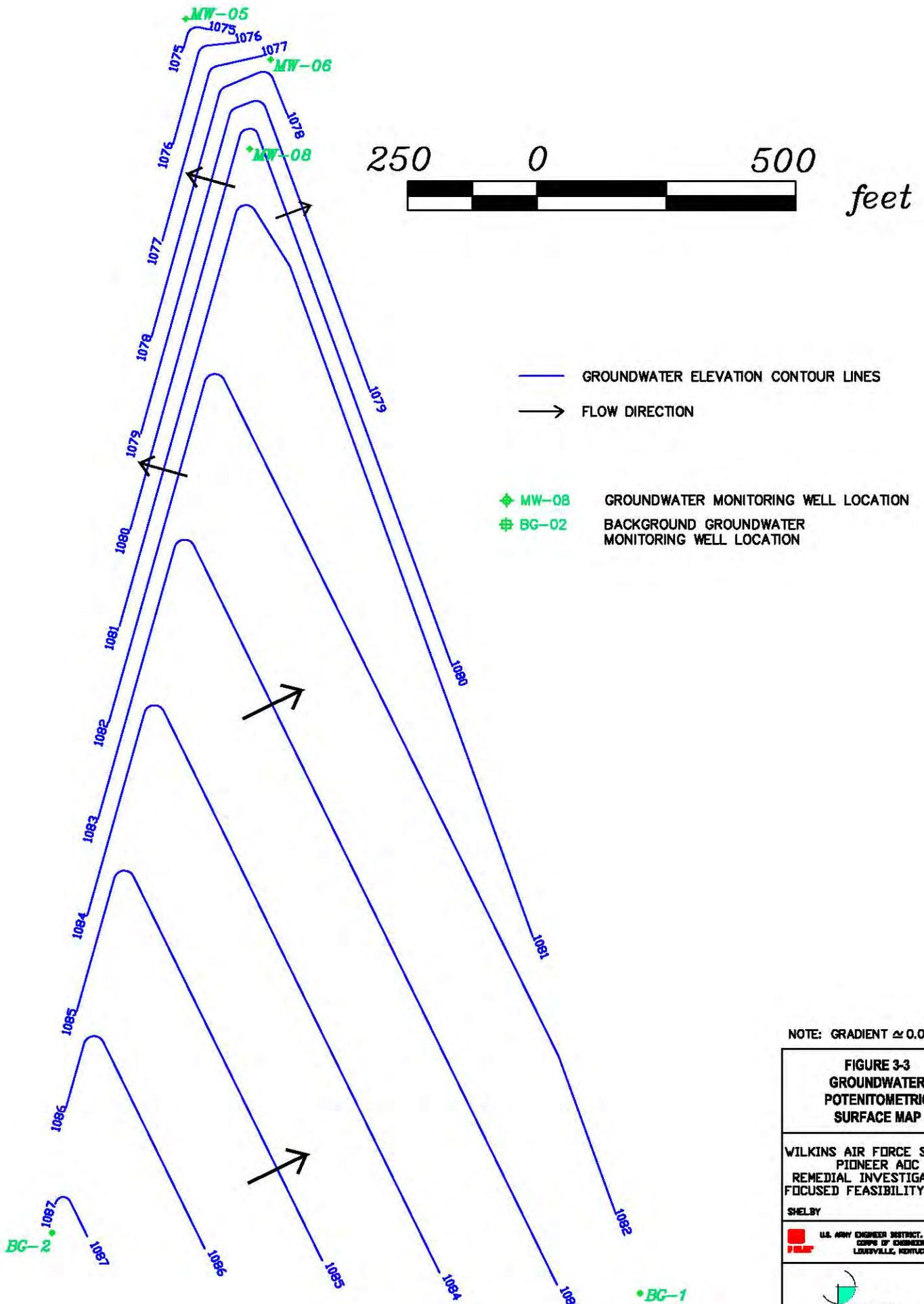
SOURCE: 7.5 MINUTE QUADRANGLE SHELBY, OHIO, 1990 (PHOTO REVISED 1982)
 BASIC LAYOUT, DRAINAGE SYSTEM, WILKINS AF SPECIALIZED DEPOT, FEBRUARY 13, 1952
 BASIC LAYOUT PLAN, SHELBY AIR FORCED DEPOT, WILKINS AIR FORCE STATION
 GEOPHYSICAL SURVEY CONDUCTED BY NAEVA GEOPHYSICS INC., CHARLOTTEVILLE, VA, AUGUST 2-3, 2000

**FIGURE 3-2
BACKGROUND SAMPLING
LOCATIONS**

WILKINS AIR FORCE STATION
 PIONEER ADC
 REMEDIAL INVESTIGATION/
 FOCUSED FEASIBILITY STUDY
 SHELBY OHIO

U.S. ARMY ENGINEER DISTRICT, LOUISVILLE
 CORPS OF ENGINEERS
 LOUISVILLE, KENTUCKY

PROJECT NO. DATE
 893E-007 JULY 2003



NOTE: GRADIENT ≈ 0.005 ft/ft

**FIGURE 3-3
GROUNDWATER
POTENTIOMETRIC
SURFACE MAP**

WILKINS AIR FORCE STATION
PIONEER ADC
REMEDIAL INVESTIGATION/
FOCUSED FEASIBILITY STUDY

SHELBY DHD

U.S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY



PROJECT NO. 0630-007 DATE JULY 2003

TABLE 3-1
Soil Gas Monitoring Log
Wilkins AFS, Pioneer AOC, Remedial Investigation

Site Name: Wilkins AFS - Pioneer AOC RI/FFS

Site Location: Shelby, Ohio - North of State Street - Former Wilkins AFS

Project Number: 8032-07A

Personnel: Claire Costello, Bill Millar

Equipment Used: Geoprobe Soil Gas Rig, Landtec a Division of CES Calibration: Calibrated the morning of the sampling.
GEM 2000 Gas Analyzer and Extraction Monitor Calibrated using methane and
with Geotechnical Instruments H₂S gas POD hydrogen sulfide standards.

Sampling Point ID	Date	Time	Depth (feet)	hydrogen sulfide (ppm)	methane (%)	CO ₂ (%)	O ₂ (%)	Comments
SG-01	4/14/2003	12:05	2-4'	0	0.1	0.0	21.6	
SG-02	4/14/2003	11:50	2-4'	0	0.1	0.0	21.6	
SG-03	4/14/2003	11:30	2-4'	1	0.0	0.1	21.1	
SG-04	4/14/2003	13:00	2-4'	0	0.1	0.0	21.8	
SG-05	4/14/2003	10:50	2-4'	1	0.1	0.0	21.6	
SG-06	4/14/2003	13:16	2-4'	1	0.1	0.0	21.9	
SG-07	4/14/2003	13:35	2-4'	0	0.2	0.0	20.9	
SG-08	4/14/2003	9:30	2-4'	0	0.0	0.0	21.8	
SG-09	4/14/2003	10:00	2-4'	1	0.0	0.0	21.6	
SG-10	4/14/2003	10:25	2-4'	0	0.0	0.0	21.6	
SG-11	4/14/2003	13:50	2-4'	0	0.0	0.0	21.9	
SG-12	4/14/2003	14:15	2-4'	0	0.0	0.0	21.8	
SG-13	4/14/2003	14:20	2-4'	0	0.0	0.0	22.0	
SG-14	4/14/2003	14:35	2-4'	0	0.0	0.0	22.1	
SG-15	4/14/2003	14:50	2-4'	0	0.0	0.0	22.0	
SG-16	4/14/2003	15:15	2-4'	0	0.0	0.0	21.6	
SG-17	4/14/2003	15:30	2-4'	0	0.0	0.0	22.1	
SG-18	4/14/2003	15:50	2-4'	0	0.0	0.0	21.7	
SG-19	4/14/2003	14:00	2-4'	0	0.0	0.0	21.7	
SG-20	4/14/2003	14:15	2-4'	0	0.0	0.0	21.5	

TABLE 3-2
 Field Description, Grain Size Analysis and
 Atterberg Limit Analysis and Comparison
 Soil Samples Collected at Wilkins AFS

Sample Number	Field Description	Gravel %	Sand %	Coarse Sand %	Medium Sand %	Fine Sand %	Silt %	Clay %	Liquid Limit	Plastic Limit	Plasticity Index
WI-SB-BG1 (10-12')	silty CLAY (CL), trace gravel, trace sand	2.7	10.6	0.7	2.1	7.7	39.4	47.3	32	20	13
WI-SB-BG2 (8-10')	clayey SILT (ML), some gravel, trace sand	6.0	28.2	4.9	8.5	14.8	28.3	37.5	22	15	7
WI-SS-21	silty CLAY (CL), some gravel, some sand	23.7	34.4	8.8	9.9	15.8	20.9	20.9	40	24	16
WI-SS-28	Silty CLAY (CL), trace gravel, trace sand	1.3	34.7	2.3	7.2	25.2	33.7	30.3	34	21	13
WI-SS-33	Silty CLAY (CL), some gravel (one small cobble), trace sand	2.3	14.3	0.0	4.1	10.2	34.7	48.8	41	22	19
WI-SS-34	Silty CLAY (CL)	2.9	18.3	3.0	4.5	10.9	30.7	48.1	42	22	20

Table 3-3
 Groundwater Monitoring Well Elevations and Groundwater Elevation
 Wilkins AFS, Pioneer AOC
 April-03

	Elevation Ground Surface (feet MSL)	Elevation Top of Casing (feet MSL)	Total Depth (feet)	Elevation Bottom of Well (feet MSL)	Screen Length (feet)	Blank Length (feet)	Date	Time	Depth to Groundwater (feet)	Groundwater Elevation (feet MSL)	Northing (feet)	Easting (feet)
MW-05	1076.32	1078.89	20.12	1058.77	10	10.12	4/17/2003	7:55	4.11	1074.78	450593.95	1920085.787
MW-06	1079.76	1082.26	21.70	1060.56	10	11.70	4/16/2003	11:55	4.28	1077.98	450515.49	1920247.727
MW-08	1082.69	1085.07	22.08	1062.99	10	12.08	4/16/2003	7:54	4.71	1080.36	450342.832	1920207.246
BG-1	1082.80	1082.42	19.71	1062.71	10	9.71	4/17/2003	12:28	0.62	1081.80	448130.399	1920959.872
BG-2	1089.86	1089.52	19.74	1069.78	10	9.74	4/17/2003	1:55	1.48	1088.04	448246.206	1919824.431

4.0 CONTAMINATION ASSESSMENT

4.1 LABORATORY ANALYSIS AND SAMPLE QUALITY ASSURANCE/QUALITY CONTROL

The quality of a data set is measured by certain characteristics of the data. Some of the parameters are expressed quantitatively, while others are expressed qualitatively. The objectives of the RI and the intended use of the data define the goals.

Precision characterizes the amount of variability and bias in the inherent data set. Precision describes the reproducibility of measurements of the same parameter for a sample under the same or similar conditions. Precision is a reflection of how close multiple measurements are to each other on the same sample. Precision is a measure of variability. Therefore, a precise set of measurements is compact and reflected by a small relative standard deviation (U.S. Army Corps of Engineers, Louisville District, *Louisville Chemistry Guidelines* [LCG] v. 5, 2002). The laboratory duplicates were analyzed and no precision problems were encountered.

Accuracy is a reflection of the correctness of the result i.e. how closely the measured results are to the true value in the sample. Since, the true value in the sample is unknown, a known concentration of surrogates (non-target analyte) are spiked into the sample matrix. The extracted surrogates are calculated as a percentage of the true value providing the accuracy of the measured value to the true value (LCG, 2002).

Accuracy is expressed as the percent recovery of surrogate and/or analyte spikes. Recoveries are calculated on net concentrations and are indicative of two factors: matrix effects and sample preparation techniques. Matrix effects or poor sample preparation results in lower recoveries, assuming analytical instruments are properly functioning, and samples are properly extracted/digested, and in case of soil matrix well homogenized (LCG, 2002).

Precision, which is expressed as the relative percent difference (RPD), is the measure of the variability of two or more measurements. Assuming instruments are properly functioning, and samples or soil matrices are homogenized, the RPD becomes a function of the preparation technique (LCG, 2002).

The data obtained during the RI are representative of actual conditions at the sampling location. The Work Plan (WP) was designed so that the samples collected were an accurate representation of actual site conditions. The rationales discussed in the WP and Quality Assurance Project Plan (QAPP) presented sample representativeness of the sampled environmental matrix. Sampling activities conformed to the protocols specified in the planning documents. The use of SW-846 analytical protocols and data deliverables prepared following SW-846 and the LCG ensured that analytical results and deliverables are representative and that they were both performed and reported consistently.

Comparability of data was achieved by utilizing standardized sampling and analysis methods and data reporting formats. Both analytical procedures and sample collection techniques maximized the comparability of the data. Using consistent units ensured that data are comparable. Laboratory data was expressed in Standard International Units, usually micrograms per liter (ug/L), milligrams per kilogram (mg/kg) or micrograms per kilogram (ug/kg).

Completeness is the number of samples analyzed compared to the number of samples that are submitted for analysis. Usability is the ratio of acceptable validated data compared to the total

data. The validator determines the completeness and usability of the data set and presents these ratios as percentages. The usability for the RI data was 100%.

The data was verified and data qualifiers assigned according to the LCG data validation protocols. The list of applicable data qualifiers is presented on the data tables in Appendices H and I. The data validation reports provide a discussion of problems encountered during laboratory analysis that resulted in the assignment of the qualifiers.

Field quality assurance/quality control samples consist of field duplicates, field blanks, trip blanks, and matrix spikes/matrix spike duplicates. The results of the analysis of the field blanks, and trip blanks are presented in Appendix I.

4.2 PRESENTATION OF ANALYTICAL RESULTS

The locations and rationales for sample collection are presented in Section 3.0 of this report. In addition, Appendix K presents a full list of the compounds that were analyzed and the methods used.

As for the soil sample results, only detected compounds are presented in Appendix H. For the groundwater sample results, only detected compounds are presented in Appendix I. The full analytical results including non-detects are presented in Appendix K.

Method Reporting Limits (MRL) for five metals detected in groundwater at the site were below the corresponding maximum contaminant level (MCL) for the metals in drinking water. The LCG sets the MRL greater than or equal to three times the method detection limit (MDL). The laboratory indicated in the QAPP that the MRL would be above the MCL per the LCG. Table 4-1 presents the reported MDL and MRL for the metals analyses compared to the MCL. The MDL for four of the five metals is below the MCL. These metals would be detected by the method at levels below the MCL, but the data would be flagged since it was below the MRL. In the case of Thallium the MCL is 2 ug/L and the MDL was 5.2 ug/L. Thallium was detected in a background well over the MCL and one site well over the MCL both results were flagged as being below the reporting limit.

4.3 PRELIMINARY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

All hazardous waste sites including Federal facilities must comply with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 and the Superfund Amendments and Reauthorization Act (SARA) of 1986, Section 120 and 121. These sections mandate that the cleanup of hazardous substances, pollutants, or investigation-derived waste comply with requirements or standards under state or Federal environmental laws that are applicable, relevant and appropriate requirements (ARARs) for the substances or circumstances at the site. More stringent state laws take precedence over less stringent Federal laws in cases where standards are promulgated by both.

Applicable requirements are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site" (53 FR 51394). Relevant and appropriate requirements are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or state law that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action,

location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site" (53 FR 51394).

The selection of ARARs for a particular site is dependent upon the hazardous substances present, the site characteristics and location, and the remedial actions selected. The requirements are referred to as chemical-, location-, or action-specific.

"Chemical-specific requirements set health or risk-based concentration limits or discharge limitations in various environmental media for specific hazardous substances, pollutants, or contaminants" (52 FR 32496). These requirements generally set protective cleanup levels for the contaminants of concern in the designated media, or allow the incorporation of safe discharge levels for the remedial action. Chemical-specific standards have been established under a number of statutes, including the Resource Conservation and Recovery Act (RCRA), the Safe Drinking Water Act (SDWA), the Clean Water Act (CWA), and the Clean Air Act (CAA). However, standards have been established for only a limited number of chemicals. In the absence of chemical-specific ARARs, it is often necessary to use nonpromulgated chemical-specific advisories or guidance documents to identify cleanup remedies that are protective of human health and the environment.

Location-specific requirements "set restrictions upon the concentrations of hazardous substances or the conduct of activities solely because they are in special locations" (53 FR 51394). These may include sites within a 100-year floodplain, sites within a wetland, sites on archaeologically significant locations, and others.

Action-specific ARARs are "technology- or activity-based requirements or limitations on actions taken with respect to hazardous wastes or requirements to conduct certain actions to address particular contaminants at a site" (53 FR 51394). Action-specific ARARs may specify performance standards or technologies, as well as specific environmental levels for discharged or residual chemicals, once a remedial action is selected. For example, conduct of a remedial action would invoke the Occupational Safety and Health Administration (OSHA) regulations for protection of site workers.

ARARs were used to identify potential remedial goals for the various media at the Pioneer AOC. ARARs are refined as the RI/FS process progresses and remedial actions are identified and evaluated. The USACE plans to formerly request from the State of Ohio a list of ARARs prior to the actual selection of remedial actions. The preliminary list of Federal ARARs is presented on Table 4-2. No State of Ohio ARARs have been developed. No chemical-specific ARARs for soil or groundwater at Pioneer AOC have been developed.

4.3.1 Health-Based ARARs

This section discusses the regulatory standards or guidelines related to specific chemicals. The chemical-specific ARARs will be presented for the compounds detected during the SI and RI in the sections in which the analytical results are presented. Various Federal regulations were reviewed to identify the chemical-specific ARARs for Pioneer AOC. Chemical specific ARARs for each medium are presented for those compounds, which were detected in that medium.

The only enforceable regulatory standards for exposure to groundwater contaminants are the Federal maximum contaminant levels (MCLs). However, MCLs have not been specified for many of the chemicals of concern. Therefore, relevant regulatory guidelines were used for

comparative purposes to infer health risks and environmental impacts. These regulatory guidelines include MCL Goals, EPA Drinking Water Health Advisories and EPA Region 9 PRGs. The environmental criteria are briefly described below.

4.3.2 Maximum Contaminant Levels

MCLs are enforced standards established by EPA's Office of Drinking Water promulgated under the SDWA and are designed for the protection of human health. The Federal MCLs appear in 40 CFR 141. MCLs are based on laboratory or epidemiological studies and are applicable to drinking water sources supplying a minimum of 25 persons. They are designed for prevention of human health effects associated with lifetime exposure (70 years) of an average adult (weighing 70 kg) consuming two liters of water per day, but they also reflect technical limits of removing the contaminant from water. These enforceable standards are also based upon the fraction of toxicant expected to be absorbed by the gastrointestinal tract.

4.3.3 Maximum Contaminant Level Goals

Maximum contaminant level goals (MCLGs) are nonenforceable guidelines based entirely on health effects. MCLGs are generally specified as zero for carcinogenic substances, based on the assumption of non-threshold toxicity, and do not consider the technical or economic feasibility of achieving these goals. Therefore, the MCLGs are often more stringent than the MCLs. When MCLs are not available, the MCLGs are useful for assessing water contamination. The MCLs have been set as close to the MCLGs as considered technologically and economically feasible.

4.3.4 EPA Region 9 Preliminary Remediation Goals

EPA Region 9 PRGs are risk-based concentrations that are intended to assist risk assessors and others in initial screening-level evaluations of environmental measurements. The PRG table contains over 600 PRGs for contaminants in soil, air, and tap water. They are viewed as preliminary clean up goals for an individual chemical, but in this context, they are best viewed as dynamic and subject to change because they are generic and based on direct contact exposures that may not address site-specific conditions and/or indirect exposure pathways. For planning purposes, these human health-based PRGs should always be considered in conjunction with ARAR-based PRGs (e.g., MCLs), ecological benchmarks, and "background" conditions before establishing a final cleanup level for a particular site.

4.3.5 Drinking Water Health Advisories

Drinking water health advisories (DWHAs) are guidelines developed by the EPA Office of Drinking Water for non-regulated contaminants in drinking water. These guidelines are designed to consider both acute and chronic toxic effects in children (with an assumed body weight of 10 kg) who consume one liter of water per day and in adults (assumed body weight of 70 kg) who consume two liters of water per day. Health Advisories are generally available for acute (1-day), subchronic (10-day), and chronic (longer term or lifetime) exposure scenarios. These guidelines are designed to consider only threshold effects and, as such, are not used to set acceptable levels for known or probable human carcinogens.

4.4 NATURE AND EXTENT OF CONTAMINATION

The validated analytical data generated during the SI and RI reveal the nature and extent of environmental contamination at the Pioneer AOC as discussed in this section. The complete validated analytical database developed during the course of the RI is included in Appendix K.

The locations of the samples are shown in Figures 3-1 and 3-2. This section is structured by the media sampled and discusses all substances detected. Section 4.2 presents the results pertaining to the soil media, Section 4.3 presents the groundwater results and Section 4.4 presents the soil gas results.

4.4.1 Field Screening Parameters

The partitioning of natural constituents and contaminants between solid, liquid, and gas phases and their transfer from one phase to another are dependent on the thermodynamics and kinetics of different types of chemical processes. Thermodynamic processes and reaction kinetics are strongly influenced by subsurface environmental conditions such as temperature, pH, ORP, and dissolved constituents. Appendices D and E present groundwater results.

4.4.2 Surface and Subsurface Soils

The soil analytical results for the SI are presented in Appendix L, Tables L-1, L-2, and L-3; and for the RI are presented in Appendix H. The distribution and occurrence of organic and inorganic compounds is presented and discussed in Section 6.1.3 Hazard Identification.

Eight surface soil samples and eleven subsurface soil samples were collected during the SI. The surface soil samples from the SI were analyzed for VOCs, SVOCs, PNAs, pesticides, polychlorinated biphenyls (PCBs), TAL metals and cyanide. One surface soil sample, SS01 and five subsurface soil samples, SB04A, SB05A, SB06A, SB07A, and SB08A were analyzed for dioxin.

VOCs, pesticides and PCBs were not detected at significant concentrations in the soil samples collected for the SI and were not analyzed in the samples collected during the RI.

Twenty-one surface samples were collected in and around the AOC on the PCTC property and seven surface soil samples were collected from background locations south of the AOC during the RI. Soil samples WI-SS-09 through WI-SS-30 were collected from the AOC and areas around the AOC. WI-SS-31 through WI-SS-37 are background samples. The samples were analyzed for SVOCs and TAL metals. One of the background samples, WI-SS-31 was analyzed for dioxin.

4.4.2.1 Semi-volatile Organic Compounds in Soil

Eighteen SVOCs were detected in one or more of the SI soil samples above the analytical detection limit. Twenty-three SVOCs were detected in one or more of the RI samples above the analytical detection limit. All the SVOCs detected in samples collected from the AOC soil mound during the SI and RI were also detected in samples collected in surface soils from areas around the site, between the AOC and the PCTC building, and in background samples.

The surface soil SVOC concentrations were generally higher in the fill area than outside the fill area. Total SVOC concentrations from surface soil samples in the fill area ranged from none detected (ND) to 39,170 ug/kg. The total SVOC concentrations for the subsurface soil samples in the fill area ranged from ND to 214 ug/kg. Low levels of SVOCs are present in surface soil throughout the area of the AOC ranging from ND to 926 ug/kg and in the background area ranging from 52 to 693 ug/kg. The available data show that the surface soils in the AOC are impacted with SVOCs at levels higher than the subsurface AOC soils, surface soils from the surrounding property, and the background surface soil levels.

Surface soil samples were collected in the area where surface water flowing through the ditch from the mound area would collect and flow as sheet flow to the north. Samples WI-SS-14, WI-SS-15, and WI-SS-16 (Figure 3-1 and Appendix H) were collected in this drainage area. SVOC concentrations in surface soils in the drainage area were similar to background surface soil concentrations.

The risk to human health from SVOCs in soil is discussed in the Human Health Risk Assessment (HHRA) Section 6.1 (see Tables 6-1 and 6-2).

4.4.2.2 Target Analyte List Metals in Soil

Twenty metals and cyanide were detected at concentrations above the detection limit in the surface and subsurface soil samples collected during the SI and RI. A tabulation of the sample results from the SI is presented in Appendix L. A table with RI results is presented in Appendix H. Tabulated statistics of the detections in soil samples from the AOC and surrounding area are presented in Table 6-1, and in background soil samples in Table 6-2. Sampling locations are illustrated in Figures 3-1 and 3-2.

The TAL metals analytical results from the SI and RI were reviewed and the highest concentration of each metal was compared to the sample location. The highest concentrations of lead, silver, chromium, copper, antimony, mercury, thallium, calcium and sodium were reported for samples collected from the fill area. These maximum concentrations in the fill area are mostly in one sample (WI-SS-11) collected from the bottom of the drainage swale. Many of the remaining metals maximum concentrations were detected in the sample collected within the drainage (WI-SS-09), near the pipe outfall at the southwest corner of the PCTC property, well removed from the fill area. Arsenic was detected in every soil sample collected including the background samples. The arsenic levels in the fill material were similar to the results from the surface soil samples outside the AOC and the background samples.

Metals results are discussed in the HHRA Section 6.1. Summary statistics for metals detections are presented on Tables 6-1 and 6-2.

4.4.2.3 Dioxin and Furans in Soil

As part of the SI, one surface soil sample and five subsurface soil samples were analyzed for dioxins. 2,3,7,8-TCDD, a dioxin, was only detected in sample WI-SB-06A at 5.5 nanograms per kilogram (ng/kg) above its residential soil PRG of 3.9 ng/kg. This sample was collected between 2- and 3-feet bgs in soil boring SB-06. Dioxin and/or related compounds were detected at low levels, below their PRGs in all six of the soil samples collected and analyzed during the SI.

In the RI, a background soil sample (WI-SS-31) was analyzed for dioxin and related compounds, which were detected at low levels in the background sample and in the duplicate sample collected.

Section 6.1 contains a discussion of the dioxin detection in soil at the Pioneer AOC, PCTC, and background samples.

4.4.3 Groundwater

Two rounds of groundwater samples were collected from the three on-site wells at the Pioneer AOC. The samples were analyzed for VOCs, SVOCs, PCBs, pesticides, and total and dissolved metals for both rounds of sampling. The SI samples were also analyzed for PNAs and dioxin. Two newly installed background wells were sampled once during the RI. The background

samples were analyzed for VOCs, SVOCs, PCBs, pesticides, total and dissolved metals, and dioxin.

Groundwater analytical results for the SI are presented in Appendix L, Tables L-4 and L-5, and for the RI are presented in Appendix I.

PCBs and pesticides were not detected in groundwater samples from either round of sampling at the AOC. PCBs and pesticides were not detected in the background samples. Inconsequential levels of SVOCs and VOCs were detected in the AOC wells both rounds, and in the background samples.

The total and dissolved metals concentrations in the groundwater samples from the AOC were similar between the two rounds. The highest metals concentrations were detected in the samples from MW05 in both rounds (note that this well had poor recharge). The exception to this is manganese, which was detected in elevated concentrations in samples from MW08 in both rounds.

Metals results for samples from MW05 are consistently higher for most metals than the other site wells; some metals were only detected in MW05. Well MW05 recharges much more slowly than the other site and background wells at Wilkins AFS. The sample that was collected from MW05 in April 2003 was turbid and the filtered sample was visually more turbid than the other filtered samples in the set. Based on the available information it appears that MW05 was screened in material that does not produce water easily. The metals results for MW05 were not observed in the other wells on-site and the metals detected are considered anomalous compared to on-site and background wells.

The arsenic detected in groundwater at the site is similar in concentration, and comparable to, arsenic detected in background wells. Arsenic was above its MCL of 10 ug/L in the total and dissolved samples collected from MW05 in both rounds. Thallium was detected above its MCL of 2 ug/L sporadically in the groundwater samples collected. Thallium was above its MCL in the sample from background well BG-1.

The manganese concentrations in MW08 were elevated in the 2001 and 2003 samples, total and dissolved. The source of the manganese is unknown and may be associated with the fill material local to the well. Manganese was not detected at these elevated concentrations in the samples from MW06, which is up- or cross-gradient from MW08. There is no MCL for manganese. There is a secondary drinking water standard for manganese of 50 ug/L. The manganese secondary drinking water standard is exceeded in MW08.

The laboratory reporting limits for thallium, arsenic, antimony, beryllium, and cadmium exceed or are equal to the MCLs for these metals. The laboratory provided the MDLs for these metals which are provided on Table I-1 in Appendix I. The MDLs for all of the metals with the exception of thallium are below the MCLs. The laboratory MDL for thallium is 5.2 ug/L and the recently set MCL is 2 ug/L.

4.4.4 Soil Gas

A soil gas survey was completed in the area of the large geophysical anomaly that includes the fill area and the smaller geophysical anomaly to the northeast of the fill area during the Pioneer AOC SI (Plexus, 2001). The results did not reveal any concerns at the site. See the SI report for the results of the soil gas survey.

During the RI field activity soil gas was tested for hydrogen sulfide, methane, and carbon dioxide. The testing was conducted to evaluate if the fill material at Pioneer AOC was generating gases that are usually related to the landfilling of putrescible waste. A grid was established around the fill area and between the fill area and the PCTC buildings. A Geoprobe® rig was used to advance a point to four feet bgs, the outer sleeve was retracted exposing a two foot screen and the soil gas was drawn through this screen through a piece of Teflon® lined tubing using an air pump. Following purging of the tube and sample point the soil gas was then drawn through the field meter and analyzed. No readings were recorded in the field to indicate the presence of concentrated landfill gases (see Table 3-1).

Table 4-1

Comparison of the Method Reporting Limits and Method Detection Limits
to Maximum Contaminant Levels for Metals in Groundwater
Pioneer AOC, Wilkins AFS, Shelby, Ohio

Metal	Method Reporting Limit ug/L	Method Detection Limit ug/L	Maximum Contaminant Level ug/L
antimony	10	3.4	6
arsenic	12	2.1	10
beryllium	5	0.6	4
cadmium	5	0.28	5
thallium	15	5.2	2

TABLE 4-2

Assessment of Federal ARARs and Other Guidelines
Pioneer AOC, Wilkins AFS, Shelby, Ohio

Regulation	Type of ARAR	Description	Site Applicability
Archeological Preservation			
Historic Sites Act of 1935 (P.L. 74-292; 49 Stat. 666; 16 U.S.C. 461-467)	Location	Requires the preservation of properties of "national historical or archeological significance."	Remedial Action
National Historic Preservation Act (16 USC 469 36 CFR 65)	Location	Requires that action be taken to preserve artifacts prior to alterations, which would threaten significant scientific, prehistoric, historic or archeological data.	Remedial Action
Archeological Resources Protection Act (P.L. 96-95; 93 Stat. 721; 16 USC 470a)	Location	Details procedures for permits and civil penalties for violations.	Remedial Action
National Environmental Policy Act	Location	Requires evaluation of the effects of major Federal actions on environmental (including cultural) resources.	Remedial Action
Hazardous Waste			
Resource Conservation and Recovery Act 40 CFR 262, 264-268, 270, 279	Action/Location	Outlines standards for the generation, transportation, and disposal of hazardous waste. Outlines groundwater protection, closure and post closure for the management of hazardous waste in surface impoundments, waste piles, land treatment, landfills, tanks, containers, miscellaneous units, and incinerators. Requires treatment of RCRA hazardous wastes prior to being placed in or on the land. Facilities must be designed operated and maintained to avoid washout by 100-year flood.	Remedial Action
Department of Transportation 40 CFR 171-177	Action	Regulates the transportation of hazardous materials.	Remedial Action
Department of Transportation, HM-164	Action	Outlines routing requirements for transport of hazardous materials through states	Remedial Action
Department of Transportation, Tariff # 6000	Action	Details regulations for transportation of hazardous materials and explosives	Remedial Action
Water Quality			
Clean Water Act, 40 CFR 110-113, 122-125, 129, 131-3	Action/Chemical	Outlines requirements and limitations for discharge of treated wastewaters, oil, and toxic effluents to US navigable waters (NPDES program) permit. Defines reportable quantities of hazardous substances.	Remedial Action

TABLE 4-2

Assessment of Federal ARARs and Other Guidelines
Pioneer AOC, Wilkins AFS, Shelby, Ohio

Regulation	Type of ARAR	Description	Site Applicability
National Primary Drinking Water Standards, 40 CFR 141	Action/Chemical	Establishes primary drinking water standards. Outlines maximum contaminant levels for organics, inorganics, turbidity, microbiological constituents, and radionuclides.	Drinking water wells, groundwater discharge to surface water sources.
National Secondary Drinking Water Standards 40 CFR 143	Action/Chemical	Promulgates standards to control contaminants that may affect aesthetic qualities of drinking water. Designed as guidelines for states.	Drinking water wells, groundwater discharge to surface water sources.
Effluent Guidelines 40 CFR 403, 414, 425	Action/Chemical	Defines pretreatment standards for effluent entering a publicly owned treatment plant.	Remedial actions may result in discharge of water to a treatment plant.
Miscellaneous			
Occupational Safety and Health Act, 29 CFR 1910	Action	Regulates worker safety. 29 CFR 1910.120 protects workers who have a potential exposure to hazardous substances at hazardous waste sites.	Remedial Action
Toxic Substances Control Act, 40 CFR 761	Chemical/Action	Regulates disposal of PCBs in concentrations greater than 50 ppm. May apply to other substances such as asbestos.	Remedial Action if PCBs are encountered at concentrations greater than 50 ppm.

5.0 CONTAMINANT FATE AND TRANSPORT

The nature and extent of contamination identified by the investigations conducted to date at the Pioneer AOC are discussed in Section 4.0. A conceptual site model was developed based on the data obtained during the sampling episodes of the SI and RI. The model presents a simplified depiction of conditions at the site with respect to the primary and secondary contaminant sources, migration pathways, and important chemical and physical processes (see Figure 6-1). This information is further developed in this section to enhance the understanding of the site with respect to how past operations may have impacted the surrounding environment and potential receptor, and realistically describe current and potential future migration and resulting levels of contamination. The results of the fate and transport analysis are used as the basis for quantifying current and future levels of contaminant exposure by human and ecological receptors as described in Section 6.0.

The process of evaluating fate and transport mechanisms requires assumptions based on professional judgment. This judgment is especially important when information such as the type and quantity of the contaminants is not known.

As discussed previously, the current conditions of the site are markedly different from the physical conditions that characterized the site when the fill was being deposited. The dumped material has been graded and a channel has been opened up through the fill. Native vegetation now covers most of the fill mound. A portion of the mound has been temporarily fenced. These changes have modified the migration pathways and rates.

Potential contamination migration routes are identified and discussed in Section 5.1. Section 5.2 presents a discussion of contaminant persistence. Section 5.3 describes the processes related to contaminant migration.

5.1 POTENTIAL MIGRATION ROUTES

In general, numerous potential migration routes exist in areas contaminated with hazardous materials. Such migration routes include, but are not limited to, groundwater, surface water, overland migration of dissolved or adsorbed contaminants, lateral migration of gases through the subsurface, and atmospheric migration via particulate or volatile emissions.

As a result of the nature and extent of contamination at the Pioneer AOC and various site-specific conditions, the potential migration routes of contaminants at the site fall into the following categories: vertical and horizontal migration through the unsaturated and saturated zones; surface transport of shallow soil contaminants via surface runoff; particulate re-suspension and atmospheric transport in a prevailing downwind direction. The low solubility of the contaminants at the site limits the potential for transport in groundwater.

At the Pioneer AOC, most of the surface area is covered with vegetation. During the RI, soil erosion due to surface runoff was observed to be minimal and only during heavy precipitation. Since a majority of the site area is covered by vegetation, soil erosion by surface runoff and wind is likely to be insignificant. Therefore, transport through surface runoff and wind is not considered to be significant under existing site conditions.

5.2 CONTAMINANT PERSISTENCE

Several transformation processes are believed to affect the persistence of organic chemicals in the environment. The primary processes affecting contaminant persistence in the environment include the following:

- Abiotic transformation and degradation processes such as hydrolysis, photolysis, and oxidation/reduction reactions; and
- Biological transformation and degradation processes.

Transformation and degradation processes are discussed below for classes of organic and inorganic compounds detected at the site.

5.2.1 Semi-Volatile Organic Compounds

SVOCs found in soil at the site include: acenophthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, benzaldehyde, 1,1'-biphenyl, bis(2-ethylhexyl)phthalate, butyl benzyl phthalate, carbazole, chrysene, dibenz(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, 2-methylnaphthalene, naphthalene, phenanthrene, phenol, and pyrene.

SVOCs detected in groundwater at the site were naphthalene, and phenanthrene. The higher molecular weight SVOCs are expected to be persistent in the soils at the site, based on their long half-lives. Most degradation of SVOCs in soil is attributed to biodegradation by the soil microbial community (Sims and Overcash, 1983). Factors shown to influence the rate of SVOC degradation in soil are temperature, soil organic matter, presence of a microbial community that is acclimated to SVOCs, and presence of easily degraded microbial food substrates.

The persistence of PAHs in the soil environment is roughly proportional to the number of fused benzene rings that comprise the compound. Anthracene, which has 3-ring SVOCs, degrades more rapidly in soil than benzo(a)pyrene and benzo(g,h,i)perylene, which are 5- and 6-ring SVOCs, respectively.

5.2.2 Inorganic Constituents

Both abiotic and biotic processes may affect the speciation of metals in soil or groundwater. Although speciation may affect metal mobility, it will not affect metal persistence. Metals will remain in the environment in one form or another.

Cyanide was detected in the soil at relatively low frequency as indicated in Appendix L. Cyanide was not detected in the groundwater. The environmental fate for cyanide is controlled mainly by biodegradation. However, volatilization is a primary pathway for hydrogen cyanide. Cyanides usually are not observed as widespread, high-level contaminants in the environment, since they are metabolized so readily; but some metalocyanide complexes may be more persistent in the environment (EPA, 1979).

5.3 CONTAMINANT MIGRATION PROCESSES

This section describes the processes that govern migration of contaminants through soil and groundwater. Fundamental processes that affect the migration of pollutants through soil and groundwater include adsorption, volatilization, dissolution and precipitation, advection and dispersion, and diffusion. These processes are discussed below for the conditions at the site.

5.3.1 Adsorption

The migration of pollutants through the subsurface is greatly affected by the extent to which they are adsorbed to soil. In the saturated zone, the potential for adsorption of chemical constituents on soil is typically expressed as K_d , the soil-water partition coefficient of the constituent. This term represents the ratio of the change in concentration of the contaminant on the soil to the change in concentration of the contaminant in groundwater. The partition coefficient is not constant for every soil type. In general, K_d increases as the fraction of organic carbon increases in the soil. In other words, the sorption of pollutants is primarily an equilibrium partitioning process into soil organic matter. K_d can be represented by:

$$K_d = (f_{oc})(K_{oc})$$

where f_{oc} is the fraction of organic carbon and K_{oc} is the partition coefficient for the organic compound into a hypothetical pure organic phase. The organic carbon partition coefficient (K_{oc}) is related to the water solubility and the K_{ow} (octanol/water partition coefficient). This parameter indicates the tendency of a chemical to bind to soil particles containing organic carbon. Chemicals with high K_{oc} , generally have low water solubilities, and vice versa. SVOCs are relatively immobile in the subsurface environment and are preferentially bound to the soil phase. These compounds are not subject to groundwater transport to the same extent as compounds with high water solubilities.

The distribution coefficient can, in turn, be used to estimate the potential for attenuation of a contaminant as a result of adsorption. The following dimensionless parameter is commonly applied in solute transport modeling (Javandel et al., 1984):

$$R = 1 + (\rho/n) K_d$$

where:

R	=	retardation factor
ρ	=	soil bulk density (kg/L)
n	=	effective porosity of the soil
K_d	=	distribution coefficient (L/kg)

The retardation factor can be interpreted as the velocity of a contaminant relative to the velocity of the groundwater. A retardation factor close to 1.0 indicates that the contaminant has little tendency to bind to soils, and thus moves freely in groundwater. By contrast, the larger the value of R, the greater the tendency for a contaminant to bind to the soil matrix, and consequently the slower it will move in groundwater.

5.3.2 Volatilization

Volatilization is the movement of a constituent from the liquid or solid phase to the gas phase. The potential for volatilization of a compound is typically expressed as either vapor pressure of the compound or as the Henry's law constant. Larger Henry's law constants indicate a greater tendency to escape the water phase and enter soil pore spaces or the atmosphere.

Volatilization is of primary significance in instances where environmental interfaces such as surface soil/air and surface water/air are important, rather than in evaluation of groundwater and subsurface soils. The vapor pressures for VOCs are generally many times higher than vapor pressures for SVOCs. Chemicals with higher vapor pressures are expected to enter the atmosphere much more readily than chemicals with lower vapor pressures. Since no surface soil

contamination by VOCs was detected, volatilization is not an important attenuation mechanism at the site.

Both vapor pressure and water solubility are of use in determining volatilization rates from surface water bodies. The Henry's law constant may also be used to calculate the equilibrium contaminant concentrations in the vapor versus liquid phases for dilute solutions commonly encountered in environmental settings.

5.3.3 Dissolution and Precipitation

The rate at which a chemical is leached from a waste deposit by infiltrating precipitation is proportional to its water solubility. More soluble chemicals are expected to enter water much more readily and rapidly than less soluble chemicals. VOCs are several orders of magnitude more soluble in water than SVOCs (including PNAs).

In general, "like dissolves like," meaning that a polar solvent such as water best dissolves polar solutes, like inorganic salts. The solubility in water of organic compounds, which are relatively nonpolar to varying degrees, is dependent on the polarity of the solute, sometimes expressed as the dielectric constant of the compound.

Dissolution and precipitation of inorganic species may be dependent on chelation, complexation, acid-base reactions, oxidation-reduction reactions, and other processes. One of the difficulties in working with inorganic contaminants is that all of these processes can be operating simultaneously. Therefore, it is sometimes difficult to determine which is the most important at a site. The relative importance of these processes not only varies from site to site, but may also vary from one area to another area within a given site. Oxidation-reduction (redox) reactions are important to subsurface contamination, because the chemical properties for the elements can change substantially with changes in oxidation state. Because redox reactions involve the transfer of electrons, the change in oxidation state of one element necessitates a change in the oxidation state of another. Redox reactions cannot occur unless there is both a suitable electron donor and a suitable electron receptor. The redox state is measured by an electrical potential in volts or millivolts at a standard electrode. This potential is called Eh of groundwater. Redox conditions in natural aquifers vary from highly oxidizing conditions (+ 800 to + 900 mv) to very reducing conditions (-200 mv). Appendices D and E present the oxidation reduction potential and pH values of the aquifer measured at monitoring wells. In general, these values appear neutral pH and redox conditions. Dissolution of inorganic compounds at the site appears to be influenced significantly by these two factors. If the concentrations of certain ions are sufficiently high, they may be removed from solution by the formation of solid phase precipitation. These precipitated minerals may dissolve later if physicochemical conditions within that portion of the aquifer change.

Elevated metals concentrations were detected in surface soil samples from two locations on the PCTC property. WI-SS-09 was collected from surface soils at the pipe outfall near the southwest corner of the PCTC property and WI-SS-11 collected from the bottom of the drainage ditch that crosses the fill area. Both of these samples were taken from locations where soils are saturated with water at least part of the time and where water can become stagnant at least some of the time. These soil conditions would tend to create reducing redox conditions; evaporating water will concentrate dissolved metals, and may have resulted in the precipitation of metals within the soils. This could be part of the reason for the elevated concentrations in these two samples.

5.3.4 Advection and Dispersion

Advection describes mass transport due simply to the flow of the water in which the mass is dissolved. The direction and rate of transport coincide with those of groundwater. But dissolved compounds are subject to sorption and attenuation by the solid surfaces that the water contacts, resulting in a solute velocity that is less than the water velocity. As discussed previously, the amount of retardation will be equal to the retardation factor, R .

Dispersion is a process of fluid mixing that causes a zone of mixing to develop between a fluid of one composition that is adjacent to, or being displaced by, a fluid of another composition (Domenico and Schwartz, 1990). Dispersion creates a zone of mixing between displacing fluid and the fluid being displaced. Also, dispersion spreads some of the mass beyond the region it would occupy due to advection alone. There is a spreading both in longitudinal and transverse directions. Dispersion in three dimensions involves spreading in two transverse directions as well as longitudinally. Transverse dispersion will reduce concentrations everywhere behind the advective front while longitudinal dispersion will only do so at the frontal portions of a plume.

5.3.5 Diffusion

Diffusion is the movement of a compound from a region of high concentration to a region of low concentration, through water or air. Diffusion in some limited way may move metals in groundwater from areas of high concentration to areas of lower concentrations.

6.0 BASELINE RISK ASSESSMENT

Under contract to Plexus, Avatar Environmental has conducted a HHRA and a screening level ecological risk assessment (SLERA) for the Pioneer AOC at the former Wilkins AFS. The Wilkins AFS site is a FUDS site that was operated by the military for storage and distribution. The purpose of this investigation is to evaluate the chemical contamination at the site and determine if it would result in unacceptable risks to human and ecological receptors. Section 6.1 presents the results of the HHRA and section 6.2 presents the results of the SLERA.

6.1 HUMAN HEALTH RISK ASSESSMENT

6.1.1 Introduction

The risks from chemical exposure associated with the current and reasonably anticipated future site uses are evaluated in the HHRA. The exposure scenarios at this site include a site worker, a site trespasser, a future construction worker, and future residents. The worker and trespasser are assumed to be exposed to surface soils at the site during work-related and recreational activities, respectively. Given the potential for future development of the site, a construction worker and future residents are evaluated. These receptors are assumed to be exposed to soil from all depths resulting from mixing that would occur during construction activities. While other exposure scenarios are possible, the scenarios evaluated represent reasonable maximum exposures (RMEs) at the site; other scenarios are likely to result in lower exposure potential.

The HHRA serves multiple roles in the decision making process, including:

- Provides the potential risks if no actions are taken (i.e., baseline conditions);
- Assists in determining the need for a remedial action at the site; and
- Establishes a basis for determining cleanup goals, if necessary.

Since there is no current use of groundwater and no reasonably anticipated future uses of groundwater at the site, consumption of groundwater is not considered a complete pathway and no evaluation of this data is presented in the HHRA. A more detailed discussion of complete exposure pathways is presented in Section 6.1.5.

6.1.2 HHRA Organization

This HHRA generally follows current USACE, EPA, and Ohio Environmental Protection Agency (OEPA) guidelines for risk assessment. There are five major components of the HHRA process:

- Hazard identification – Describes the previous and current investigations at the site, data usability, data validation, and the guidelines for data reduction for risk assessment purposes; outlines the data evaluation approach, and identifies the COPCs (Section 6.1.3);
- Toxicity assessment – Presents the approach to evaluating the potential cancer risks and noncancer health effects and presents the toxicity factors that were used for the COPCs identified in the hazard identification (Section 6.1.4);
- Exposure assessment – Describes the exposure setting and local land and water uses. Presents a conceptual site model that outlines sources of contamination, affected media, and exposure scenarios and their associated exposure pathways. Methods for estimating the contaminant exposure point concentrations (EPCs) are also presented (Section 6.1.5);

- Risk characterization – Integrates the toxicity assessment and the exposure assessment to characterize both potential cancer risk and noncancer health effects (Section 6.1.6); and
- Uncertainty analysis – Identifies the important uncertainties in the risk assessment process and describes the potential impact of alternative approaches on the overall estimate of risk (Section 6.1.7).

6.1.3 Hazard Identification

The objective of the hazard identification is to present the data available to assess site risks, outline the approach used to summarize data, and identify COPCs. The hazard identification process involves the following tasks:

- Evaluation of data usability and data validation;
- Establishment of guidelines for data reduction;
- Evaluation of data for use in the risk assessment; and
- Selection of COPCs.

The following subsections describe each of these tasks in greater detail.

6.1.3.1 Data Usability and Data Validation

Data quality can be evaluated in five general categories: data quality objectives (DQOs), documentation, analytical methods/detection limits (DLs), data quality indicators (DQIs), and data validation. The DQOs refer to whether the type and scope of the data collection and analyses are applicable for risk assessment purposes. Documentation ensures that the data collection, handling, transport, and analysis were sufficiently recorded and in compliance with the DQOs. The analytical methods/DLs are reviewed to confirm that the chemical analyses performed are appropriate for use in the risk assessment. Factors evaluated as part of the DQIs include completeness, comparability, precision, accuracy, representativeness, and sensitivity. Data validation includes reviewing and evaluating the chemical data and can be performed to meet varying levels.

All available data were reviewed for quality and usability prior to inclusion in the HHRA in accordance with applicable site sampling and quality assurance plans.

6.1.3.2 Guidelines for Data Reduction

The following guidelines for data reduction were used to produce the data summaries for the site and background surface soil evaluated in the HHRA. These approaches are consistent with *Risk Assessment Guidance for Superfund (RAGS), Volume 1, Human Health Evaluation (Part A)* (EPA, 1989).

- If a chemical was not positively identified in any sample, because it was reported as a non-detect or because it was rejected by the data validator (indicated by an “R” qualifier), it will not be addressed;
- All chemical data with “J” qualifiers will be assumed to be positive identifications. “J” indicates that the numerical value is an estimated concentration (e.g., is reported below the minimum confident sample quantitation limit);
- All “U” qualified data represent non-detected samples for the parameter evaluated. A value of one-half the sample quantitation limit (SQL) was used for all non-detected samples in the calculation of the 95 percent upper-confidence limit of the mean; and

- If a sample duplicate was collected and analyzed, the average of the two reported concentrations was used for subsequent calculations unless there was a greater than 50 percent difference in soil concentrations, in which case the higher of the two concentrations was used. In the case of a detected sample and a non-detected duplicate, the detected concentration was carried through subsequent calculations.

6.1.3.3 Data Evaluation

The objectives of the data evaluation are to summarize the data by medium and location and to evaluate the usability of the data for the risk assessment. The data summaries are presented in tabular format and include the following site-related data:

- List of chemicals detected at the site;
- Frequency of detection;
- Range of detected concentrations;
- Range of SQLs;
- Arithmetic mean concentration of the detected concentrations; and
- Arithmetic mean concentration of the detection limits.

Multiple methods were used to analyze samples for PAHs. The rationale is as follows: the risk screening criteria used in the study were the USEPA Region 9 PRGs. The standard analytical method for SVOCs, of which the PAHs are a subset, is USEPA Method SW8270C, which did not provide sufficient sensitivity for the sample results to be reliably compared to the PRGs. For that reason, Plexus initially specified the use of Method SW8310, which did provide the needed sensitivity. Subsequently, however, the selected laboratory made available to Plexus a modification of method SW8270C that employed Single Ion Monitoring or SIM. The SIM modification, which is now often used as the standard method for PAHs throughout the industry, provides sensitivity equivalent to the SW8310 method while retaining all of the other advantages of GS/MS technology over the high performance liquid chromatography (HPLC) method (i.e., SW8310). Those advantages include more reliable compound identification and a vastly superior ability to cope with matrix interferences.

However, in addition to the PAHs, the work plan called for the analysis of all of the other SVOCs as well. Thus, the SW8270C standard method was still necessary. As a matter of convenience for the laboratory, and because there was no cost involved, the laboratory reported all of the SVOCs, including the PAHs in the standard SW8270 results. The PAH results for the standard SW8270 analysis were not used for risk assessment purposes. Only the data from the more sensitive SW8310 and SW8270 SIM were used for that purpose. Plexus made use of standard SW8270 PAH results only as an additional quality control for the PAH data. A comparison of the PAH results by the standard SW8270 to the alternative, more sensitive methods displays very good correlation, once the difference in detection limit is taken into account. Only 1 of 74 instances where PAHs were positively identified by both approaches displays a RPD greater than 50% and the average difference is less than 1%. In all cases where there is a positive result reported by only one of the two approaches the more sensitive method displays the positive result.

In summary, multiple methods were used for PAH analysis. Those methods were consistent with the DQOs for the analytes in question. The appropriate (i.e., most sensitive) method was used

for risk assessment. And finally, the correlation between results by the various methods is quite good.

For the site-related data, summaries for two data groupings are presented, one for the surface soil and one for soil from all depths (i.e., aggregate soil). Table 6-1 presents the list of chemicals that were detected, along with the summary information, in the site surface soil collected from 0 to 0.5 feet bgs. A total of 57 chemicals were detected in the site surface soil. Twenty-four inorganics, including 23 metals and cyanide, and 33 organic compounds, including 17 PAHs, PCB 1260, dioxins/furans, and others, were detected. The surface soil data were grouped and summarized because it is assumed that certain potential receptors (e.g., site worker or trespasser) would contact the top layer of soil.

Table 6-2 presents the list of chemicals that were detected, along with the summary information, in the site soil collected from all depths (0 to 10 ft bgs). A total of 61 chemicals were detected in the aggregate soil. Twenty-four inorganics, including 23 metals and cyanide, and 37 organic compounds, including 17 PAHs, PCBs 1254 and 1260, dioxins/furans, and others, were detected. The soil data from all depths were grouped and summarized because it is assumed that potential future receptors (e.g., construction workers or residents) would contact soil from all depths as a result of mixing from construction activities at the site.

Table 6-3 presents the list of chemicals detected in the background soil samples. A total of 40 chemicals were detected in the background surface soil samples. The detected chemicals consisted of 19 metals and 21 organics, including 16 PAHs, dioxins/furans, and other SVOCs.

Tables 6-1 through 6-3 present the results for only those chemicals that were positively detected at the site or background locations. Tables K-1 and K-9 of Appendix K present the results of the data evaluation based on the entire list of analyzed contaminants.

6.1.3.4 Selection of Chemicals of Potential Concern

The COPC selection process was conducted to identify a subset of chemicals that were detected at the Pioneer AOC that could pose a potential risk to exposed human receptors. The criteria that were used to determine COPCs included:

- Nondetection;
- A comparison of site concentrations to health protective screening values; and
- A comparison of site concentrations with background levels.

In addition, any detected metals considered to be essential nutrients were eliminated from consideration as COPCs. The COPC selection process was performed for both data groupings (surface soil [0 – 0.5 ft bgs] and the aggregate soil [0 – 10 ft bgs]). The following sections describe the COPC selection process in greater detail.

6.1.3.4.1 *Non-detection*

If a chemical was not positively detected in any samples, it was not evaluated as a COPC.

6.1.3.4.2 *Comparison to Screening Criteria*

The COPC screening process included a comparison to the EPA Region 9 PRGs (EPA, 2004a). This step consisted of two, separate comparisons. First, the maximum detected concentrations in site surface soil were compared to the residential soil PRGs, which are calculated based on frequent exposure at a residential property through three pathways: incidental ingestion, dermal

absorption, and inhalation. This was done to determine the COPCs for the current use exposure scenarios at the site. Current exposure at the Pioneer AOC is assumed to occur to a site worker during typical maintenance and grounds-keeping activities and to a trespasser who may visit the site on an infrequent basis through these same exposure pathways. Therefore, the use of the residential soil PRGs for screening COPCs serves as conservative, health-protective screening criteria for the current receptors.

Second, the maximum detected concentrations from the aggregate soil were compared to the residential soil PRGs. This was done to select the COPCs for the potential future exposure scenarios at the site (i.e., construction workers and residents).

For COPC screening purposes, a target hazard quotient (THQ) for noncancer based PRGs of 0.1 was used, and a target risk (TR) for cancer based PRGs of one-in-a-million (e.g., 1E-06) was used. In cases where a chemical has both a cancer and noncancer PRG, the lower (i.e., more stringent) of the two values was used for screening.

If the maximum detected concentration for a chemical was less than its PRG, that chemical was eliminated from consideration as a COPC and was not evaluated further in the risk assessment. All of the chemicals that exceeded their respective PRGs were retained as COPCs and evaluated in the risk assessment. Tables 6-1 and 6-2 present the comparison of the maximum detected concentrations and the residential soil PRGs for the surface soil and aggregate soil data groupings, respectively.

6.1.3.4.3 Comparison to Background Concentrations

Certain metals that were detected at the Pioneer AOC may be naturally occurring. While a comparison to background concentrations is not a criterion for eliminating COPCs, it was conducted for informational purposes. The inorganic COPCs identified in Table 6-1 were compared to background levels. This comparison considered the data collected from the surface soil because the background dataset contains only results from the surface soil. The results of these comparisons were evaluated to determine if site concentrations exceed background levels. The Uncertainty Analysis (Section 6.1.7) includes a description of elevated background concentrations of inorganic COPCs and the contribution to site risks (EPA, 2002a). The organic COPCs that exceeded their PRGs were also compared to background concentrations for informational purposes only.

Numerical comparisons were performed, and included a comparison of the site and background maximum detected concentrations and arithmetic means. Table 6-4 presents this comparison. In every case, the maximum site metal concentrations exceeded the background levels. Except for mercury and thallium, the site maximums slightly exceeded background with ratios ranging from 1.2 to 6.5. When the means are compared, the site means for aluminum, arsenic, chromium, iron, and vanadium are less than or equal to the background mean. The site mean for manganese marginally exceeded the background level.

6.1.3.4.4 COPC Selection Results

Tables 6-1 and 6-2 summarize all of the chemicals that were detected in surface soil and aggregate soil at the Pioneer AOC, respectively. In addition, the EPA Region 9 residential soil PRGs are presented along with the ratio of the maximum detected concentration and the PRG. Based on these comparisons, the following organic compounds exceeded their PRGs and were

retained as COPCs in surface soil and aggregate soil, unless noted otherwise (compounds are shaded in the tables):

- Benzo(a)anthracene;
- Benzo(a)pyrene;
- Benzo(b)fluoranthene;
- Dibenz(a,h)anthracene;
- Indeno(1,2,3-cd)pyrene; and
- 2,3,7,8-TCDD toxic equivalence (TEQ).

A number of metals also exceeded their PRGs including:

- Aluminum,
- Antimony (aggregate soil only),
- Cadmium (aggregate soil only),
- Arsenic,
- Chromium, total;
- Iron;
- Lead (aggregate soil only),
- Manganese;
- Mercury;
- Thallium; and
- Vanadium.

Four metals (calcium, magnesium, potassium, and sodium) that were detected at the site were also eliminated from consideration as COPCs since they are considered essential nutrients.

6.1.4 Toxicity Assessment

The primary purpose of the toxicity assessment is to identify the toxicity values for the COPCs used in the estimation of potential cancer risks and noncancer health effects. It also provides a description of the terms that are used to estimate toxic effects (i.e., cancer and noncancer effects) along with the data sources. Summary tables are included that present the toxicity values for each of the COPCs.

6.1.4.1 Cancer effects

For cancer effects, the toxicity values are expressed as cancer slope factors (CSFs) in units of milligrams COPC per kilogram body weight per day (mg/kg-day)⁻¹. EPA has developed two types of CSFs: oral CSFs (CSF_o) and inhalation CSFs (CSF_i), each of which relates to the route in which a receptor is exposed. The cancer potency of a chemical is directly proportional to the CSF value; the higher the CSF, the more potent the chemical as a carcinogen.

EPA has also assigned each chemical a “weight-of-evidence”, which represents the likelihood of it being a human carcinogen (EPA, 1989). Six weight-of-evidence categories exist:

- A – Human carcinogen;
- B1 – Probable human carcinogen, limited human data are available;
- B2 – Probable human carcinogen, sufficient evidence in animals and inadequate or no evidence in humans;
- C – Possible human carcinogen;

- D – Not classifiable as to human carcinogenicity; and
- E – Evidence of noncarcinogenicity for humans.

Chemicals that are classified in categories A through C are generally carried through the risk characterization step if CSFs have been developed.

6.1.4.2 Noncancer Effects

Noncarcinogens refer to chemicals that cause toxic effects other than cancer. Noncancer effects can include, for example, central nervous system damage, reproductive effects, and other systemic effects. For noncancer effects, the toxicity values are expressed as reference doses (RfDs) in units of mg/kg-day. The premise of a reference dose is that there is an exposure level below which deleterious noncancer effects are not expected to occur. Similar to CSFs, EPA has developed two route-dependent RfDs: oral RfDs (RfD_o) and inhalation RfDs (RfD_i). An RfD value is inversely proportional to the toxic potency of a chemical.

6.1.4.3 Sources of Toxicity Values

When available, cancer slope factors and reference doses were obtained from the following sources in the order presented (EPA, 2003a):

- Tier 1 – Integrated Risk Information System (IRIS) (EPA, 2005);
- Tier 2 – Provisional Peer Review Toxicity Values (PPRTVs); and
- Tier 3 – Other Toxicity Values (can include values from the Health Effects Assessment Summary Tables [EPA, 1997a] and the National Center for Environmental Assessment [NCEA] as presented on the EPA Region 9 PRG Table).

6.1.4.4 Route-to-Route Extrapolation

In some cases, a COPC has an oral toxicity value (i.e., CSF_o or RfD_o) but does not have an inhalation value (i.e., CSF_i and RfD_i). In these cases, the available oral toxicity value was used as a provisional value to estimate the inhalation exposure route. The use of the toxicity value developed for one exposure to evaluate toxicity from another is known as route-to-route extrapolation. No adjustments were made to the toxicity values when using route-to-route extrapolation (i.e., the same value was used for both routes). This adds uncertainty to the derived provisional values by not accounting for route-specific differences in chemical absorption, metabolism, and potential target tissues.

The EPA carcinogenic classifications for cadmium and chromium (Cr VI) apply only to the inhalation route of exposure. EPA does not consider these metals to be known or potential human carcinogens via the oral or dermal routes. The evidence of carcinogenicity for these metals is primarily for localized respiratory tract tumors in inhalation studies. Therefore, the cancer risk associated with these metals was calculated for the inhalation route only.

6.1.4.5 Dermal Exposure

Toxicity values have not been developed for the dermal absorption pathway. Dermal toxicity values were derived from the oral toxicity values as described in EPA dermal risk assessment guidance (EPA, 2004b). In general, the oral CSFs and oral RfDs are expressed as administered doses (i.e., the amount of a chemical administered per unit time and weight). Conversely, exposures resulting from the dermal pathway are expressed as absorbed doses. Therefore, it is

necessary to make an adjustment to the oral toxicity value to account for the chemical-specific absorption efficiency.

The fraction of a COPC that is absorbed in the gastrointestinal tract, also known as ABS_{GI} , is a critical factor when adjusting from an administered to an absorbed dose. The ABS_{GI} values used in this risk assessment were obtained from EPA (2001a) and are presented on Table 6-4. The oral CSFs and oral RfDs are each adjusted using different methods to an absorbed dose. The dermal CSF (CSF_d) is derived by dividing the oral CSF by the ABS_{GI} as shown below.

$$CSF_d = \frac{CSF_o}{ABS_{GI}}$$

Where:

- CSF_d = Dermal cancer slope factor (mg/kg-day)⁻¹
- CSF_o = Oral cancer slope factor (mg/kg-day)⁻¹
- ABS_{GI} = Fraction of contaminant absorbed in the gastrointestinal tract (unitless).

The dermal reference dose (RfD_d) is derived by multiplying the oral RfD by the ABS_{GI} as shown below:

$$RfD_d = RfD_o \times ABS_{GI}$$

Where:

- RfD_d = Dermal reference dose (mg/kg-day).
- RfD_o = Oral reference dose (mg/kg-day).
- ABS_{GI} = Fraction of contaminant absorbed in the gastrointestinal tract (unitless).

6.1.4.6 Toxicity Values Used in the Risk Assessment

Table 6-6 presents the CSFs and RfDs (oral, dermal, and inhalation), if available, as well as the source, the EPA weight-of-evidence category for each COPC, the route of administration, and the critical effect.

6.1.4.7 Dioxins and Furans

Dioxins and furans are made up of complex mixtures of 210 individual congeners. The most frequently studied of the congeners is 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD), a known human carcinogen. Seventeen congeners exhibit human toxicity that is similar to 2,3,7,8-TCDD. Cancer risk associated with dioxins and furans were calculated using a toxic equivalence (TEQ) approach. Each congener was assigned a toxic equivalency factor (TEF) to represent the congener-specific toxicity relative to 2,3,7,8-TCDD. Table 6-6 summarizes these TEFs.

TEQs were calculated for each sample and included the detected concentrations and the non-detected congeners at one-half of the sample quantitation limit. A sample was considered detected if at least one of the seventeen congeners was positively detected. The concentration of each congener was multiplied by its TEF and the results were summed for all of the congeners, which yielded the total 2,3,7,8-TCDD TEQ for that sample. The calculated TEQs were summarized and screened in the COPC selection process. The exposure doses and cancer risks were calculated based on the TEQ concentrations.

6.1.4.8 Lead

EPA has not assigned verified or provisional toxicity values (i.e., CSFs and RfDs) to lead because the toxicity data available to date are inadequate for evaluation by their current methodology. Therefore, lead risk was not evaluated using the conventional risk assessment approach.

EPA has developed the *Integrated Exposure Uptake Biokinetic* (IEUBK) model (EPA, 2004c) to indirectly characterize lead risk based on environmental exposure to lead-contaminated media. This model is premised on the protection of young children or the fetus from chronic lead toxicity. The IEUBK model is used to predict blood lead levels in children based on studies of real time human exposures and measurements of blood lead levels correlated with behavioral toxicity information in children. Concentrations of lead in the blood reflect exposure to environmental lead through a number of contact routes, including soil ingestion, dust inhalation, dermal contact with soil, and lead received from maternal blood during gestation. The IEUBK model predicts child blood lead levels from media concentrations and exposure parameters supplied by the user in combination with the pharmacokinetic constants modeled from scientific data and the empirical human data. The default concentrations and exposure input values recommended for the IEUBK model are based on experimental data (EPA, 1994).

The EPA has established a threshold blood lead level of 10 µg/dL. This level is based on the most significant concern with environmental lead exposure, the potential for causing behavioral neurotoxicity in young children as a result of chronic, low-level lead exposure through various contact mechanisms. The IEUBK model predicts the blood lead levels in children based on site-specific inputs. However, direct exposure of young children to environmental lead is not the only potential mechanism of lead-induced behavioral neurotoxicity. The IEUBK model is predicated on the assumption of a 95% probability that the blood lead level in child or the fetus should not exceed 10 µg/dL in order to be protective against neurotoxic potential.

6.1.5 Exposure Assessment

The objective of the exposure assessment is to estimate the nature, extent, and magnitude of potential exposure of human receptors to COPCs. The exposure assessment involves several steps:

- Evaluating the exposure setting, including describing local land and water uses and identifying potentially exposed human populations.
- Developing the conceptual site model, including sources, transport and release mechanisms, exposure media, exposure routes, and potentially exposed populations.
- Calculating exposure point concentrations (EPCs) for each COPC for each of the exposure scenarios and routes.
- Identifying the exposure models and parameters with which to calculate the exposure doses.
- Calculating exposure doses.

6.1.5.1 Exposure Setting

6.1.5.1.1 Local Land Uses

The Pioneer AOC is located on the property of the PCTC, a vocational school for adolescents and adults. The PCTC serves over 1,000 students (high school students and adults) and employs

a staff of approximately 150. The vocational school is located on the eastern portion of the property and consists of buildings and parking lots. The Pioneer AOC is located on the western portion of the property and has dense vegetative cover including high grass, shrubs, and trees. There is a fence around the perimeter of the AOC but a number of gaps exist where the fence has been damaged. The most prominent feature at the Pioneer AOC is a landfill mound that covers approximately 2.75 acres. Previously, PCTC staff excavated a ditch through the landfill mound to facilitate drainage.

The immediate area surrounding the Pioneer AOC is well maintained by workers at the PCTC. The land that is adjacent to the PCTC property is used for different purposes. To the north, the Shelby Horizons property land is used as a parking lot for tractor-trailers. To the south, the COIP land consists of warehouses that are used by a variety of commercial/industrial vendors. To the west, the land is currently being used for agricultural purposes (corn field). Based on a discussion with PCTC staff, the AOC is neither currently used for any purpose nor intended for any future use.

6.1.5.1.2 Local Water Uses

The overland flow of surface water at the Pioneer AOC is generally in a northeasterly direction. Surface water from the Pioneer AOC either infiltrates into the ground or is intercepted by a drainage ditch that lies to the south of the nearby Shelby Horizons property. Once in the drainage ditch, the water flows easterly to a retention pond and, although not confirmed, it is assumed that the retention pond drains to the north and eventually discharges into Marsh Run during periods of heavy rain. Upon entering Marsh Run, the surface water flows approximately two miles to the Black Fork Mohican River, which then flows to the east for about 11 miles to Charles Mills Lake.

The majority of the population within a 4-mile radius of the site relies on municipal water provided by the Shelby Water Department. The Water Department provides service to all areas within the city of Shelby as well as areas that are just outside of the city limits. There are no other public water systems in the area. The system serves about 4,300 connections (between 9,800 and 10,000 people). The system obtains its water from two surface water intakes and has two wells for backup. Surface water currently supplies 40 percent of the area's water needs. Surface water and groundwater mixing occurs within the system. However, surface water is preferred, as it is not as hard. The backup wells are about 30 feet deep and are located behind the water plant at 110 North Gamble, which is upgradient of the site. The surface water intakes are located on Marsh Run (primary intake) just upstream from the confluence with the Black Fork Mohican River and at the dam at the south end of Park Avenue in Shelby. The Marsh Run intake is downstream of the likely entry point of the surface water runoff from the northern portion of the former Wilkins AFS.

Some areas outside of the city limits obtain their drinking water from private wells. There are over 1,100 homes within four miles that lie outside of the city limits that are assumed to use private wells for drinking water. It is estimated that the wells serve about 2,700 residents. The groundwater underlying and immediately down gradient of the site is not used for any purpose at the current time. The Shelby Water Department provides drinking water to PCTC and the businesses in the immediate area. If the Pioneer AOC is developed in the future, it is assumed that drinking water will be provided by the Shelby Water Department.

6.1.5.1.3 *Identification of Potentially Exposed Human Populations*

Based on the current and potential future land and water uses, the types of activities, and the transport of contamination to various media, the following populations were identified for evaluation in this risk assessment:

- **Site workers** – are assumed to be exposed to site COPCs in surface soil during typical activities such as groundskeeping. Exposure is limited to the maintained area that surrounds the mound area. A discussion with PCTC staff indicated that site workers do not come into contact with the mound area. This practice is not likely to change in the future.
- **Older child trespassers** – are assumed to be exposed to site COPCs in surface soil while visiting the site. The trespassers are assumed to come into contact with soil from the mound area. Younger children and adults were not evaluated, as site conditions and location make the area unattractive for these populations.
- **Construction workers** – given the potential for construction activities at the site in the future, a construction worker scenario was evaluated. Construction workers are assumed to be exposed to site COPCs in aggregate soil during construction activities. It is assumed that construction activities would be of relatively short duration (i.e., 6 months or less).
- **Future residents** – although unlikely given both the current and potential future land uses of the site and the surrounding area, a future residential scenario was included to determine an upper-bound on the level of risk posed by the site and will assist in determining the need for site restrictions, if required. Residents are assumed to be exposed to site COPCs in aggregate soil.

6.1.5.2 Conceptual Site Model

A conceptual site model (CSM) describes the contaminant sources, the release and transport mechanisms, the exposure media, the exposure routes, and the potentially exposed human populations. The primary objective of the CSM is to identify the complete and incomplete exposure pathways. A complete pathway has all of the components listed above, whereas an incomplete pathway is missing one or more. Figure 6-1 presents the CSM for the Pioneer AOC. Each element is described in detail in the following sections.

6.1.5.2.1 *Source of Contamination*

The primary source of chemical contamination at the Pioneer AOC is the site soils. The contamination is the result of past activities at the site. While owned by the Federal government, two areas of potential concern were identified on the western half of the PCTC property: an open storage yard and a disposal area. The open storage yard has been paved over and is now a parking lot. The former disposal area corresponds to the mound at the Pioneer AOC, which is likely the primary source of chemical contamination at the site.

6.1.5.2.2 *Release and Transport Mechanisms*

There are three primary mechanisms that can release and transport chemical contaminants at the Pioneer AOC: surface water runoff, leaching into groundwater, and wind erosion. Surface water runoff occurs during precipitation events when contaminants in the soil are released and transported to other areas, including transport to other areas on-site and to a lesser extent to off-

site water bodies via the site drainage. The transport of site contaminants to other areas on-site is of primary concern in the risk assessment.

It is suspected that contaminants may also be transported via the drainage system to an off-site water body (Marsh Run) that has an intake for the city of Shelby public water supply downstream of where site runoff enters the water body. However, it is assumed that any discharge of site runoff to Marsh Run would not be of human health concern given the distance to Marsh Run and the assumption that there would be mixing with un-impacted surface water prior to intake. Further, the Shelby public water is obtained from both surface and ground water sources. Surface water supplies less than half (about 40 percent) of the total drinking water and is taken from two sources: Marsh Run and the Black Fork Mohican River in Shelby. Thus, surface water from Marsh Run contributes only a fraction of the total water supply. Lastly, any site contaminants that are taken into the public water system would likely be removed during treatment process. Given these factors, human exposure resulting from drinking water supplied by the Shelby Water Department was not evaluated in the risk assessment.

Site contaminants can also migrate to the groundwater through leaching. However, there is no current site use of the groundwater and all residents of Shelby are served by the municipal water supply. The nearest residential drinking water well is approximately 0.5 miles away and extremely unlikely to be impacted by off-site transport. Therefore, drinking water is not considered a complete pathway for the risk assessment.

Given the dense vegetation at the AOC and the absence of any detected VOCs in the soil, emissions of volatile compounds into the air were not considered to be of human health concern. However, wind erosion can play a role in releasing contaminants from the soil. This holds true in areas with less than 50 percent vegetative cover and where activities such as heavy truck traffic on unpaved roads and other construction related activity is occurring (EPA, 2001). While the site is densely covered with vegetation and unlikely to experience any significant wind erosion, particulate emissions were evaluated to provide a conservative evaluation of site risk for the current use scenarios. This is also true for the future residents.

During construction activities, dust can be generated by a number of mechanisms including truck traffic on temporary, unpaved roads, wind erosion, and other construction related activities (e.g., earth moving and excavation). It is estimated that dust emissions generated from truck traffic on unpaved roads contributes the vast majority of emissions during construction activities (EPA, 2002b). Therefore, for the construction worker, the focus of particulate emissions is truck traffic on unpaved roads.

6.1.5.2.3 Exposure Media and Routes of Exposure

Contaminants in soil may be ingested and absorbed through the skin by exposed human receptors. In addition, any particulate released from the site into the air would be available for inhalation by the same receptors.

6.1.5.2.4 Exposed Populations

There are four potentially exposed populations that were evaluated in this risk assessment. Two were based on the current use and accessibility of the site. The first is a site worker who is exposed to site soil during his/her routine activities at the PCTC. Site worker exposure is limited to the maintained lawn area that surrounds the mound area. The second consists of a site trespasser. The trespasser is an older child and was assumed to visit the site for recreational

purposes. The trespasser was assumed to be exposed to the soil located on the mound area, which constitutes the Pioneer AOC.

Two potentially exposed populations were evaluated based on assumed construction and future residential use of the site. They include a construction worker and hypothetical future residents (child and adult). Given the potential for construction activities at the site in the future, a construction worker scenario was evaluated. It is assumed that construction activities would be of relatively short duration (i.e., 6 months or less). While future residential development is unlikely due to the current and expected future land use at the site and the surrounding area, it was included to determine an upper-bound on the level of risk posed by the site and will assist in determining the need for site restrictions, if required.

All of the potentially exposed populations are assumed to be exposed to COPCs through incidental ingestion and dermal absorption of soil, and inhalation of airborne particulates.

6.1.5.3 Exposure Point Concentrations

Exposure point concentrations (EPCs) are the COPC concentrations that a receptor may come in contact with at an area. The EPC used for each COPC in most cases is the one-sided 95-percent upper confidence limit (95% UCL) of the mean. EPA's ProUCL software program was used to calculate the UCLs in this risk assessment (EPA, 2004d). This program allows the user to calculate distribution-specific UCLs, as well as UCLs for data that do not exhibit a specific distribution (EPA, 2002c, 2004d). In cases where the 95% UCL exceeds the maximum detected concentration, the maximum concentration was used as the EPC.

Three sets of EPCs were calculated based on the current and future uses of the site. Currently, there are two separate areas at the Pioneer AOC that support different types of exposure. The first area consists of the maintained lawn that surrounds the mound area. A site worker who mows the lawn and maintains the grounds could be exposed to COPCs in surface soil in this area. The second area consists of the mound area. It was assumed that a trespasser could be exposed to COPCs in surface soil during visits to this area. It is conservatively assumed that the entire site could be developed in the future and used for residential purposes. It is assumed that construction workers and future residents could be exposed to COPCs in soil from all depths resulting from mixing that occurs during construction activities. Based on this, EPCs were calculated for the maintained area, the mound area, and the entire area.

The first step in computing a 95% UCL is to test for the data distribution. ProUCL tests for normal, lognormal, and gamma distributions. There are a number of procedures used to test for data distribution, including:

- Graphical test based upon a Q-Q plot.
- Lilliefors test (tests for normality or lognormality for data sets with sample sizes greater than or equal to 50).
- Shapiro-Wilk W test (tests for normality or lognormality for data sets with sample sizes less than 50).
- Anderson Darling test (tests for gamma distribution).
- Kolmogorov-Smirnov test (tests for gamma distribution).

ProUCL recommends that the graphical Q-Q plot test should always be accompanied by other more powerful tests (i.e., Lilliefors, Shapiro-Wilk, Anderson Darling, and Kolmogorov-Smirnov tests). For datasets with sample sizes less than 50 (i.e., the maintained and mound areas), the

Shapiro-Wilk test was run at a 0.05 level of significance in conjunction with the Q-Q plot to test for normality or lognormality. For datasets with sample sizes greater than 50 (i.e., the entire area), the Lilliefors test was run at a 0.05 level of significance in conjunction with the Q-Q plot to test for normality or lognormality. The Anderson Darling and Kolmogorov-Smirnov tests were run to test for gamma distribution at a 0.05 level of significance.

ProUCL calculates both parametric (for normal, lognormal, and gamma distributions) and non-parametric UCLs and provides recommendations on which UCL to use depending upon distributional assumptions and the skewness (as represented by the standard deviation of the data). The UCL calculation methods were selected based on the data characteristics presented in the table below.

For each COPC, the UCL calculated based on the data distribution recommended by ProUCL was used. A summary of the EPCs used in the risk assessment along with the data distribution and the UCL calculation method are presented in Tables 6-8 through 6-10 for the maintained area, the mound area, and the entire area soil, respectively. Appendix M presents the output of the ProUCL runs for each COPC.

Data Distribution	UCL Method Used
Normal	Student's t statistic
Lognormal ¹	H-statistic 95 percent Chebyshev Minimum Variance Unbiased Estimate (MVUE) 97.5 percent Chebyshev MVUE 99 percent Chebyshev MVUE 95 percent Chebyshev (Mean, Std) 99 percent Chebyshev (Mean, Std)
Gamma ²	Approximate gamma Adjusted gamma 95 percent based on Bootstrap-t Hall's bootstrap
Either Lognormal and Gamma	Assumed gamma distribution. See UCL calculation methods for gamma distribution.
Either Normal, Lognormal, or Gamma ³	See UCL methods for normal, lognormal, and gamma distributions.
Non-parametric ⁴	95 percent Chebyshev (Mean, Std) 97.5 percent Chebyshev (Mean, Std) 99 percent Chebyshev (Mean, Std) 95 percent Student's t or Modified t-statistic Hall's bootstrap
1 = ProUCL recommends one of six methods based on the skewness and sample size of the data set. 2 = ProUCL recommends one of four methods based on the skewness and sample size of the data set. 3 = When ProUCL indicates that the distribution of a dataset may be either normal, lognormal, or gamma, the distribution and UCL calculation method recommended by ProUCL was used. 4 = ProUCL recommends one of six methods based on the skewness and sample size of the data set.	

6.1.5.4 Identification of Exposure Equations and Parameters

This section describes the equations and parameters that were used to estimate the chronic daily intakes (CDIs; exposure doses) of the COPCs for each receptor through the applicable exposure

pathways. Exposure doses are dependent upon the magnitude, frequency, and duration of exposure. They are estimated by combining the COPC concentration (i.e., the EPC) and the exposure parameters. The exposure doses are expressed as intakes in mg/kg-day. Two types of doses are typically calculated in a risk assessment. The cancer dose (lifetime average daily dose [LADD]) is averaged over a 70-year lifetime. The noncancer average daily dose (ADD) is averaged over the actual exposure duration for each receptor.

The following list presents the exposure parameters that are used to estimate COPC intakes:

- Exposure frequency (EF) – represents the number of days per year (days/year) that a human receptor is engaged in a particular activity that could result in exposure;
- Exposure duration (ED) – represents the total length of time in years that a receptor engages in an activity that could result in exposure;
- Body weight (BW) – represents the average receptor body weight over the exposure period, expressed in kilograms (kg);
- Averaging time (AT) – represents the period over which exposure is averaged, expressed in days. Averaging time is dependent on the type of evaluation: cancer or noncancer. The cancer AT is based on a 70-year lifetime for all age groups, which equals 25,550 days (i.e., 70 years x 365 days/year). The noncancer AT equals the receptor specific ED multiplied by 365 days/year;
- Soil ingestion rate (IRS) – represents the amount of soil that is incidentally ingested on a daily basis, expressed in units of milligram per day (mg/day);
- Fraction ingested (FI) – a unitless term that represents the fraction of soil that is ingested from the contaminated source;
- Exposed skin surface area (SA) – represents the amount of skin exposed to contaminated soil, expressed in units of square centimeters (cm²);
- Soil-to-skin adherence factor (AF) – describes the amount of soil that adheres to the skin per surface area unit, expressed as milligrams per square centimeter (mg/cm²);
- Dermal absorption factor (ABS_d) – a unitless, COPC-specific term that represents the fraction of COPC that is assumed to penetrate the skin after dermal exposure with contaminated soils. Table 6-9 presents the ABS_d factors for the COPCs;
- Inhalation rate (IRA) – represents the amount of soil that is inhaled through released particulates on a daily basis, expressed as cubic meters per day (m³/day); and
- Particulate emission factor (PEF) – relates the concentration of contaminant in soil to the concentration of dust particles in air, expressed as cubic meters per kilogram (m³/kg).

The EPA-recommended exposure factors, along with professional judgment and site-specific information were used to develop the exposure parameters. The following subsections present the exposure parameters for each of the evaluated receptors. Tables 6-12 through 6-24 present the algorithms and parameters that were used to estimate the exposure doses for each of the pathways for each of the receptors.

6.1.5.4.1 Site Worker

A site worker could be exposed to contaminants while performing routine activities at the site such as site maintenance and grounds-keeping. It is assumed that a site worker's exposure is limited to the maintained area that surrounds the mound area. This is supported by a discussion with staff from the PCTC. The dense, overgrown vegetation and the fence around the mound area also support this assumption.

Based on professional judgment, a site worker at the Pioneer AOC is assumed to be exposed twice a week during the months of April through October, which equates to an EF of 56 days/year. The twice per week assumption is probably an overestimate and would cover any additional site activities by the worker in other months of the year. The EPA recommended worker ED of 25 years was used (EPA, 2002b). The carcinogenic averaging time is 25,550 days (i.e., 70 years x 365 days/year). The noncancer averaging time is 9,125 days (i.e., assumed to be the ED multiplied by 365 days/year). The adult body weight is assumed to be 70 kg (EPA, 1997b). The EPA recommended soil ingestion rate for an outdoor commercial/industrial worker of 100 mg per day (mg/day) was used (EPA, 2002b). A value of one (1.0) was used for the fraction ingestion indicating that site workers are assumed to ingest 100 percent of their daily soil intake from the Pioneer AOC. For dermal exposure, the exposed SA was assumed to be 3,300 cm² per day (equating to the 50th percentile values for head, forearms, and hands) (EPA, 2004b). The geometric mean soil-to-skin AF value has been estimated to be 0.2 mg/cm² and is based on a utility worker (EPA, 2004b). The COPC-specific ABS_d factors are presented on Table 6-11. For exposure to particulate, the inhalation rate was assumed to be 20 m³/d based on EPA guidance for worker exposure (EPA, 2002b). The PEF was assumed to be 2.80E+09 m³/kg which is based on the Zone VII Cleveland, OH Q/C, a site size of approximately 10 acres, and assuming that 90% of the site is currently vegetated (EPA, 2002b). Tables 6-12 through 6-14 present the dose equations for the site worker.

6.1.5.4.2 *Trespasser*

While no evidence exists of individuals visiting the mound area, it was assumed that trespassers could be exposed to site contaminants in the mound area to provide a conservative estimate of potential risk. Trespassing exposure is expected to be minimal because of fencing and the fact that an individual would be unlikely to regularly visit the mound area for recreational purposes. The area is dominated by commercial and/or industrial uses with few residences in close proximity. The site itself is also heavily vegetated and offers little in the way of attractive recreational opportunities.

For the purposes of the risk assessment, it is assumed that an older child trespasser visits the site once a week for 52 weeks of the year resulting in an EF of 52 days/year. The older child is assumed to be exposed from ages 7 through 18 years. This equates to an older child ED of 12 years. The carcinogenic averaging time is based on a 70-year lifetime (25,550 days). The noncancer averaging time for the older child is 4,380 days (i.e., assumes the ED multiplied by 365 days/year). The older child body weight is assumed to be 45 kg (EPA, 1997b). The EPA recommended soil ingestion rates for a residential exposure were used for the trespasser. The older child ingestion rate is 100 mg/day (EPA, 1997b). A value of 0.5 was used for the fraction ingestion indicating that the trespassers ingest half (50 percent) of their daily soil intakes from the Pioneer AOC. For the dermal exposure, the recommended values for residential exposure that are presented in EPA's dermal risk assessment guidance (EPA, 2004b) were used. The older child is assumed to wear a short-sleeved shirt and shorts with shoes. Thus, the exposed body parts consist of the head, hands, forearms, and lower legs. The exposed SA for the older child is 4,373 cm². The recommended AF for the older child is 0.07 mg/cm². This is based on the geometric mean AF value for gardeners. The COPC-specific ABS_d factors are presented on Table 6-11. For exposure to particulate, the inhalation rate was assumed to be 20 m³/d based on EPA guidance for adult exposure (EPA, 2002b). The PEF was assumed to be 3.11E+09 m³/kg which is based on the Zone VII Cleveland, OH Q/C, a site size of approximately 5 acres, and

assuming that 90% of the site is currently vegetated (EPA, 2002b). Tables 6-15 through 6-17 presents the dose equations for the site trespasser.

6.1.5.4.3 Construction Worker

Given the potential for future construction activities at the Site, a construction worker scenario was evaluated. The construction worker is assumed to be exposed to soil from all depths as a result of mixing that would occur during construction activities. Construction activities are assumed to last for six months. Thus, an ED of 0.5 was used. An EF of 125 days/year was used, which is based on exposure 5 days a week for 25 weeks of the year. The carcinogenic averaging time is 25,550 days (i.e., 70 years x 365 days/year). The noncancer averaging time is 183 days/year, which equates to approximately one-half year. The adult body weight is 70 kg (EPA, 1997b). The soil ingestion rate for construction workers of 330 mg/day was used (EPA, 2002b). A value of 1.0 was used for the fraction ingested, indicating that 100% of ingested soil is from the site. For dermal exposure, the exposed SA was 3,300 cm²/day (equating to the 50th percentile values for head, forearms, and hands) (EPA, 2004b). The 95th percentile soil-to-skin AF value for construction workers of 0.3 mg/cm² was used (EPA, 2004b). The COPC-specific ABS_d factors are presented on Table 6-11. For exposure to particulate, the inhalation rate was assumed to be 20 m³/day (EPA, 2002b). During construction activities, fugitive dust can be generated via truck traffic on temporary, unpaved roads, wind erosion, and other construction related activities (e.g., earth moving and excavation). However, emissions from truck traffic on unpaved roads typically contribute the vast majority of dust emissions during construction activities with insignificant contributions from wind erosion and other activities (EPA, 2002b). Thus, for the construction worker, the calculated PEF focused on emissions from truck traffic on unpaved roads only. The estimated PEF was 9.33E+05 m³/kg. A number of parameters were estimated to calculate the PEF including the number of days with at least 0.01 inches of rainfall, the average vehicle weight, and the sum of vehicle distance traveled on site during construction (EPA, 2002b). Tables 6-18 through 6-20 present the dose equations and exposure parameters for the construction worker. Table 6-21 presents the equation used to calculate the PEF along with the site-specific parameters.

6.1.5.4.4 Future Resident

Future residential development is very unlikely due to the existing and likely future land use at the site and the nature of the site activities and surroundings. However, a future residential scenario was evaluated to determine an upper-bound on the level of risk posed by the site.

Default exposure factors were used for the hypothetical future residential exposure scenario. For the cancer evaluation, the age-adjusted approach was used. An EF of 350 days/year was used (EPA, 2002b). An ED of 30 years (24 years as an adult and 6 years as a child) was used (EPA, 2002b). The cancer averaging time is based on a 70-year lifetime (25,550 days). The noncancer averaging time for the child and adult were 2,190 days and 8,760 days, respectively, which are based on the child and adult EDs (6 and 24) multiplied by 365 days/year. The child and adult BWs were 15 kg and 70 kg, respectively (EPA, 1997b). The IRS for the child and adult were 200 mg/day and 100 mg/day, respectively (EPA, 2002b). A value of 1.0 was used for the fraction ingested indicating that 100 percent of ingested soil is from the site. For dermal exposure, the recommended values for residential exposure that are presented in EPA guidance were used. The exposed SAs for the child and adult resident of 2,800 cm²/day and 5,700 cm²/day were used, respectively (EPA, 2004b). Soil-to-skin AFs of 0.2 mg/cm² and 0.07 mg/cm² were used for the

child and adult, respectively (EPA, 2004b). The COPC-specific ABS_d factors are presented in Table 6-11. For exposure to particulate, the inhalation rate was $10 \text{ m}^3/\text{day}$ and $20 \text{ m}^3/\text{day}$ for the child and adult, respectively (EPA, 2002b). The PEF was assumed to be $5.59\text{E}+08 \text{ m}^3/\text{kg}$ which is based on the Zone VII Cleveland, OH Q/C, a site size of 10 acres, and assuming that 50% of the site is vegetated following development (EPA, 2002b). Tables 6-22 through 6-24 present the dose equations and exposure parameters for the future residents.

6.1.5.5 Calculated Exposure Doses

Table 6-25 presents the calculated exposure doses from incidental ingestion, dermal contact, and inhalation of COPCs in surface soil from the maintained area for the site worker for both cancer and noncancer effects. Table 6-26 presents cancer and noncancer doses for the older child trespasser exposed to COPCs in surface soil in the mound area. Tables 6-27 and 6-28 present cancer and noncancer doses for the construction worker and future residents exposed to COPCs in aggregate soil, respectively.

6.1.6 Risk Characterization

The objective of the risk characterization is to integrate the information developed in the exposure assessment and the toxicity assessment into an evaluation of the potential risks associated with site contaminants. Both cancer risks and noncancer health effects were evaluated.

6.1.6.1 Cancer Risk

Potential cancer risks were calculated by multiplying the estimated LADD intake that is calculated for a COPC through an exposure route by the exposure-route-specific CSF, as follows:

$$\text{Risk} = \text{LADD} * \text{CSF}$$

Where:

- LADD = Lifetime average daily dose; intake averaged over a 70-year lifetime as mg COPC/kg-body weight per day.
CSF = Chemical- and route-specific cancer slope factor $(\text{mg}/\text{kg}\text{-day})^{-1}$.

Cancer risks were summed across all relevant pathways for a given receptor and exposure scenario to yield a cumulative lifetime risk. EPA's cancer risk range is an increased risk of developing cancer, based on a plausible upper-bound estimate of risk, of approximately 1 in 1,000,000 ($1\text{E}-06$) to 1 in 10,000 ($1\text{E}-04$). Risks greater than this range typically require some type of remedial action, while risks below this risk range do not. Risks that fall within this range ($1\text{E}-06$ – $1\text{E}-04$) are typically evaluated by risk managers to determine the necessity of remedial action. The OEPA Division of Hazardous Waste Management has established a $1\text{E}-05$ cancer risk benchmark. Cancer risks are compared to both EPA and OEPA criteria.

6.1.6.2 Noncancer Health Effects

Potential noncancer health effects were evaluated by the calculation of hazard quotients (HQs) and hazard indices (HIs). An HQ is the ratio of the exposure duration averaged estimated daily

intake (ADD) through a given exposure route to the chemical- and route-specific RfD. The HQ-RfD relationship is illustrated by the following equation:

$$HQ = ADD/RfD$$

Where:

- HQ = Hazard quotient.
- ADD = Average daily dose; estimated daily intake averaged over the exposure duration (mg/kg-day).
- RfD = Reference dose (mg/kg-day).

HQs were summed to calculate HIs for each scenario. HIs were calculated for each exposure route, and a total HI was calculated based on exposure to all site contaminants from all exposure routes for each receptor. HIs of less than one indicate that adverse health effects associated with the exposure scenario are unlikely to occur and that remedial action is not warranted. The EPA and the OEPA both use an HI of one as the appropriate health effect benchmark.

6.1.6.3 Risk Results

6.1.6.3.1 Site Worker

As presented on Table 6-29, the total cancer risk (2.12E-06) from all COPCs for all exposure pathways is at the low end of the EPA risk range and below the OEPA risk level. The soil ingestion and dermal contact pathways contributed about 77 and 22 percent of the total cancer risk, respectively. The total risk from the inhalation of particulate is over 200 times less than the low end of the EPA risk range. Arsenic (1.67E-06) was the only COPC with a cancer risk greater than 1E-06. Arsenic contributed approximately 79 percent of the total risk.

Table 6-30 presents the HQs and HIs for the site worker. The total HI (1.00E+00) from all COPCs for all exposure pathways is equal to the EPA and OEPA benchmark of one. The dermal contact pathway contributed about 95 percent of the total HI.

The results of the risk assessment indicate that a site worker's current activities on the maintained area do not pose unacceptable risk levels (cancer or noncancer) via the soil ingestion, dermal contact, and inhalation of particulate exposure routes.

6.1.6.3.2 Trespasser

As presented on Table 6-31, the total cancer risk (1.77E-06) from all COPCs for all exposure pathways is at the low end of the EPA risk range and below the OEPA risk level. None of the COPCs had a total cancer risk greater than 1E-06. The soil ingestion and dermal contact pathways contributed about 70 and 30 percent of the total cancer risk, respectively. The total risk from the inhalation of particulate is over 150 times less than the low end of the EPA risk range.

Table 6-32 presents the HQs and HIs from exposure to surface soil for the older child trespasser. The total HI (3.92E-01) is less than half of the EPA and OEPA benchmark risk level of one. The dermal contact pathway contributed about 89 percent of the total HI.

The results of the risk assessment indicate that a site trespasser's activities on the mound area do not pose unacceptable risk levels (cancer or noncancer) via soil ingestion, dermal contact, and inhalation of particulate exposure routes.

6.1.6.3.3 Construction Worker

As presented on Table 6-33, the total cancer risk ($1.16\text{E}-06$) from all COPCs for all exposure pathways is at the low end of the EPA risk range and below the OEPA risk level. None of the COPCs had a total cancer risk greater than $1\text{E}-06$. The inhalation of particulate and soil ingestion pathways contributed about 72 and 24 percent of the total cancer risk, respectively.

Table 6-34 presents the HQs and HIs for the future construction worker. The total HI ($6.45\text{E}+00$) from all COPCs for all exposure pathways is about 6 times greater than the EPA and OEPA benchmark of one. The inhalation pathway HI ($4.76\text{E}+00$) contributed over 73 percent of the total HI. The dermal contact pathway HI ($1.30\text{E}+00$) contributed about 20 percent of the total. The total HI for manganese ($5.15\text{E}+00$) was the only COPC with an HI greater than 1.

The results of the risk assessment indicate that a future construction worker's activities do not pose unacceptable cancer risk levels from the exposure routes evaluated. There is minimal noncancer hazard from manganese from the inhalation of particulate and dermal contact pathways.

6.1.6.3.4 Future Residents

As presented on Table 6-35, the total cancer risk ($4.46\text{E}-05$) from all COPCs for all exposure pathways falls within the EPA risk range but exceeds the OEPA risk level. The soil ingestion and dermal contact pathways contributed about 86 and 14 percent of the total cancer risk, respectively. The total risks from arsenic ($3.15\text{E}-05$), benzo(a)pyrene ($8.47\text{E}-06$), dibenz(a,h)anthracene ($1.48\text{E}-06$), and 2,3,7,8-TCDD TEQ ($1.35\text{E}-06$) exceed $1\text{E}-06$. The total risk from arsenic contributes over 70 percent of the total.

Table 6-36 presents the HQs and HIs for the future residents. For the child, the total HI ($1.28\text{E}+01$) from all COPCs for all exposure pathways exceeds the EPA and OEPA benchmark of one. The total HI for manganese ($9.36\text{E}+00$) was the only COPC with an HI greater than one. The dermal contact and soil ingestion pathway HIs ($9.63\text{E}+00$ and $3.11\text{E}+00$, respectively) contributed about 75 and 24 percent of the total HI, respectively. For the adult, the total HI ($1.82\text{E}+00$) slightly exceeds the EPA and OEPA benchmark of one. The total HI for manganese ($1.42\text{E}+00$) was the only COPC with an HI greater than one. The dermal contact pathway contributed about 81 percent of the total.

Although highly unlikely given both the current and potential future uses of the site, a future residential scenario was evaluated to determine an upper-bound on the level of risk posed by the site. The results of the risk assessment indicate that future residential use poses unacceptable risk levels. The total cancer risk exceeds the OEPA risk level, $1\text{E}-05$. The total HIs for the child and adult both exceed the noncancer benchmark of one.

6.1.6.3.5 Lead

Blood lead levels were estimated for the hypothetical future child resident scenario using the IEUBK model (EPA, 2004c). The average lead concentration from aggregate soil was used in the IEUBK evaluation. This value (45.2 mg/kg) was used for both the indoor and outdoor dust lead levels. The child's age was assumed to be 1 to 6 years and all other default model assumptions

were used. Based on the above input parameters and assumptions, the geometric mean blood lead level for the hypothetical child resident was 2.1 µg/dL, which is below the EPA recommended threshold of 10 µg/dL. Given the conservative assumptions and the geometric mean, the future child resident is not at risk for behavioral neurotoxicity due to site lead concentrations.

In addition to evaluating the results of the IEUBK model, the aggregate soil average lead concentration was compared to the lead soil target level of 400 mg/kg. This value is based on the RCRA residential cleanup value. The average lead concentration for the future resident (45.2 mg/kg) is well below the lead soil target level and therefore, the adult lead model evaluation was not necessary.

6.1.7 Uncertainty Analysis

The goal of an uncertainty analysis in a risk assessment is to provide to the appropriate decision makers (i.e., risk managers) information about the key assumptions, their inherent uncertainty and variability, and the impact of this uncertainty and variability on the estimates of risk. The uncertainty analysis should show that risks are relative in nature and do not represent an absolute quantification. This is an important point that is vital to the proper interpretation and understanding of the risks presented in this report. The primary sources of uncertainty in this risk assessment include:

- **The selection of exposure scenarios** – The exposure scenarios were designed to identify reasonably maximum exposed (RME) individuals with consideration given to the current and potential future uses of the site. Other scenarios could have been developed for individuals who might come into contact with site soils, but these scenarios would generally result in a lower level of exposure. Therefore, it is likely that the exposure scenarios evaluated in this risk assessment would more than account for other potential exposures. For example, the residential scenario (child and adult) was evaluated even though it is very unlikely that this site will ever be used for residential purposes.
- **The selection of exposure parameters** – It is very likely that the approach taken in selecting exposure parameters would overestimate realistic exposures, and therefore, overestimate the risk. This is appropriate when performing risk assessments of this type so that the risk managers can be reasonably assured that the risks to the public are not underestimated. Much of the uncertainty involves the use of exposure factors relating to frequency of visits to the contaminated area, daily soil ingestion rates, length of exposure, etc. These factors are designed to account for reasonably maximum exposed individuals who could theoretically frequent the site for many years. It is very likely that an actual individual would be exposed to a lesser degree than the hypothetical individuals evaluated in this risk assessment.
- **The evaluation of metals as COPCs** – A number of metals were evaluated as COPCs because the site concentrations exceeded conservative, health-based screening concentrations. However, as presented in Table 6-4, the comparison of site and background concentrations indicates that the concentrations of the majority of the metals are very similar, with the exception of mercury and thallium which had site concentrations that far exceeded what was detected in the background samples. The comparison of maximum detections, mercury and thallium excluded, yielded ratios ranging from 1.2 to 6.5, with the site concentrations exceeding the background in every case. When the averages are compared, again with mercury and thallium excluded, the site concentrations are essentially the same or less than the background concentrations.

Based on this, the metals concentrations are unlikely to be site related. Risks estimates (cancer and noncancer) were driven by the estimated risks from exposure to metals, especially arsenic and manganese. Removing metals (other than mercury and thallium) from the evaluation would reduce risks for all of the exposure scenarios, except the future residential cancer risks, to below the cancer and noncancer risk benchmarks. The future residential cancer risk if metals were removed from the evaluation would be driven by PAHs and would slightly exceed 1E-05.

- **The use of cancer slope factors and reference doses** – Both cancer risks and noncancer health effects were evaluated using standard EPA toxicity criteria. These criteria were developed using conservative approaches to ensure protection of public health and would be unlikely to underestimate cancer risks and noncancer health effects estimates.
- **The use of oral toxicity values as inhalation toxicity values** – No adjustments were made to the oral toxicity values extrapolating to the inhalation route (i.e., the same value was used for both routes). This adds uncertainty to the derived provisional values by not accounting for route-specific differences in chemical absorption, metabolism, and potential target tissues. The impact of this to the risk estimates cannot be determined.

Considering all the above-mentioned uncertainties, the risk assessment performed for the site would tend to overestimate actual risk, most likely to a significant degree. Therefore, the site-related risks should be evaluated in light of this overestimation of actual risk.

6.1.8 HHRA Summary and Conclusions

An evaluation of potential human health risks was conducted for the Pioneer AOC and the surrounding maintained area considering the current and reasonably anticipated future uses. Conservative, health-protective exposure scenarios and assumptions were used in this evaluation of risks that would tend to overestimate actual risks. Even with this conservative approach, the cancer risk estimates for the site worker, site trespasser, and construction worker scenarios were below or within relevant EPA and OEPA benchmarks. The noncancer evaluation resulted in HIs less than or equal to the noncancer benchmark of one for the site worker and site trespasser scenarios. The construction worker scenario resulted in a minor exceedance of the noncancer benchmark.

Residential development is not a likely to occur in the future given the current and future uses of the site (industrial). For conservatism, however, a future residential scenario was evaluated to determine an upper-bound on the level of risk posed by the site. The results of the risk assessment indicate that future residential use poses unacceptable risk levels.

6.2 ECOLOGICAL RISK ASSESSMENT (LEVEL 1 - SCOPING)

6.2.1 Introduction

The purpose of the Level I (Scoping) ecological risk assessment (ERA) is to determine whether there are any reasons to believe that “important ecological resources” are present or potentially present at or in the locality of the Pioneer site, and to investigate the potential of (a) release(s) of an ecological stressor (OEPA, 2003). Sites that do not have an important ecological resource or for which there is no reason to believe a release of an ecological stressor has occurred, do not require the ERA process to continue.

A Level I ERA includes two primary components: 1) a site assessment that determines the potential for releases of ecological stressors that may have occurred at the site, and 2) a habitat

evaluation based on a site visit and literature review that determine whether “important ecological resources” are present on-site or in the locality of the site.

Section 6.2.2 presents the findings of the site-visit/habitat-assessment and other information required to complete the Level I (Scoping) ERA and provides recommendations as to further risk evaluations that may be required.

6.2.1.1 Local Land Uses

The Pioneer AOC is located on the property of the Pioneer Career and Technology Center, a vocational school for adolescents and adults. The PCTC serves over 1,000 students (high school students and adults) and employs a staff of approximately 150. The vocational school is located on the eastern portion of the property and consists of buildings and parking lots. The Pioneer AOC is located on the western portion of the property and has dense vegetative cover including high grass, shrubs, and trees. There is a fence around the perimeter of the AOC but a number of gaps exist where the fence has been damaged. The most prominent feature at the Pioneer AOC is a landfill mound that covers approximately 2.75 acres. Previously, PCTC staff excavated a ditch through the landfill mound to facilitate drainage.

The immediate area surrounding the Pioneer AOC is a mowed lawn maintained by workers at the PCTC. The land that is adjacent to the PCTC property is used for different purposes. To the north, the Shelby Horizons property land is used as a parking lot for tractor-trailers. To the south, the COIP land consists of warehouses that are used by a variety of commercial/industrial vendors. To the west, the land is currently being used for agricultural purposes (corn field). Based on a discussion with PCTC staff, the AOC is not currently used for any purpose nor is there any intention to use it in the future.

6.2.1.2 Local Water Uses

When sufficient precipitation occurs, overland flow of surface water at the Pioneer AOC is generally in a northeasterly direction through the fill area drainage ditch (see Figure 3-1). Surface water from the Pioneer AOC either infiltrates into the ground or is intercepted by a drainage ditch that lies to the south of the nearby Shelby Horizons property, just north of the AOC. Once in the off-site drainage ditch, the water flows easterly to a retention pond and, although not confirmed, it is assumed the retention pond drains to the north and eventually discharges into Marsh Run during periods of heavy rain. Upon entering Marsh Run, the surface water flows approximately two miles to the Black Fork Mohican River, which then flows to the east for about 11 miles to Charles Mills Lake.

6.2.2 Site-Visit / Habitat Evaluation (Identification of Important Ecological Resources)

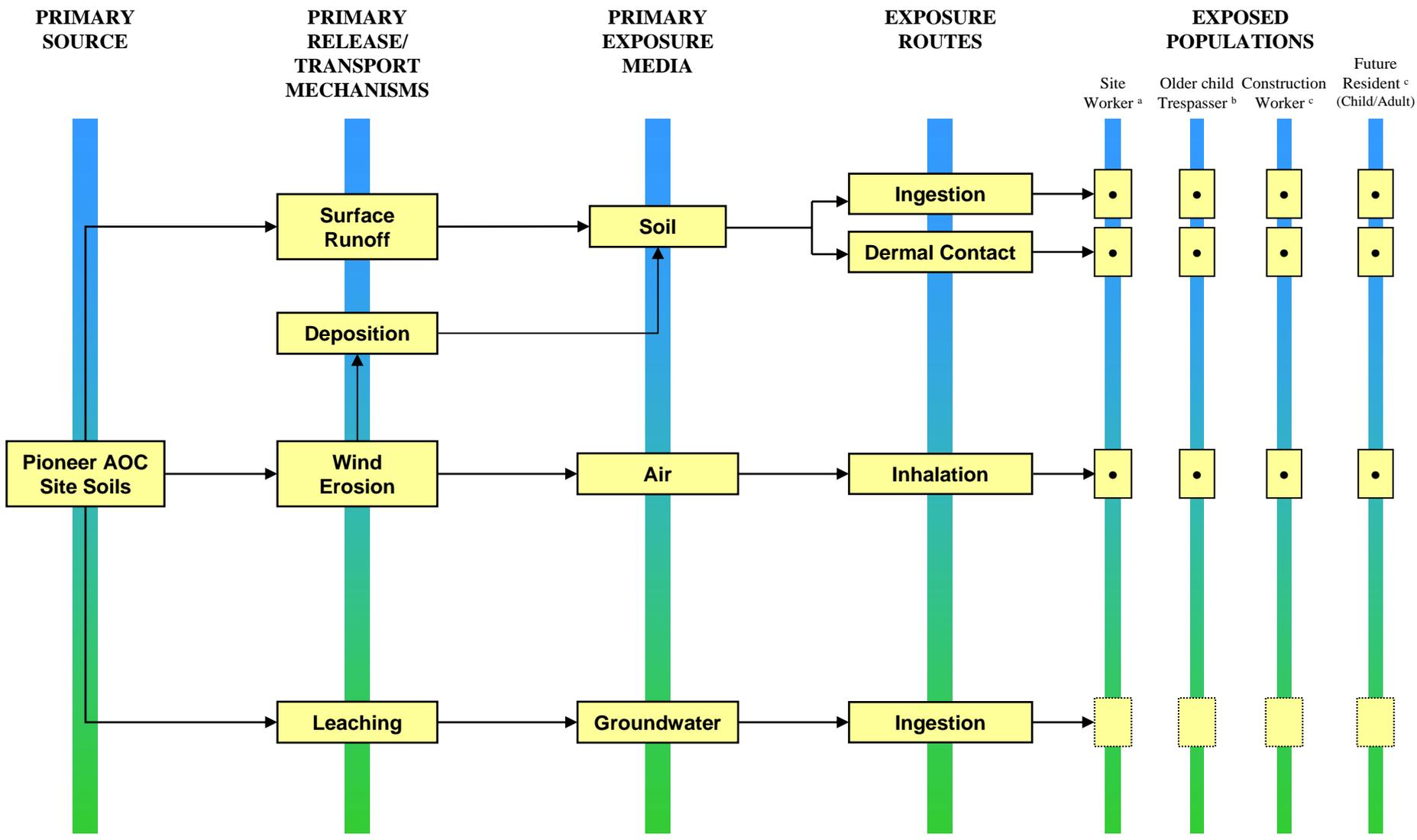
A site visit was conducted in July 2003 to evaluate the potential for “important ecological resources” on-site or in the locality of the site. During a site visit in July, it was determined that the fill area portion of the site is approximately 2.75 acres in size and is dominated by scrub/shrub habitat. The perimeter of the fill area is primarily herbaceous vegetation (i.e., grasses and common invasive plants). There are several mid-size to large deciduous trees [mostly quaking aspen (*Populus tremuloides*), black locust (*Robinia pseudoacacia*) and red oak (*Quercus rubra*)] scattered throughout the fill area. Common herbaceous and scrub/shrub vegetation include: ragweed (*Ambrosia artemisiifolia*), golden rod (*Solidago spp.*), honeysuckle (*Lonicera spp.*), multiflora rose (*Rosa multiflora*), asters (*Aster spp.*) and smooth sumac (*Rhus glabra*). With the exception small wooded drainage ditches (that are not part of the AOC)

northwest and southwest of the fill area, there is little suitable wildlife habitat on the property. The mixed vegetation habitats on the property appear to support a limited terrestrial community, typical of a highly disturbed, early successional site. Wildlife species or signs observed during the site visit included: blue jay (*Cyanocitta cristata*), mourning dove (*Zenaida macroura*), mockingbird (*Mimus polyglottos*), American goldfinch (*Carduelis tristis*) and several woodchuck (*Marmota monax*) and small mammal burrows. A detailed description of the site including: the site visit findings, vegetation cover types and site photographs is provided in Appendix N (Ecological Scoping).

There is a small drainage ditch that bisects the northern portion of the fill area. No water was observed in the ditch during the site visit and vegetation present in and adjacent to this ditch was typical of the rest of the fill area (i.e., not aquatic vegetation), indicating that water is present infrequently. As presented in the Site Inspection Report (Plexus, 2001) and Section 6.2.1.2, water only accumulates or flows in the fill area ditch after substantial rainfall. Water that leaves the fill area ditch flows in a northeastern direction and is discharged as sheet-flow over the maintained lawn and during heavy precipitation events may leave the site and discharge into an off-site drainage ditch.

A review of the Ohio Natural Heritage Database (Appendix N) identified three state protected and one state endangered plants within a 15 mile radius downstream of the Wilkins Air Force Station. The marsh fivefinger (*Potentilla palustris*), large cranberry (*Vaccinium macrocarpon*) and swamp cottonwood (*Populus heterophylla*) are identified as potentially threatened by the state and the sharp-glumed manna-grass (*Glyceria acutiflora*) is a state endangered species. These four plant species were identified to potentially inhabit the Black Fork Mohican River approximately 15 miles downstream from the Wilkins Site. There were no important ecological resources identified on the site or within the general vicinity of the site.

Based on the site visit, the threatened and endangered species search and a review of historical information, it was concluded that the site does not impact any ‘ecologically important resources’ and therefore does not warrant any further ecological risk assessment activity.



LEGEND:

• = Complete exposure pathway recommended for evaluation.

□ = Incomplete exposure pathway.

^a The site worker was assumed to be exposed to surface soil on the maintained (i.e., mowed) area that surrounds the mound area.

^b The trespassers were assumed to be exposed to surface soil on the mound area.

^c The construction workers and future residents were assumed to be exposed to soil from all depths from the entire area.

FIGURE 6-1
CONCEPTUAL SITE MODEL
HUMAN HEALTH RISK ASSESSMENT
Pioneer AOC, Former Wilkins AFS
Shelby, OH

TABLE 6-1
Summary of Detected Chemical Concentrations in Surface Soil (0-0.5 feet bgs)^f and Comparison to Residential Soil PRGs
Pioneer AOC, Former Wilkins AFS, Shelby, Ohio

Chemical	Frequency of Detection ^b	Range of Detected Concentrations	Mean Detected Concentration ^b	Range of Sample Quantitation Limits	Mean Nondetected Concentration ^b	Residential Soil PRG (THQ = 0.1) ^d	Ratio of Maximum Detected Concentration to Residential Soil PRG
Organics							
Acenaphthene	14 / 35	1.20E-03 - 5.50E-02	9.96E-03	6.20E-03 - 1.19E+01	1.46E+00	3.70E+02	1.5E-04
Acenaphthylene	6 / 24	1.10E-03 - 3.20E-02	8.75E-03	6.70E-03 - 1.50E-02	9.16E-03	3.70E+02 ^e	8.6E-05
Acetone	1 / 13	2.90E-03 - 2.90E-03	2.90E-03	6.20E-03 - 2.38E-02	1.79E-02	1.40E+03	2.1E-06
Anthracene	19 / 35	1.80E-03 - 3.10E-01	2.82E-02	6.00E-03 - 5.95E+00	9.57E-01	2.20E+03	1.4E-04
Benzaldehyde	9 / 22	1.80E-02 - 7.30E-02	4.36E-02	3.90E-01 - 7.40E-01	4.84E-01	6.10E+02	1.2E-04
Benz(a)anthracene	31 / 35	1.90E-03 - 1.40E+00	1.58E-01	1.70E-03 - 2.55E-02	1.30E-02	6.20E-01	2.3E+00
Benzo(a)pyrene	32 / 34	2.70E-03 - 1.80E+00	1.80E-01	1.16E-02 - 1.26E-02	1.21E-02	6.20E-02	2.9E+01
Benzo(b)fluoranthene	34 / 35	3.20E-03 - 1.70E+00	1.78E-01	1.16E-02 - 1.16E-02	1.16E-02	6.20E-01	2.7E+00
Benzo(ghi)perylene	29 / 35	2.30E-03 - 7.30E-01	8.37E-02	1.80E-03 - 1.19E+00	2.48E-01	2.30E+02 ^f	3.2E-03
Benzo(k)fluoranthene	34 / 35	1.60E-03 - 1.00E+00	9.22E-02	1.16E-02 - 1.16E-02	1.16E-02	6.20E+00	1.6E-01
Biphenyl, 1,1-	1 / 22	1.10E-01 - 1.10E-01	1.10E-01	3.90E-01 - 8.00E-01	4.84E-01	3.00E+02	3.7E-04
Bis(2-ethylhexyl) phthalate	22 / 35	2.60E-02 - 8.00E-01	3.54E-01	2.00E-01 - 6.60E-01	4.00E-01	3.50E+01	2.3E-02
Carbazole	6 / 35	2.30E-02 - 3.90E-01	1.46E-01	5.80E-02 - 7.40E-01	4.22E-01	2.40E+01	1.6E-02
Chloroform	3 / 13	2.10E-03 - 8.00E-03	5.30E-03	7.36E-04 - 1.60E-03	1.12E-03	2.20E-01	3.6E-02
Chrysene	34 / 35	2.80E-03 - 1.70E+00	1.76E-01	1.16E-02 - 1.16E-02	1.16E-02	6.20E+01	2.7E-02
DDD, p,p'	5 / 12	3.50E-03 - 1.60E-01	4.71E-02	2.00E-03 - 1.91E-01	4.86E-02	2.40E+00	6.7E-02
DDE, p,p'	6 / 12	4.90E-03 - 1.60E-01	4.00E-02	1.20E-03 - 1.91E-01	5.62E-02	1.70E+00	9.4E-02
DDT, p,p'	7 / 12	5.40E-03 - 3.80E-01	7.13E-02	2.50E-03 - 4.33E-02	2.96E-02	1.70E+00	2.2E-01
Dibenz(ah)anthracene	19 / 35	1.40E-03 - 1.70E-01	1.80E-02	1.10E-03 - 5.95E-01	9.78E-02	6.20E-02	2.7E+00
Dibenzofuran	7 / 35	4.20E-02 - 1.10E+00	2.56E-01	5.10E-02 - 8.51E-01	4.32E-01	1.50E+01	7.3E-02
Diethyl phthalate	3 / 13	3.70E-02 - 1.70E-01	9.07E-02	2.90E-02 - 8.51E-01	4.24E-01	4.90E+03	3.5E-05
Di-n-butyl phthalate	2 / 13	2.50E-01 - 8.30E-01	5.40E-01	3.70E-01 - 8.51E-01	4.55E-01	6.10E+02	1.4E-03
Fluoranthene	26 / 34	5.00E-03 - 6.40E+00	4.84E-01	2.31E-02 - 1.19E+00	2.32E-01	2.30E+02	2.8E-02
Fluorene	17 / 35	1.20E-03 - 1.40E-01	3.85E-02	2.60E-03 - 1.25E+00	1.92E-01	2.70E+02	5.2E-04
Hexachlorocyclohexane, beta-	1 / 11	3.50E-03 - 3.50E-03	3.50E-03	7.40E-04 - 2.02E-01	6.08E-02	3.20E-01	1.1E-02
Indeno(1,2,3-cd)pyrene	31 / 35	1.90E-03 - 1.30E+00	1.20E-01	1.30E-02 - 1.19E+00	3.68E-01	6.20E-01	2.1E+00
Methylene chloride	6 / 13	1.50E-03 - 6.10E-03	5.07E-03	1.80E-03 - 3.59E-03	2.74E-03	9.10E+00	6.7E-04
Methylnaphthalene, 2-	14 / 35	2.40E-02 - 4.20E+00	5.28E-01	7.00E-02 - 8.51E-01	4.65E-01	5.60E+00 ^g	7.5E-01
Naphthalene	27 / 35	1.10E-03 - 1.60E+00	1.38E-01	4.70E-03 - 2.58E+00	8.25E-01	5.60E+00	2.9E-01
Phenanthrene	32 / 35	2.90E-03 - 6.00E+00	4.27E-01	3.70E-03 - 1.16E-01	4.11E-02	2.20E+03 ^h	2.7E-03
Pyrene	34 / 35	4.30E-03 - 5.70E+00	4.34E-01	2.31E-02 - 2.31E-02	2.31E-02	2.30E+02	2.5E-02
Polychlorinated Bipheyls							
PCB 1260	2 / 13	1.50E-02 - 5.00E-02	3.25E-02	2.60E-02 - 4.26E-02	3.79E-02	1.10E-01	4.5E-01
Dioxins/Furans							
2,3,7,8-TCDD TEQ ^c	2 / 2	5.52E-06 - 6.65E-06	5.98E-06	-	-	3.90E-06	1.7E+00
Inorganics							
Aluminum	35 / 35	3.85E+03 - 1.38E+04	9.26E+03	-	-	7.60E+03	1.8E+00
Antimony	6 / 35	3.90E-01 - 1.30E+00	7.82E-01	4.60E-01 - 3.87E+01	4.87E+00	3.10E+00	4.2E-01
Arsenic	35 / 35	4.60E+00 - 3.36E+01	1.10E+01	-	-	3.90E-01	8.6E+01

TABLE 6-1
Summary of Detected Chemical Concentrations in Surface Soil (0-0.5 feet bgs)^f and Comparison to Residential Soil PRGs
Pioneer AOC, Former Wilkins AFS, Shelby, Ohio

Chemical	Frequency of Detection ^b	Range of Detected Concentrations	Mean Detected Concentration ^b	Range of Sample Quantitation Limits	Mean Nondetected Concentration ^b	Residential Soil PRG (THQ = 0.1) ^d	Ratio of Maximum Detected Concentration to Residential Soil PRG
Barium	35 / 35	3.13E+01 - 3.16E+02	9.06E+01	-	-	5.40E+02	5.9E-01
Beryllium	35 / 35	2.30E-01 - 1.20E+00	5.45E-01	-	-	1.50E+01	8.0E-02
Cadmium	30 / 35	2.10E-02 - 2.90E+00	6.03E-01	5.90E-01 - 2.30E+00	9.70E-01	3.70E+00	7.8E-01
Calcium	35 / 35	2.75E+03 - 1.32E+05	2.46E+04	-	-	ND	ND
Chromium, total	35 / 35	9.70E+00 - 3.86E+01	1.50E+01	-	-	2.20E+01	1.8E+00
Cobalt	35 / 35	3.40E+00 - 1.95E+01	8.41E+00	-	-	1.40E+02	1.4E-01
Copper	35 / 35	9.20E+00 - 5.17E+01	2.31E+01	-	-	3.10E+02	1.7E-01
Iron	35 / 35	7.68E+03 - 4.52E+04	1.92E+04	-	-	2.30E+03	2.0E+01
Lead	35 / 35	9.10E+00 - 1.11E+02	2.74E+01	-	-	4.00E+02	2.8E-01
Magnesium	35 / 35	1.88E+03 - 1.97E+04	6.09E+03	-	-	ND	ND
Manganese	35 / 35	1.38E+02 - 4.28E+03	5.55E+02	-	-	1.80E+02	2.4E+01
Mercury	35 / 35	3.80E-02 - 6.10E+00	6.47E-01	-	-	2.30E+00	2.7E+00
Nickel	35 / 35	1.08E+01 - 4.17E+01	2.11E+01	-	-	1.60E+02	2.6E-01
Potassium	35 / 35	4.15E+02 - 2.29E+03	1.08E+03	-	-	ND	ND
Selenium	26 / 35	4.80E-01 - 2.70E+00	1.10E+00	2.40E+00 - 3.87E+01	1.80E+01	3.90E+01	6.9E-02
Silver	10 / 35	1.30E-01 - 1.70E+00	4.41E-01	1.00E-01 - 2.58E+00	1.07E+00	3.90E+01	4.4E-02
Sodium	7 / 35	5.20E+01 - 1.10E+02	6.93E+01	1.18E+02 - 6.45E+02	2.78E+02	ND	ND
Thallium	6 / 35	5.00E-01 - 9.50E-01	7.53E-01	1.80E+00 - 2.58E+02	9.42E+01	5.20E-01	1.8E+00
Vanadium	35 / 35	1.09E+01 - 3.63E+01	2.19E+01	-	-	7.80E+00	4.7E+00
Zinc	34 / 35	4.12E+01 - 5.57E+02	1.06E+02	8.30E+01 - 8.30E+01	8.30E+01	2.30E+03	2.4E-01
Cyanide, total	2 / 13	2.40E-01 - 3.30E-01	2.85E-01	9.20E-02 - 1.29E+00	1.01E+00	1.20E+02	2.8E-03

Notes: All units are in mg/kg.

Shading indicates maximum detected concentration exceeds the residential soil PRG.

ND = PRG has not been derived.

^a Includes one sample that was collected from 0.3 to 0.8 feet bgs.

^b Based on dataset that includes the average of duplicate data.

^c Includes ½ reporting level for all nondetected congeners.

^d Residential Soil Preliminary Remediation Goals from USEPA Region IX, 2004, unless otherwise specified. All noncarcinogenic PRGs adjusted to a target hazard quotient of 0.1.

^e Acenaphthene PRG was used for screening.

^f Pyrene PRG was used for screening.

^g Naphthalene PRG was used for screening.

^h Anthracene PRG was used for screening.

TABLE 6-2
Summary of Detected Chemical Concentrations in Aggregate Soil (0-10 feet bgs) and Comparison to Residential Soil PRGs
Pioneer AOC, Former Wilkins AFS, Shelby, Ohio

Chemical	Frequency of Detection ^a	Range of Detected Concentrations	Mean Detected Concentration ^a	Range of Sample Quantitation Limits	Mean Nondetected Concentration ^a	Residential Soil PRG (THQ = 0.1) ^c	Ratio of Maximum Detected Concentration to Residential Soil PRG
Organics							
Acenaphthene	14 / 52	1.20E-03 - 5.50E-02	9.96E-03	6.10E-03 - 1.29E+01	1.48E+00	3.7E+02	1.5E-04
Acenaphthylene	6 / 25	1.10E-03 - 3.20E-02	8.75E-03	6.60E-03 - 1.50E-02	9.03E-03	3.7E+02 ^d	8.6E-05
Acetone	12 / 30	2.60E-03 - 1.50E-02	8.18E-03	2.40E-03 - 2.63E-02	1.78E-02	1.4E+03	1.1E-05
Anthracene	19 / 52	1.80E-03 - 3.10E-01	2.82E-02	6.00E-03 - 6.44E+00	8.51E-01	2.2E+03	1.4E-04
Benzaldehyde	9 / 22	1.80E-02 - 7.30E-02	4.36E-02	3.90E-01 - 7.40E-01	4.84E-01	6.1E+02	1.2E-04
Benz(a)anthracene	37 / 52	1.90E-03 - 1.70E+00	1.83E-01	1.70E-03 - 2.38E-01	4.80E-02	6.2E-01	2.7E+00
Benzo(a)pyrene	35 / 51	2.70E-03 - 2.10E+00	2.25E-01	1.70E-03 - 2.30E-01	3.91E-02	6.2E-02	3.4E+01
Benzo(b)fluoranthene	42 / 52	3.20E-03 - 1.80E+00	1.90E-01	2.60E-03 - 2.30E-01	5.40E-02	6.2E-01	2.9E+00
Benzo(ghi)perylene	34 / 52	2.30E-03 - 7.30E-01	9.68E-02	1.80E-03 - 1.19E+00	1.45E-01	2.3E+02 ^e	3.2E-03
Benzo(k)fluoranthene	39 / 52	1.60E-03 - 1.00E+00	1.04E-01	9.80E-04 - 2.30E-01	4.59E-02	6.2E+00	1.6E-01
Biphenyl, 1,1-	1 / 22	1.10E-01 - 1.10E-01	1.10E-01	3.90E-01 - 8.00E-01	4.84E-01	3.0E+02	3.6E-04
Bis(2-ethylhexyl) phthalate	23 / 51	2.60E-02 - 8.00E-01	3.44E-01	2.00E-01 - 6.60E-01	3.93E-01	3.5E+01	2.3E-02
Carbazole	7 / 51	2.30E-02 - 3.90E-01	1.61E-01	5.70E-02 - 7.40E-01	4.06E-01	2.4E+01	1.6E-02
Carbon disulfide	3 / 30	2.30E-03 - 3.90E-03	3.00E-03	6.78E-04 - 2.30E-03	1.13E-03	3.6E+01	1.1E-04
Chloroform	3 / 30	2.10E-03 - 8.00E-03	5.30E-03	6.78E-04 - 1.66E-03	1.06E-03	2.2E-01	3.6E-02
Chrysene	42 / 52	1.30E-03 - 1.80E+00	1.88E-01	1.16E-02 - 2.30E-01	5.50E-02	6.2E+01	2.9E-02
DDD, p,p'-	6 / 29	3.50E-03 - 1.60E-01	4.96E-02	2.00E-03 - 1.91E-01	3.01E-02	2.4E+00	6.6E-02
DDE, p,p'-	7 / 29	4.90E-03 - 1.60E-01	4.23E-02	1.20E-03 - 1.91E-01	3.13E-02	1.7E+00	9.3E-02
DDT, p,p'-	8 / 29	5.40E-03 - 3.80E-01	6.46E-02	2.40E-03 - 4.33E-02	2.38E-02	1.7E+00	2.2E-01
Dibenz(ah)anthracene	19 / 52	1.40E-03 - 1.70E-01	1.80E-02	1.10E-03 - 6.44E-01	8.62E-02	6.2E-02	2.7E+00
Dibenzofuran	8 / 51	4.20E-02 - 1.10E+00	2.35E-01	5.00E-02 - 8.51E-01	4.13E-01	1.5E+01	7.6E-02
Dichloroethene, 1,1-	4 / 30	8.20E-04 - 1.40E-03	1.04E-03	1.80E-03 - 4.97E-03	2.90E-03	1.2E+01	1.1E-04
Diethyl phthalate	6 / 29	3.70E-02 - 3.10E-01	1.25E-01	2.90E-02 - 8.51E-01	4.10E-01	4.9E+03	6.3E-05
Di-n-butyl phthalate	3 / 29	2.50E-01 - 5.10E+00	2.06E+00	3.70E-01 - 8.51E-01	4.24E-01	6.1E+02	8.3E-03
Fluoranthene	28 / 50	5.00E-03 - 6.40E+00	4.60E-01	3.40E-03 - 1.19E+00	1.20E-01	2.3E+02	2.8E-02
Fluorene	19 / 52	1.20E-03 - 2.30E-01	4.68E-02	2.60E-03 - 2.30E+00	2.90E-01	2.8E+02	8.4E-04
Hexachlorocyclohexane, beta-	2 / 28	3.50E-03 - 4.10E-02	2.23E-02	7.30E-04 - 2.02E-01	3.69E-02	3.2E-01	1.3E-01
Indeno(1,2,3-cd)pyrene	33 / 52	1.90E-03 - 1.30E+00	1.52E-01	3.00E-03 - 1.19E+00	1.43E-01	6.2E-01	2.1E+00
Methylene chloride	10 / 30	1.50E-03 - 6.10E-03	4.34E-03	1.80E-03 - 4.97E-03	2.83E-03	9.1E+00	6.7E-04
Methylnaphthalene, 2-	17 / 51	2.40E-02 - 4.20E+00	4.52E-01	6.90E-02 - 8.51E-01	4.32E-01	5.6E+00 ^f	7.5E-01
Naphthalene	27 / 52	1.10E-03 - 1.60E+00	1.38E-01	4.60E-03 - 6.44E+00	7.75E-01	5.6E+00	2.9E-01
Phenanthrene	38 / 52	2.90E-03 - 6.00E+00	4.34E-01	3.60E-03 - 2.30E+00	4.03E-01	2.2E+03 ^g	2.7E-03
Pyrene	42 / 52	3.20E-03 - 5.70E+00	4.87E-01	2.31E-02 - 2.38E-01	6.65E-02	2.3E+02	2.5E-02
Toluene	1 / 30	1.50E-03 - 1.50E-03	1.50E-03	1.36E-03 - 3.31E-03	1.98E-03	6.6E+01	2.3E-05
Polychlorinated Bipheyls							
PCB 1254	1 / 30	1.10E-01 - 1.10E-01	1.10E-01	1.50E-02 - 8.72E-02	6.35E-02	1.1E-01	9.8E-01
PCB 1260	3 / 30	1.50E-02 - 1.00E-01	5.50E-02	2.60E-02 - 4.30E-02	3.86E-02	1.1E-01	8.9E-01
Dioxins/Furans							
2,3,7,8-TCDD TEQ ^b	6 / 7	8.28E-07 - 6.65E-06	3.92E-06	5.38E-07 - 5.38E-07	5.38E-07	3.9E-06	1.7E+00

TABLE 6-2
Summary of Detected Chemical Concentrations in Aggregate Soil (0-10 feet bgs) and Comparison to Residential Soil PRGs
Pioneer AOC, Former Wilkins AFS, Shelby, Ohio

Chemical	Frequency of Detection ^a	Range of Detected Concentrations	Mean Detected Concentration ^a	Range of Sample Quantitation Limits	Mean Nondetected Concentration ^a	Residential Soil PRG (THQ = 0.1) ^c	Ratio of Maximum Detected Concentration to Residential Soil PRG
Inorganics							
Aluminum	52 / 52	3.10E+03 - 1.84E+04	9.41E+03	-	-	7.6E+03	2.4E+00
Antimony	13 / 52	3.90E-01 - 3.16E+01	3.19E+00	4.50E-01 - 3.87E+01	6.41E+00	3.1E+00	1.0E+01
Arsenic	52 / 52	4.60E+00 - 3.36E+01	1.11E+01	-	-	3.9E-01	8.6E+01
Barium	52 / 52	1.49E+01 - 4.70E+02	9.26E+01	-	-	5.4E+02	8.7E-01
Beryllium	52 / 52	1.20E-01 - 1.20E+00	5.08E-01	-	-	1.5E+01	7.8E-02
Cadmium	38 / 52	2.10E-02 - 1.22E+01	8.59E-01	5.90E-01 - 1.86E+01	4.18E+00	3.7E+00	3.3E+00
Calcium	52 / 52	2.75E+03 - 1.86E+05	3.00E+04	-	-	ND	ND
Chromium, total	52 / 52	8.80E+00 - 1.39E+02	1.74E+01	-	-	2.2E+01	6.2E+00
Cobalt	52 / 52	3.40E+00 - 1.95E+01	8.54E+00	-	-	1.4E+02	1.4E-01
Copper	52 / 52	9.20E+00 - 2.94E+02	2.84E+01	-	-	3.1E+02	9.4E-01
Iron	52 / 52	7.68E+03 - 4.52E+04	2.07E+04	-	-	2.4E+03	1.9E+01
Lead	52 / 52	6.80E+00 - 1.19E+03	4.52E+01	-	-	4.0E+02	3.0E+00
Magnesium	52 / 52	1.88E+03 - 3.07E+04	7.12E+03	-	-	ND	ND
Manganese	52 / 52	1.38E+02 - 4.28E+03	4.91E+02	-	-	1.8E+02	2.4E+01
Mercury	52 / 52	1.60E-02 - 4.54E+01	1.33E+00	-	-	2.4E+00	1.9E+01
Nickel	52 / 52	1.08E+01 - 4.54E+01	2.33E+01	-	-	1.6E+02	2.9E-01
Potassium	52 / 52	4.15E+02 - 2.29E+03	1.21E+03	-	-	ND	ND
Selenium	29 / 52	4.80E-01 - 2.70E+00	1.11E+00	2.40E+00 - 3.91E+01	2.91E+01	3.9E+01	6.9E-02
Silver	11 / 52	1.30E-01 - 2.78E+01	2.93E+00	1.00E-01 - 2.60E+00	1.54E+00	3.9E+01	7.1E-01
Sodium	16 / 52	5.20E+01 - 4.45E+02	1.15E+02	1.18E+02 - 6.51E+02	3.54E+02	ND	ND
Thallium	12 / 52	5.00E-01 - 1.00E+00	7.72E-01	1.80E+00 - 2.60E+02	1.36E+02	5.2E-01	1.9E+00
Vanadium	52 / 52	1.09E+01 - 4.26E+01	2.29E+01	-	-	7.8E+00	5.4E+00
Zinc	51 / 52	3.29E+01 - 1.64E+03	1.26E+02	8.30E+01 - 8.30E+01	8.30E+01	2.4E+03	7.0E-01
Cyanide, total	5 / 30	2.40E-01 - 2.50E+00	7.86E-01	9.10E-02 - 1.30E+00	1.07E+00	1.2E+02	2.1E-02

Notes: All units are in mg/kg.

Shading indicates maximum detected concentration exceeds the residential soil PRG.

ND = PRG has not been derived.

^a Based on dataset that includes the average of duplicate data.

^b Includes ½ reporting level for all nondetected congeners.

^c Residential Soil Preliminary Remediation Goals from USEPA Region IX, 2004, unless otherwise specified. All noncarcinogenic PRGs adjusted to a target hazard quotient of 0.1.

^d Acenaphthene PRG was used for screening.

^e Pyrene PRG was used for screening.

^f Naphthalene PRG was used for screening.

^g Anthracene PRG was used for screening.

TABLE 6-3
Summary of Detected Chemical Concentrations in Background Surface Soil (0-0.5 feet bgs) and Comparison to Residential Soil PRGs
Pioneer AOC, Former Wilkins AFS, Shelby, Ohio

Chemical	Frequency of Detection ^a	Range of Detected Concentrations	Mean Detected Concentration ^a	Range of Sample Quantitation Limits	Mean Nondetected Concentration ^a	Residential Soil PRG (THQ = 0.1) ^c	Ratio of Maximum Detected Concentration to Residential Soil PRG
Organics							
Acenaphthene	1 / 7	1.20E-03 - 2.90E-03	2.90E-03	8.10E-03 - 1.00E-02	8.75E-03	3.70E+02	7.8E-06
Anthracene	2 / 7	1.00E-03 - 1.00E-02	5.50E-03	8.10E-03 - 1.00E-02	8.82E-03	2.20E+03	4.5E-06
Benzaldehyde	4 / 7	2.00E-02 - 2.90E-02	2.40E-02	4.00E-01 - 5.00E-01	4.43E-01	6.10E+02	4.8E-05
Benzo(a)anthracene	6 / 7	1.20E-03 - 3.40E-02	7.97E-03	8.60E-03 - 8.60E-03	8.60E-03	6.20E-01	5.5E-02
Benzo(a)pyrene	7 / 7	1.30E-03 - 3.60E-02	7.86E-03	-	-	6.20E-02	5.8E-01
Benzo(b)fluoranthene	7 / 7	2.80E-03 - 4.10E-02	9.99E-03	-	-	6.20E-01	6.6E-02
Benzo(ghi)perylene	7 / 7	1.80E-03 - 2.40E-02	6.04E-03	-	-	2.30E+02 ^d	1.0E-04
Benzo(k)fluoranthene	6 / 7	1.40E-03 - 3.30E-02	7.28E-03	8.50E-03 - 8.50E-03	8.50E-03	6.20E+00	5.3E-03
Bis(2-ethylhexyl) phthalate	7 / 7	1.90E-02 - 3.90E-01	1.21E-01	-	-	3.50E+01	1.1E-02
Butylbenzyl phthalate	1 / 7	5.00E-02 - 5.00E-02	5.00E-02	3.90E-01 - 5.00E-01	4.36E-01	1.20E+03	4.2E-05
Chrysene	7 / 7	4.20E-03 - 4.70E-02	1.13E-02	-	-	6.20E+01	7.6E-04
Dibenz(ah)anthracene	2 / 7	1.90E-03 - 5.50E-03	3.70E-03	8.10E-03 - 1.00E-02	8.80E-03	6.20E-02	8.9E-02
Fluoranthene	7 / 7	2.00E-03 - 7.10E-02	1.51E-02	-	-	2.30E+02	3.1E-04
Fluorene	1 / 7	3.40E-03 - 3.40E-03	3.40E-03	8.00E-03 - 1.00E-02	8.75E-03	2.70E+02	1.3E-05
Indeno(1,2,3-cd)pyrene	7 / 7	1.50E-03 - 1.90E-02	4.81E-03	-	-	6.20E-01	3.1E-02
Methylnaphthalene, 2-	1 / 7	5.00E-02 - 6.00E-02	5.50E-02	4.00E-01 - 5.00E-01	4.35E-01	5.60E+00 ^e	1.1E-02
Naphthalene	7 / 7	1.20E-03 - 4.30E-02	7.39E-03	-	-	5.60E+00	7.7E-03
Phenanthrene	7 / 7	1.90E-03 - 5.80E-02	1.17E-02	-	-	2.20E+03 ^f	2.6E-05
Phenol	1 / 7	5.20E-02 - 5.20E-02	5.20E-02	3.90E-01 - 5.00E-01	4.35E-01	3.70E+03	1.4E-05
Pyrene	7 / 7	3.10E-03 - 6.90E-02	1.46E-02	-	-	2.30E+02	3.0E-04
Dioxins/Furans							
2,3,7,8-TCDD TEQ ^b	1 / 1	4.52E-06 - 4.62E-06	4.57E-06	-	-	3.90E-06	1.2E+00
Inorganics							
Aluminum	7 / 7	7.24E+03 - 1.15E+04	9.99E+03	-	-	7.60E+03	1.5E+00
Arsenic	7 / 7	9.80E+00 - 1.21E+01	1.10E+01	-	-	3.90E-01	3.1E+01
Barium	7 / 7	6.25E+01 - 1.00E+02	8.47E+01	-	-	5.40E+02	1.9E-01
Beryllium	7 / 7	5.40E-01 - 7.10E-01	6.34E-01	-	-	1.50E+01	4.7E-02
Cadmium	7 / 7	2.90E-02 - 2.10E-01	1.04E-01	-	-	3.70E+00	5.7E-02
Calcium	7 / 7	1.08E+04 - 3.82E+04	2.43E+04	-	-	ND	ND
Chromium, total	7 / 7	1.17E+01 - 1.75E+01	1.52E+01	-	-	2.20E+01	8.0E-01
Cobalt	7 / 7	7.80E+00 - 1.11E+01	9.06E+00	-	-	1.40E+02	7.9E-02
Copper	7 / 7	2.06E+01 - 2.44E+01	2.24E+01	-	-	3.10E+02	7.9E-02
Iron	7 / 7	1.97E+04 - 2.55E+04	2.20E+04	-	-	2.30E+03	1.1E+01
Lead	7 / 7	1.46E+01 - 2.79E+01	2.03E+01	-	-	4.00E+02	7.0E-02
Magnesium	7 / 7	3.65E+03 - 1.55E+04	8.86E+03	-	-	ND	ND
Manganese	7 / 7	2.91E+02 - 6.62E+02	4.35E+02	-	-	1.80E+02	3.7E+00
Mercury	7 / 7	4.30E-02 - 6.00E-02	5.14E-02	-	-	2.30E+00	2.6E-02
Nickel	7 / 7	2.21E+01 - 2.77E+01	2.48E+01	-	-	1.60E+02	1.7E-01
Potassium	7 / 7	9.71E+02 - 1.37E+03	1.15E+03	-	-	ND	ND
Selenium	7 / 7	6.90E-02 - 1.10E+00	7.48E-01	2.40E+00 - 2.40E+00	-	3.90E+01	2.8E-02
Vanadium	7 / 7	1.86E+01 - 2.65E+01	2.34E+01	-	-	7.80E+00	3.4E+00
Zinc	7 / 7	7.19E+01 - 1.05E+02	8.09E+01	-	-	2.30E+03	4.6E-02

Notes: All units are in mg/kg.

Shading indicates maximum detected concentration exceeds the residential soil PRG.

ND = PRG has not been derived.

^a Based on dataset that includes the average of duplicate data.

^b Includes ½ reporting level for all nondetected congeners.

^c Residential Soil Preliminary Remediation Goals from USEPA Region IX, 2004, unless otherwise specified. All noncarcinogenic PRGs adjusted to a target hazard quotient of 0.1.

^d Pyrene PRG was used for screening.

^e Naphthalene PRG was used for screening.

Table 6-4
Comparison of Site Surface Soil Data and Background Concentrations (0-0.5 feet bgs)
Pioneer AOC, Former Wilkins AFS, Shelby, OH

Chemical	Site Concentrations		Background Concentrations		Ratio of Site and Background Maximum Detects	Ratio of Site and Background Arithmetic Means
	Maximum Detected Concentration	Arithmetic Mean	Maximum Detected Concentration	Arithmetic Mean		
Organics						
Benz(a)anthracene	1.40E+00	8.55E-02	3.40E-02	8.29E-03	4.1E+01	1.03E+01
Benzo(a)pyrene	1.80E+00	9.61E-02	3.60E-02	7.86E-03	5.0E+01	1.22E+01
Benzo(b)fluoranthene	1.70E+00	9.48E-02	4.10E-02	9.99E-03	4.1E+01	9.49E+00
Dibenz(ah)anthracene	1.70E-01	5.79E-02	5.50E-03	6.25E-03	3.1E+01	9.26E+00
Indeno(1,2,3-cd)pyrene	1.30E+00	2.44E-01	1.90E-02	4.81E-03	6.8E+01	5.07E+01
Dioxins/Furans						
2,3,7,8-TCDD TEQ	6.65E-06	5.98E-06	4.62E-06	4.57E-06	1.4E+00	1.31E+00
Inorganics						
Aluminum	1.38E+04	9.26E+03	1.15E+04	9.99E+03	1.2E+00	9.27E-01
Arsenic	3.36E+01	1.10E+01	1.21E+01	1.10E+01	2.8E+00	1.00E+00
Chromium, total	3.86E+01	1.50E+01	1.75E+01	1.52E+01	2.2E+00	9.87E-01
Iron	4.52E+04	1.92E+04	2.55E+04	2.20E+04	1.8E+00	8.73E-01
Manganese	4.28E+03	5.55E+02	6.62E+02	4.35E+02	6.5E+00	1.28E+00
Mercury	6.10E+00	6.47E-01	6.00E-02	5.14E-02	1.0E+02	1.26E+01
Thallium	9.50E-01	4.75E+01	NDB	NDB	NDB	NDB
Vanadium	3.63E+01	2.19E+01	2.65E+01	2.34E+01	1.4E+00	9.36E-01

Notes: All units are in mg/kg.
NDB = not detected in background samples.

TABLE 6-5
 Summary of the Gastrointestinal Absorption Factors (ABS_{GI})
 Pioneer AOC, Former Wilkins AFS
 Shelby, OH

COPC	ABS _{GI}
<i>Organics</i>	
Benzo(a)anthracene	1.0
Benzo(a)pyrene	1.0
Benzo(b)fluoranthene	1.0
Dibenz(a,h)anthracene	1.0
Indeno(1,2,3-cd)pyrene	1.0
2,3,7,8-TCDD TEQ	1.0
<i>Inorganics</i>	
Aluminum	1.0
Antimony	0.15
Arsenic	1.0
Cadmium	0.025
Chromium	0.025
Iron	1.0
Lead	1.0
Manganese	0.04
Mercury	0.07
Thallium	1.0
Vanadium	0.026

Source: Exhibit 4-1, *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Part E – Supplemental Guidance for Dermal Risk Assessment* (EPA, 2004b).

TABLE 6-6
Summary of the Cancer Slope Factors and Reference Doses
Pioneer AOC, Former Wilkins AFS
Shelby, OH

COPC	Weight of Evidence	CSF _i (mg/kg-day) ⁻¹	CSF _o (mg/kg-day) ⁻¹	ABS _{gi}	CSF _d (mg/kg-day) ⁻¹	Source	RfD _i (mg/kg-day)	RfD _o (mg/kg-day)	Route of Administration	Critical Effect	ABS _{gi}	RfD _d (mg/kg-day)	Source
Organics													
Benzo(a)anthracene	B2	7.3E-01*	7.3E-01	1.0	7.3E-01	NCEA	---	---	---	---	1.0	---	---
Benzo(a)pyrene	B2	7.3E+00*	7.3E+00	1.0	7.3E+00	IRIS	---	---	---	---	1.0	---	---
Benzo(b)fluoranthene	B2	7.3E-01*	7.3E-01	1.0	7.3E-01	NCEA	---	---	---	---	1.0	---	---
Dibenz(a,h)anthracene	B2	7.3E+00*	7.3E+00	1.0	7.3E+00	NCEA	---	---	---	---	1.0	---	---
Indeno(1,2,3-cd)pyrene	B2	7.3E-01*	7.3E-01	1.0	7.3E-01	NCEA	---	---	---	---	1.0	---	---
2,3,7,8-TCDD TEQ	A	1.5E+05	1.5E+05	1.0	1.5E+05	HEAST	---	---	---	---	1.0	---	---
Inorganics													
Aluminum	NCL	---	---	---	---	---	1.4E-03	1E+00	No information	No information	1.0	1E+00	PPRTV
Antimony	NCL	---	---	---	---	---	4E-04*	4E-04	Diet	Blood effects	0.15	6E-05	IRIS
Arsenic	A	1.5E+01	1.5E+00	1.0	1.5E+00	IRIS	3E-04*	3.0E-04	Diet	Skin effects; vascular complications	1.0	3.0E-04	IRIS
Cadmium	B1 ^a	6.3E+00	NTV	0.025	NTV	IRIS	5E-04*	5E-04	Drinking water	Proteinuria	0.025	1.3E-05	IRIS
Chromium	A ^a	4.1E+01	NTV	0.025	NTV	IRIS	3E-05	3E-03	Drinking water	No observed adverse effects	0.025	7.5E-05	IRIS
Iron	NCL	---	---	---	---	---	3E-01*	3E-01	No information	No information	1.0	3E-01	NCEA
Lead	B2	NTV	NTV	1.0	NTV	IRIS	NTV	NTV	No information	No information	1.0	NTV	---
Manganese	D	---	---	0.04	---	IRIS	1.4E-05	2.4E-02	Diet	Central nervous system effects	0.04	2.1E-05	IRIS
Mercury	C	---	---	0.07	---	IRIS	8.6E-05	3.0E-04	Subcutaneous	Autoimmune effects	0.07	9.6E-04	IRIS

TABLE 6-6, continued
 Summary of the Cancer Slope Factors and Reference Doses
 Pioneer AOC, Former Wilkins AFS
 Shelby, OH

COPC	Weight of Evidence	CSF _i (mg/kg-day) ⁻¹	CSF _o (mg/kg-day) ⁻¹	ABS _{gi}	CSF _d (mg/kg-day) ⁻¹	Source	RfD _i (mg/kg-day)	RfD _o (mg/kg-day)	Route of Administration	Critical Effect	ABS _{gi}	RfD _d (mg/kg-day)	Source
Thallium	D	---	---	1.0	---	IRIS	6.6E-05	6.6E-05	Gavage	No adverse effects	1.0	6.6E-05	IRIS
Vanadium	NCL	---	---	---	---	---	1E-03 ^a	1E-03	No information	No information	0.026	2.6E-05	NCEA

Notes:

* Oral slope factor was used as a surrogate.

HEAST = Health Effects Assessment Summary Table.

IRIS = Integrated Risk Information System.

NCEA = National Center for Environmental Assessment (as presented on the EPA Region IX PRG Table).

PPRTV = Provisional Peer-Reviewed Toxicity Value.

^a Classification based on inhalation route. Evidence for carcinogenicity in oral studies is limited or lacking.

TABLE 6-7
 Summary of the Toxic Equivalency Factors (TEFs) for Dioxins and Furans
 Pioneer AOC, Former Wilkins AFS
 Shelby, OH

Congener	TEF
Chlorodibenzo-p-dioxins (CDDs)	
2,3,7,8-TCDD	1
1,2,3,7,8-PeCDD	1
1,2,3,4,7,8-HxCDD 1,2,3,6,7,8-HxCDD 1,2,3,7,8,9-HxCDD	0.1
1,2,3,4,6,7,8-HpCDD	0.01
OCDD	0.0001
Chlorodibenzofurans (CDFs)	
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF 2,3,4,7,8-PeCDF	0.05 0.5
1,2,3,4,7,8-HxCDF 1,2,3,6,7,8-HxCDF 1,2,3,7,8,9-HxCDF 2,3,4,6,7,8-HxCDF	0.1
1,2,3,4,6,7,8-HpCDF 1,2,3,4,7,8,9-HpCDF	0.01
OCDF	0.0001

Source: Van den Berg *et al.*, 1998.

TABLE 6-8
 Summary of the COPC-Specific Exposure Point Concentrations in Soil (0-0.5 feet bgs)^a
 Maintained Area
 Pioneer AOC, Former Wilkins AFS
 Shelby, OH

COPC	Maximum Detected Concentration	Data Distribution	95% UCL Calculation Method	95% UCL ^b	Exposure Point Concentration ^c
Organics					
Benzo(a)anthracene	1.20E+00	lognormal	95% Chebyshev (MVUE) UCL	2.13E-01	2.13E-01
Benzo(a)pyrene	1.20E+00	lognormal	95% Chebyshev (MVUE) UCL	2.18E-01	2.18E-01
Benzo(b)fluoranthene	1.60E+00	lognormal	H-UCL	2.29E-01	2.29E-01
Dibenz(a,h)anthracene	1.70E-01	non-parametric	99% Chebyshev (Mean, SD) UCL	1.01E-01	1.01E-01
Indeno(1,2,3-cd)pyrene	8.90E-01	non-parametric	99% Chebyshev (Mean, SD) UCL	4.91E-01	4.91E-01
Inorganics					
Aluminum	1.62E+04	normal	Student's-t UCL	1.06E+04	1.06E+04
Arsenic	3.36E+01	gamma	approximate gamma UCL	1.19E+01	1.19E+01
Chromium, total	2.45E+01	gamma	approximate gamma UCL	1.56E+01	1.56E+01
Iron	4.52E+04	non-parametric	Modified-t UCL	2.17E+04	2.17E+04
Manganese	4.28E+03	non-parametric	95% Chebyshev (Mean, SD) UCL	1.35E+03	1.35E+03
Mercury	6.10E+00	non-parametric	99% Chebyshev (Mean, SD) UCL	3.07E+00	3.07E+00
Thallium	9.50E-01	non-parametric	99% Chebyshev (Mean, SD) UCL	1.44E+02	9.50E-01
Vanadium	3.81E+01	non-parametric	Modified-t UCL	2.42E+01	2.42E+01

Note - all units presented in mg/kg.

^aThere is no data for dioxins/furans in the maintained area; therefore, 2,3,7,8-TCDD TEQ was not evaluated as a COPC in this area.

^bNondetects were included at one-half the sample quantitation limit.

^cBased on the 95% UCL or the maximum detected concentration, whichever was lower.

UCL = Upper confidence limit.

TABLE 6-9
 Summary of the COPC-Specific Exposure Point Concentrations in Soil (0-0.5 feet bgs)
 Mound Area
 Pioneer AOC, Former Wilkins AFS
 Shelby, OH

COPC	Maximum Detected Concentration	Data Distribution	95% UCL Calculation Method	95% UCL ^a	Exposure Point Concentration ^b
Organics					
Benzo(a)anthracene	1.40E+00	gamma	adjusted gamma UCL	8.89E-01	8.89E-01
Benzo(a)pyrene	1.80E+00	gamma	approximate gamma UCL	1.00E+00	1.00E+00
Benzo(b)fluoranthene	1.70E+00	gamma	adjusted gamma UCL	1.05E+00	1.05E+00
Dibenz(a,h)anthracene	6.80E-02	gamma	adjusted gamma UCL	2.11E-01	6.80E-02
Indeno(1,2,3-cd)pyrene	1.30E+00	gamma	adjusted gamma UCL	9.25E-01	9.25E-01
2,3,7,8-TCDD TEQ	6.65E-06	ND	NC	NC	6.65E-06
Inorganics					
Aluminum	1.22E+04	normal	Student's-t UCL	9.90E+03	9.90E+03
Arsenic	1.91E+01	normal	Student's-t UCL	1.51E+01	1.51E+01
Chromium, total	3.86E+01	non-parametric	Modified-t UCL	2.27E+01	2.27E+01
Iron	2.57E+04	normal	Student's-t UCL	2.09E+04	2.09E+04
Manganese	7.40E+02	normal	Student's-t UCL	5.61E+02	5.61E+02
Mercury	5.00E+00	gamma	approximate gamma UCL	2.39E+00	2.39E+00
Thallium	8.10E-01	non-parametric	99% Chebyshev (Mean, SD) UCL	2.52E+02	8.10E-01
Vanadium	2.73E+01	normal	Student's-t UCL	2.41E+01	2.41E+01

Note - all units presented in mg/kg.

^a Nondetects were included at one-half the sample quantitation limit.

^b Based on the 95% UCL or the maximum detected concentration, whichever was lower.

UCL = Upper confidence limit.

NC = Not calculated, insufficient sample size.

ND = Not determined, insufficient sample size.

TABLE 6-10
Summary of the COPC-Specific Exposure Point Concentrations in Soil (0-10 feet bgs)

Pioneer AOC, Former Wilkins AFS
Shelby, OH

COPC	Maximum Detected Concentration	Data Distribution	95% UCL Calculation Method	95% UCL ^a	Exposure Point Concentration ^b
Organics					
Benzo(a)anthracene	1.70E+00	non-parametric	97.5% Chebyshev (Mean, SD) UCL	4.34E-01	4.34E-01
Benzo(a)pyrene	2.10E+00	non-parametric	97.5% Chebyshev (Mean, SD) UCL	5.26E-01	5.26E-01
Benzo(b)fluoranthene	1.80E+00	lognormal	H-UCL	2.53E-01	2.53E-01
Dibenz(a,h)anthracene	1.70E-01	non-parametric	97.5% Chebyshev (Mean, SD) UCL	9.18E-02	9.18E-02
Indeno(1,2,3-cd)pyrene	1.30E+00	non-parametric	97.5% Chebyshev (Mean, SD) UCL	3.73E-01	3.73E-01
2,3,7,8-TCDD TEQ	6.65E-06	normal	Student's-t UCL	5.27E-06	5.27E-06
Inorganics					
Aluminum	1.84E+04	normal	Student's-t UCL	1.02E+04	1.02E+04
Antimony	3.16E+01	non-parametric	97.5% Chebyshev (Mean, SD) UCL	7.77E+00	7.77E+00
Arsenic	3.36E+01	lognormal	H-UCL	1.23E+01	1.23E+01
Cadmium	1.22E+01	non-parametric	97.5% Chebyshev (Mean, SD) UCL	3.20E+00	3.20E+00
Chromium, total	1.39E+02	non-parametric	Modified-t UCL	2.19E+01	2.19E+01
Iron	4.52E+04	non-parametric	Modified-t UCL	2.24E+04	2.24E+04
Lead	1.19E+03	non-parametric	95% Chebyshev (Mean, SD) UCL	1.44E+02	1.44E+02
Manganese	4.28E+03	lognormal	H-UCL	5.31E+02	5.31E+02
Mercury	4.54E+01	non-parametric	97.5% Chebyshev (Mean, SD) UCL	6.81E+00	6.81E+00
Thallium	1.00E+00	non-parametric	99% Chebyshev (Mean, SD) UCL	1.36E+02	1.00E+00
Vanadium	4.26E+01	normal	Student's-t UCL	2.45E+01	2.45E+01

Note - all units presented in mg/kg.

^a Nondetects were included at one-half the sample quantitation limit.

^b Based on the 95% UCL or the maximum detected concentration, whichever was lower.

UCL = Upper confidence limit.

NC = Not calculated, insufficient sample size.

ND = Not determined, insufficient sample size.

TABLE 6-11
 Summary of the COPC-Specific Dermal Absorption Factors (ABS_d)
 Pioneer AOC, Former Wilkins AFS
 Shelby, OH

COPC	ABS _d
<i>Organics</i>	
Benzo(a)anthracene	0.13
Benzo(a)pyrene	0.13
Benzo(b)fluoranthene	0.13
Dibenz(a,h)anthracene	0.13
Indeno(1,2,3-cd)pyrene	0.13
2,3,7,8-TCDD TEQ	0.03
<i>Inorganics</i>	
Aluminum	0.01
Antimony	0.01
Arsenic	0.03
Cadmium	0.001
Chromium	0.01
Iron	0.01
Lead	0.01
Manganese	0.01
Mercury	0.01
Thallium	0.01
Vanadium	0.01

Source:

Exhibit 3-4, *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Part E – Supplemental Guidance for Dermal Risk Assessment* (EPA, 2004b).

TABLE 6-12
Dose Equation for Incidental Ingestion of Soil by a Site Worker
Pioneer AOC, Former Wilkins AFS
Shelby, OH

Dose from Soil Ingestion (mg/kg - day) = $\frac{CS \times IRS \times FI \times CF \times EF \times ED}{BW \times AT}$	
Where:	Value
CS = Chemical concentration in soil (mg/kg).	COPC-specific; See Table 6-8
IRS = Soil ingestion rate (mg/day).	100
FI = Fraction of soil ingested from contaminated source (unitless).	1.0
CF = Conversion factor (kg/mg).	0.000001
EF = Exposure frequency (days/year).	56
ED = Exposure duration (years).	25
BW = Body weight (kg).	70
AT = Averaging time (days).	Cancer – 25,550 Noncancer – 9,125

TABLE 6-13
Dose Equation for Dermal Contact with Soil by a Site Worker
Pioneer AOC, Former Wilkins AFS
Shelby, OH

Dose from Dermal Absorption (mg/kg - day) = $\frac{CS \times CF \times SA \times AF \times ABS_d \times EF \times ED}{BW \times AT}$	
Where:	Value
CS = Chemical concentration in soil (mg/kg).	COPC-specific; See Table 6-8
CF = Conversion factor (kg/mg).	0.000001
SA = Skin surface area available for contact (cm ² /day).	3,300
AF = Soil-to-skin adherence factor (mg/cm ²).	0.2
ABS _d = Dermal absorption factor (unitless).	COPC-specific; See Table 6-11
EF = Exposure frequency (days/year).	56
ED = Exposure duration (years).	25
BW = Body weight (kg).	70
AT = Averaging time (days).	Cancer – 25,550 Noncancer – 9,125

TABLE 6-14
Dose Equation for Inhalation of Particulate by a Site Worker
Pioneer AOC, Former Wilkins AFS
Shelby, OH

Dose from Particulate Inhalation (mg/kg - day) = $\frac{CS \times IRA \times EF \times ED}{BW \times AT \times PEF}$	
Where:	Value
CS = Chemical concentration in soil (mg/kg).	COPC-specific; See Table 6-8
IRA = Inhalation rate (m ³ /day).	20
EF = Exposure frequency (days/year).	56
ED = Exposure duration (years).	25
BW = Body weight (kg).	70
AT = Averaging time (days).	Cancer – 25,550 Noncancer – 9,125
PEF = Particulate emission factor (m ³ /kg).	2.80E+09

TABLE 6-15
Dose Equation for Incidental Ingestion of Soil by a Site Trespasser
Pioneer AOC, Former Wilkins AFS
Shelby, OH

Dose from Soil Ingestion (mg/kg - day) = $\frac{CS \times IRS \times FI \times CF \times EF \times ED}{BW \times AT}$	
Where:	Value
CS = Chemical concentration in soil (mg/kg).	COPC-specific; See Table 6-9
IRS = Soil ingestion rate (mg/day).	100
FI = Fraction of soil ingested from contaminated source (unitless).	0.5
CF = Conversion factor (kg/mg).	0.000001
EF = Exposure frequency (days/year).	52
ED = Exposure duration (years).	12
BW = Body weight (kg).	45
AT = Averaging time (days).	Cancer – 25,550 Noncancer – 4,380

Table 6-16
Dose Equation for Dermal Contact with Soil by a Site Trespasser
Pioneer AOC, Former Wilkins AFS
Shelby, OH

$\text{Dose from Dermal Absorption (mg/kg - day)} = \frac{\text{CS} \times \text{CF} \times \text{SA} \times \text{AF} \times \text{ABS}_d \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$	
Where:	Value
CS = Chemical concentration in soil (mg/kg).	COPC-specific; See Table 6-9
CF = Conversion factor (kg/mg).	0.000001
SA = Skin surface area available for contact (cm ² /day).	4,373
AF = Soil-to-skin adherence factor (mg/cm ²).	0.07
ABS _d = Dermal absorption factor (unitless).	COPC-specific; See Table 6-11
EF = Exposure frequency (days/year).	52
ED = Exposure duration (years).	12
BW = Body weight (kg).	45
AT = Averaging time (days).	Cancer – 25,550 Noncancer – 4,380

TABLE 6-17
Dose Equation for Inhalation of Particulate by a Site Trespasser
Pioneer AOC, Former Wilkins AFS
Shelby, OH

$\text{Dose from Particulate Inhalation (mg/kg-day)} = \frac{\text{CS} \times \text{IRA} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT} \times \text{PEF}}$	
Where:	Value
CS = Chemical concentration in soil (mg/kg).	COPC-specific; See Table 6-9
IRA = Inhalation rate (m ³ /day).	20
EF = Exposure frequency (days/year).	52
ED = Exposure duration (years).	12
BW = Body weight (kg).	45
AT = Averaging time (days).	Cancer – 25,550 Noncancer – 4,380
PEF = Particulate emission factor (m ³ /kg).	3.11E+09

TABLE 6-18
Dose Equation for Incidental Ingestion of Soil by a Future Construction Worker
Pioneer AOC, Former Wilkins AFS
Shelby, OH

Dose from Soil Ingestion (mg/kg - day) = $\frac{CS \times IRS \times FI \times CF \times EF \times ED}{BW \times AT}$		
Where:		Value
CS	= COPC concentration in soil (mg/kg).	COPC-specific; See Table 6-10
IRS	= Soil ingestion rate (mg/day).	330
FI	= Fraction of soil ingested from contaminated source (unitless).	1.0
CF	= Conversion factor (kg/mg).	0.000001
EF	= Exposure frequency (days/year).	125
ED	= Exposure duration (years).	0.5
BW	= Body weight (kg).	70
AT	= Carcinogenic averaging time (days).	Cancer – 25,550 Noncancer – 183

TABLE 6-19
Dose Equation for Dermal Contact with Soil by a Future Construction Worker
Pioneer AOC, Former Wilkins AFS
Shelby, OH

Dose from Dermal Absorption (mg/kg - day) = $\frac{CS \times CF \times SA \times AF \times ABS_d \times EF \times ED}{BW \times AT}$	
Where:	Value
CS = COPC concentration in soil (mg/kg).	COPC-specific; See Table 6-10
CF = Conversion factor (kg/mg).	0.000001
SA = Skin surface area available for contact (cm ² /day).	3,300
AF = Soil-to-skin adherence factor (mg/cm ²).	0.3
ABS _d = Dermal absorption factor (unitless).	COPC-specific; See Table 6-11
EF = Exposure frequency (days/year).	125
ED = Exposure duration (years).	0.5
BW = Body weight (kg).	70
AT = Carcinogenic averaging time (days).	Cancer – 25,550 Noncancer – 183

TABLE 6-20
Dose Equation for Inhalation of Particulate by a Future Construction Worker
Pioneer AOC, Former Wilkins AFS
Shelby, OH

Dose from Particulate Inhalation (mg/kg - day) = $\frac{CS \times IRA \times EF \times ED}{BW \times AT \times PEF}$	
Where:	Value
CS = COPC concentration in soil (mg/kg).	COPC-specific; See Table 6-10
IRA = Inhalation rate (m ³ /day).	20
EF = Exposure frequency (days/year).	125
ED = Exposure duration (years).	0.5
BW = Body weight (kg).	70
AT = Carcinogenic averaging time (days).	Cancer – 25,550 Noncancer – 183
PEF = Particulate emission factor (m ³ /kg). See Table 6-21.	9.33E+05

TABLE 6-21
 Particulate Emission Factor (PEF) Equation for the Construction Worker
 Scenario
 Pioneer AOC, Former Wilkins AFS
 Shelby, OH

$$PEF (m^3/kg) = Q/C_{sr} \times \frac{1}{F_D} \times \left[\frac{T \times A_R}{556 \times \left(\frac{W}{3}\right)^{0.4} \times \frac{(365 \text{ d/yr} - p)}{365 \text{ d/yr}} \times \sum VKT} \right]$$

Where:

$$Q/C_{sr} (g/m^2 - s \text{ per } kg/m^3) = A \times \exp \left[\frac{(\ln A_s - B)^2}{C} \right]$$

$$A_R (m^2) = (L_R \times W_R)$$

Where:	Value
PEF = Particulate emission factor from truck traffic on unpaved roads (m ³ /kg).	9.33E+05
Q/C _{sr} = Inverse of 1-h average air concentration along a straight road segment bisecting a 5-acre square site (g/m ² -s per kg/m ³).	15.2
F _D = Dispersion correction factor (unitless). Default value (EPA, 2002b).	0.185
T = Total time over which construction occurs (s).	3.6E+06 ^a
A _R = Surface area of contaminated road segment (m ²).	1206
W = Mean vehicle weight (tons).	8 ^b
p = Number of days with at least 0.01 inches of precipitation (days/year).	140 ^c
VKT = Sum of fleet vehicle kilometers traveled during the exposure duration (km).	754 ^d
A = Constant (unitless). Default value (EPA, 2002b).	12.9351
A _s = Areal extent of site soil contamination (acres). Approximation.	10
B = Constant (unitless). Default value (EPA, 2002b).	5.7383
C = Constant (unitless). Default value (EPA, 2002b).	71.7711
L _R = Length of road segment (m). Site-specific	201 ^e
W _R = Width of road segment (m). Default value (EPA, 2002b).	6

^a Assumes exposure 125 days/year for 8 hours/day.

^b Weighted average that assumes 20 cars/day at 2 tons, 10 trucks/day at 20 tons.

^c See Exhibit 5-2 (EPA, 2002b).

^d VKT = 30 vehicles x 0.201 km/day (see L_r) x 125 days/year.

^e Calculated based on the area of the site. Assumes site is roughly configured as a square with the unpaved road transecting the area evenly. Value is equal to the square root of the area where 10 acres equals 40,469 m².

TABLE 6-22
 Cancer Dose Equations for the Future Residential Scenario
 Pioneer AOC, Former Wilkins AFS
 Shelby, OH

$\text{Dose from Soil Ingestion (mg/kg - day)} = \frac{\text{CS} \times \text{IFS}_{\text{adj}} \times \text{FI} \times \text{CF} \times \text{EF}}{\text{AT}_c}$	
$\text{Dose from Dermal Absorption (mg/kg - day)} = \frac{\text{CS} \times \text{CF} \times \text{SFS}_{\text{adj}} \times \text{ABS}_d \times \text{EF}}{\text{AT}_c}$	
$\text{Dose from Particulate Inhalation (mg/kg - day)} = \frac{\text{CS} \times \text{IFA}_{\text{adj}} \times \text{EF}}{\text{AT}_c \times \text{PEF}}$	
Where:	Value
CS = COPC concentration in soil (mg/kg).	COPC-specific; See Table 6-10
IFS _{adj} = Age-adjusted soil ingestion factor (mg-year/kg-day). See Table 6-23.	114
FI = Fraction of soil ingested from contaminated source (unitless).	1.0
CF = Conversion factor (kg/mg).	0.000001
EF = Exposure frequency (days/year).	350
AT _c = Carcinogenic averaging time (days).	25,550
SFS _{adj} = Age-adjusted soil contact factor (mg-year/kg-day). See Table 6-23.	361
ABS _d = Dermal absorption factor (unitless).	COPC-specific; See Table 6-11
IFA _{adj} = Age-adjusted inhalation factor (m ³ -year/kg-day). See Table 6-23.	11
PEF = Particulate emission factor (m ³ /kg).	9.24E+08

TABLE 6-23
 Calculation of the Age-Adjusted Factors for the Future Residential Scenario
 Pioneer AOC, Former Wilkins AFS
 Shelby, OH

$\text{IFS}_{\text{adj}} \text{ (mg - year/kg - day)} = \frac{\text{IRS}_c \times \text{ED}_c}{\text{BW}_c} + \frac{\text{IRS}_a \times \text{ED}_a}{\text{BW}_a}$ $\text{SFS}_{\text{adj}} \text{ (mg - year/kg - day)} = \frac{\text{SA}_c \times \text{AF}_c \times \text{ED}_c}{\text{BW}_c} + \frac{\text{SA}_a \times \text{AF}_a \times \text{ED}_a}{\text{BW}_a}$ $\text{IFA}_{\text{adj}} \text{ (m}^3 \text{ - year/kg - day)} = \frac{\text{IRA}_c \times \text{ED}_c}{\text{BW}_c} + \frac{\text{IRA}_a \times \text{ED}_a}{\text{BW}_a}$	
Where:	Value
IFS _{adj} = Age-adjusted soil ingestion factor (mg-year/kg-day).	114
SFS _{adj} = Age-adjusted soil contact factor (mg-year/kg-day).	361
IFA _{adj} = Age-adjusted inhalation factor (m ³ -year/kg-day).	11
IRS _c = Child soil ingestion rate (mg/day).	200
IRS _a = Adult soil ingestion rate (mg/day).	100
ED _c = Child exposure duration (years).	6
ED _a = Adult exposure duration (years).	24
BW _c = Child body weight (kg).	15
BW _a = Adult body weight (kg).	70
SA _c = Child exposed skin surface area (cm ² /day).	2,800
AF _c = Child soil-to-skin adherence factor (mg/cm ²).	0.2
SA _a = Adult exposed skin surface area (cm ² /day).	5,700
AF _a = Adult soil-to-skin adherence factor (mg/cm ²).	0.07
IRA _c = Child inhalation rate (m ³ /day).	10
IRA _a = Adult inhalation rate (m ³ /day).	20

TABLE 6-24
 Noncancer Dose Equations for the Future Residential Scenario
 Pioneer AOC, Former Wilkins AFS
 Shelby, OH

$\text{Dose from Soil Ingestion (mg/kg - day)} = \frac{\text{CS} \times \text{IRS} \times \text{FI} \times \text{CF} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$	
$\text{Dose from Dermal Absorption (mg/kg - day)} = \frac{\text{CS} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{SA} \times \text{AF} \times \text{ABS}_d}{\text{BW} \times \text{AT}}$	
$\text{Dose from Particulate Inhalation (mg/kg - day)} = \frac{\text{CS} \times \text{IRA} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT} \times \text{PEF}}$	
Where:	Value
CS = COPC concentration in soil (mg/kg).	COPC-specific; See Table 6-10
IRS = Child soil ingestion rate (mg/day). = Adult soil ingestion rate (mg/day).	200
	100
FI = Fraction of soil ingested from contaminated source (unitless).	1.0
CF = Conversion factor (kg/mg).	0.000001
EF = Exposure frequency (days/year).	350
ED = Child exposure duration (years). = Adult exposure duration (years).	6
	24
BW = Child body weight (kg). = Adult body weight (kg).	15
	70
AT = Child averaging time (days). = Adult averaging time (days).	2,190
	8,760
SA = Child exposed skin surface area (cm ² /day). = Adult exposed skin surface area (cm ² /day).	2,800
	5,700
AF = Child soil-to-skin adherence factor (mg/cm ²). = Adult soil-to-skin adherence factor (mg/cm ²).	0.2
	0.07
ABS _d = Dermal absorption factor (unitless).	COPC-specific; See Table 6-11
IRA = Child inhalation rate (m ³ /day). = Adult inhalation rate (m ³ /day).	10
	20
PEF = Particulate emission factor (m ³ /kg).	9.24E+08

Table 6-25

**Cancer and Noncancer Doses for Site Worker Exposure to Soil (0-0.5 feet bgs)
Maintained Area
Pioneer AOC, Former Wilkins AFS
Shelby, OH**

COPC	EPC (mg/kg)	Cancer Doses			Noncancer Doses		
		Soil Ingestion (mg/kg-day)	Dermal Contact (mg/kg-day)	Inhalation (mg/kg-day)	Soil Ingestion (mg/kg-day)	Dermal Contact (mg/kg-day)	Inhalation (mg/kg-day)
<i>Organics</i>							
Benzo(a)anthracene	2.13E-01	1.67E-08	1.43E-08	1.19E-12	4.67E-08	4.00E-08	3.33E-12
Benzo(a)pyrene	2.18E-01	1.71E-08	1.46E-08	1.22E-12	4.78E-08	4.10E-08	3.41E-12
Benzo(b)fluoranthene	2.29E-01	1.80E-08	1.54E-08	1.28E-12	5.03E-08	4.31E-08	3.59E-12
Dibenz(a,h)anthracene	1.01E-01	7.88E-09	6.76E-09	5.63E-13	2.21E-08	1.89E-08	1.58E-12
Indeno(1,2,3-cd)pyrene	4.91E-01	3.84E-08	3.30E-08	2.74E-12	1.08E-07	9.23E-08	7.69E-12
<i>Inorganics</i>							
Aluminum	1.06E+04	8.32E-04	5.49E-05	5.95E-08	2.33E-03	1.54E-04	1.66E-07
Arsenic	1.19E+01	9.31E-07	1.84E-07	6.65E-11	2.61E-06	5.16E-07	1.86E-10
Chromium, total	1.56E+01	1.22E-06	8.07E-08	8.73E-11	3.42E-06	2.26E-07	2.44E-10
Iron	2.17E+04	1.70E-03	1.12E-04	1.21E-07	4.75E-03	3.13E-04	3.39E-07
Manganese	1.35E+03	1.06E-04	6.99E-06	7.56E-09	2.96E-04	1.96E-05	2.12E-08
Mercury	3.07E+00	2.40E-07	1.59E-08	1.72E-11	6.73E-07	4.44E-08	4.81E-11
Thallium	9.50E-01	7.44E-08	4.91E-09	5.31E-12	2.08E-07	1.37E-08	1.49E-11
Vanadium	2.42E+01	1.90E-06	1.25E-07	1.35E-10	5.31E-06	3.50E-07	3.79E-10

Table 6-26

**Cancer and Noncancer Doses for Older Child Trespasser Exposure to Soil (0-0.5 feet bgs)
Mound Area
Pioneer AOC, Former Wilkins AFS
Shelby, OH**

COPC	EPC (mg/kg)	Cancer Doses			Noncancer Doses		
		Soil Ingestion (mg/kg-day)	Dermal Contact (mg/kg-day)	Inhalation (mg/kg-day)	Soil Ingestion (mg/kg-day)	Dermal Contact (mg/kg-day)	Inhalation (mg/kg-day)
<i>Organics</i>							
Benzo(a)anthracene	1.40E+00	3.80E-08	2.94E-08	4.89E-12	2.22E-07	1.71E-07	2.85E-11
Benzo(a)pyrene	1.80E+00	4.88E-08	3.78E-08	6.28E-12	2.85E-07	2.20E-07	3.66E-11
Benzo(b)fluoranthene	1.70E+00	4.61E-08	3.57E-08	5.93E-12	2.69E-07	2.08E-07	3.46E-11
Dibenz(a,h)anthracene	6.80E-02	1.85E-09	1.43E-09	2.37E-13	1.08E-08	8.32E-09	1.38E-12
Indeno(1,2,3-cd)pyrene	1.30E+00	3.53E-08	2.73E-08	4.54E-12	2.06E-07	1.59E-07	2.65E-11
2,3,7,8-TCDD TEQ	6.65E-06	1.80E-13	3.22E-14	2.32E-17	1.05E-12	1.88E-13	1.35E-16
<i>Inorganics</i>							
Aluminum	1.22E+04	3.31E-04	1.97E-05	4.26E-08	1.93E-03	1.15E-04	2.48E-07
Arsenic	1.91E+01	5.18E-07	9.25E-08	6.67E-11	3.02E-06	5.39E-07	3.89E-10
Chromium, total	3.86E+01	1.05E-06	6.23E-08	1.35E-10	6.11E-06	3.63E-07	7.86E-10
Iron	2.57E+04	6.97E-04	4.15E-05	8.97E-08	4.07E-03	2.42E-04	5.23E-07
Manganese	7.40E+02	2.01E-05	1.19E-06	2.58E-09	1.17E-04	6.97E-06	1.51E-08
Mercury	5.00E+00	1.36E-07	8.07E-09	1.75E-11	7.91E-07	4.71E-08	1.02E-10
Thallium	8.10E-01	2.20E-08	1.31E-09	2.83E-12	1.28E-07	7.63E-09	1.65E-11
Vanadium	2.73E+01	7.41E-07	4.41E-08	9.53E-11	4.32E-06	2.57E-07	5.56E-10

Table 6-27

Cancer and Noncancer Doses for Construction Worker Exposure to Soil (All Depths)

Pioneer AOC, Former Wilkins AFS
Shelby, OH

COPC	EPC (mg/kg)	Cancer Doses			Noncancer Doses		
		Soil Ingestion (mg/kg-day)	Dermal Contact (mg/kg-day)	Inhalation (mg/kg-day)	Soil Ingestion (mg/kg-day)	Dermal Contact (mg/kg-day)	Inhalation (mg/kg-day)
<i>Organics</i>							
Benzo(a)anthracene	4.34E-01	5.01E-09	1.95E-09	3.25E-10	7.01E-07	2.74E-07	4.56E-08
Benzo(a)pyrene	5.26E-01	6.07E-09	2.37E-09	3.94E-10	8.50E-07	3.31E-07	5.52E-08
Benzo(b)fluoranthene	2.53E-01	2.92E-09	1.14E-09	1.89E-10	4.08E-07	1.59E-07	2.65E-08
Dibenz(a,h)anthracene	9.18E-02	1.06E-09	4.13E-10	6.88E-11	1.48E-07	5.78E-08	9.63E-09
Indeno(1,2,3-cd)pyrene	3.73E-01	4.30E-09	1.68E-09	2.79E-10	6.02E-07	2.35E-07	3.91E-08
2,3,7,8-TCDD TEQ	5.27E-06	6.08E-14	5.47E-15	3.95E-15	8.51E-12	7.66E-13	5.53E-13
<i>Inorganics</i>							
Aluminum	1.02E+04	1.17E-04	3.52E-06	7.61E-06	1.64E-02	4.92E-04	1.07E-03
Antimony	7.77E+00	8.96E-08	2.69E-09	5.82E-09	1.25E-05	3.76E-07	8.15E-07
Arsenic	1.23E+01	1.41E-07	1.27E-08	9.18E-09	1.98E-05	1.78E-06	1.29E-06
Cadmium	3.20E+00	3.70E-08	1.11E-10	2.40E-09	5.17E-06	1.55E-08	3.36E-07
Chromium, total	2.19E+01	2.53E-07	7.58E-09	1.64E-08	3.54E-05	1.06E-06	2.30E-06
Iron	2.24E+04	2.58E-04	7.73E-06	1.67E-05	3.61E-02	1.08E-03	2.34E-03
Lead	1.44E+02	1.66E-06	4.97E-08	1.08E-07	2.32E-04	6.95E-06	1.51E-05
Manganese	5.31E+02	6.12E-06	1.84E-07	3.98E-07	8.57E-04	2.57E-05	5.57E-05
Mercury	6.81E+00	7.85E-08	2.36E-09	5.10E-09	1.10E-05	3.30E-07	7.14E-07
Thallium	1.00E+00	1.15E-08	3.46E-10	7.49E-10	1.61E-06	4.84E-08	1.05E-07
Vanadium	2.45E+01	2.83E-07	8.48E-09	1.84E-08	3.96E-05	1.19E-06	2.57E-06

Table 6-28

Cancer Doses for Future Residential Exposure to Soil (All Depths)

Pioneer AOC, Former Wilkins AFS
Shelby, OH

COPC	EPC (mg/kg)	Cancer Doses			Noncancer Doses					
		Soil Ingestion (mg/kg-day)	Dermal Contact (mg/kg-day)	Inhalation (mg/kg-day)	Child			Adult		
					Soil Ingestion (mg/kg-day)	Dermal Contact (mg/kg-day)	Inhalation (mg/kg-day)	Soil Ingestion (mg/kg-day)	Dermal Contact (mg/kg-day)	Inhalation (mg/kg-day)
<i>Organics</i>										
Benzo(a)anthracene	4.34E-01	6.78E-07	2.79E-07	6.99E-11	5.55E-06	2.02E-06	3.01E-10	5.95E-07	3.09E-07	1.29E-10
Benzo(a)pyrene	5.26E-01	8.22E-07	3.38E-07	8.47E-11	6.73E-06	2.45E-06	3.64E-10	7.21E-07	3.74E-07	1.56E-10
Benzo(b)fluoranthene	2.53E-01	3.95E-07	1.63E-07	4.07E-11	3.23E-06	1.18E-06	1.75E-10	3.46E-07	1.80E-07	7.50E-11
Dibenz(a,h)anthracene	9.18E-02	1.43E-07	5.90E-08	1.48E-11	1.17E-06	4.27E-07	6.35E-11	1.26E-07	6.52E-08	2.72E-11
Indeno(1,2,3-cd)pyrene	3.73E-01	5.83E-07	2.40E-07	6.01E-11	4.77E-06	1.74E-06	2.58E-10	5.11E-07	2.65E-07	1.11E-10
2,3,7,8-TCDD TEQ	5.27E-06	8.23E-12	7.82E-13	8.48E-16	6.74E-11	5.66E-12	3.65E-15	7.22E-12	8.64E-13	1.56E-15
<i>Inorganics</i>										
Aluminum	1.02E+04	1.59E-02	5.02E-04	1.64E-06	1.30E-01	3.64E-03	7.03E-06	1.39E-02	5.55E-04	3.01E-06
Antimony	7.77E+00	1.21E-05	3.84E-07	1.25E-09	9.93E-05	2.78E-06	5.37E-09	1.06E-05	4.25E-07	2.30E-09
Arsenic	1.23E+01	1.91E-05	1.82E-06	1.97E-09	1.57E-04	1.32E-05	8.48E-09	1.68E-05	2.01E-06	3.63E-09
Cadmium	3.20E+00	5.00E-06	1.58E-08	5.16E-10	4.10E-05	1.15E-07	2.22E-09	4.39E-06	1.75E-08	9.50E-10
Chromium, total	2.19E+01	3.42E-05	1.08E-06	3.53E-09	2.80E-04	7.85E-06	1.52E-08	3.00E-05	1.20E-06	6.50E-09
Iron	2.24E+04	3.49E-02	1.11E-03	3.60E-06	2.86E-01	8.00E-03	1.55E-05	3.06E-02	1.22E-03	6.63E-06
Lead	1.44E+02	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	5.31E+02	8.29E-04	2.63E-05	8.55E-08	6.79E-03	1.90E-04	3.67E-07	7.27E-04	2.90E-05	1.57E-07
Mercury	6.81E+00	1.06E-05	3.37E-07	1.10E-09	8.71E-05	2.44E-06	4.71E-09	9.33E-06	3.72E-07	2.02E-09
Thallium	1.00E+00	1.56E-06	4.95E-08	1.61E-10	1.28E-05	3.58E-07	6.92E-10	1.37E-06	5.47E-08	2.97E-10
Vanadium	2.45E+01	3.83E-05	1.21E-06	3.94E-09	3.13E-04	8.77E-06	1.70E-08	3.36E-05	1.34E-06	7.26E-09

NA - Lead exposure was evaluated using the IEUBK model.

Table 6-29

**Summary of the Cancer Risks from Site Worker Exposure to Soil (0-0.5 feet bgs)
Maintained Area
Pioneer AOC, Former Wilkins AFS
Shelby, OH**

COPC	Cancer Risks			
	Soil Ingestion	Dermal Contact	Inhalation	Total
<i>Organics</i>				
Benzo(a)anthracene	1.22E-08	1.04E-08	8.69E-13	2.26E-08
Benzo(a)pyrene	1.25E-07	1.07E-07	8.90E-12	2.32E-07
Benzo(b)fluoranthene	1.31E-08	1.12E-08	9.36E-13	2.44E-08
Dibenz(a,h)anthracene	5.75E-08	4.94E-08	4.11E-12	1.07E-07
Indeno(1,2,3-cd)pyrene	2.81E-08	2.41E-08	2.00E-12	5.21E-08
<i>Inorganics</i>				
Aluminum	NC	NC	NC	---
Arsenic	1.40E-06	2.77E-07	1.00E-09	1.67E-06
Chromium, total	NA	NA	3.58E-09	3.58E-09
Iron	NC	NC	NC	---
Manganese	NC	NC	NC	---
Mercury	NA	NA	NA	---
Thallium	NC	NC	NC	---
Vanadium	NC	NC	NC	---
Total:	1.63E-06	4.79E-07	4.60E-09	2.12E-06

Table 6-30

Summary of the Hazard Quotients from Site Worker Exposure to Soil (0-0.5 feet bgs)
 Maintained Area
 Pioneer AOC, Former Wilkins AFS
 Shelby, OH

COPC	Hazard Quotients			
	Soil Ingestion	Dermal Contact	Inhalation	Total
Organics				
Benzo(a)anthracene	NA	NA	NA	---
Benzo(a)pyrene	NA	NA	NA	---
Benzo(b)fluoranthene	NA	NA	NA	---
Dibenz(a,h)anthracene	NA	NA	NA	---
Indeno(1,2,3-cd)pyrene	NA	NA	NA	---
Inorganics				
Aluminum	2.33E-03	1.54E-04	1.19E-04	2.60E-03
Arsenic	8.69E-03	1.72E-03	6.21E-07	1.04E-02
Chromium, total	1.14E-03	3.01E-03	8.15E-06	4.16E-03
Iron	1.58E-02	1.04E-03	1.13E-06	1.69E-02
Manganese	1.24E-02	9.32E-01	1.48E-03	9.46E-01
Mercury	2.24E-03	4.63E-05	5.59E-07	2.29E-03
Thallium	3.15E-03	2.08E-04	2.25E-07	3.36E-03
Vanadium	5.31E-03	1.35E-02	3.79E-07	1.88E-02
Total:	5.10E-02	9.51E-01	1.61E-03	1.00E+00

NA - No toxicity value available.

Table 6-31

**Summary of the Cancer Risks from Trespasser Exposure to Soil (0-0.5 feet bgs)
Mound Area
Pioneer AOC, Former Wilkins AFS
Shelby, OH**

COPC	Cancer Risks			
	Soil Ingestion	Dermal Contact	Inhalation	Total
<i>Organics</i>				
Benzo(a)anthracene	2.77E-08	2.14E-08	3.57E-12	4.92E-08
Benzo(a)pyrene	3.57E-07	2.76E-07	4.59E-11	6.32E-07
Benzo(b)fluoranthene	3.37E-08	2.60E-08	4.33E-12	5.97E-08
Dibenz(a,h)anthracene	1.35E-08	1.04E-08	1.73E-12	2.39E-08
Indeno(1,2,3-cd)pyrene	2.58E-08	1.99E-08	3.31E-12	4.57E-08
2,3,7,8-TCDD TEQ	2.71E-08	4.83E-09	3.48E-12	3.19E-08
<i>Inorganics</i>				
Aluminum	NC	NC	NC	---
Arsenic	7.77E-07	1.39E-07	1.01E-09	9.17E-07
Chromium, total	NA	NA	5.52E-09	5.52E-09
Iron	NC	NC	NC	---
Manganese	NC	NC	NC	---
Mercury	NA	NA	NA	---
Thallium	NC	NC	NC	---
Vanadium	NC	NC	NC	---
Total:	1.26E-06	4.97E-07	6.59E-09	1.77E-06

NA - No toxicity value available.

NC - Not classified as a carcinogen.

Table 6-32

Summary of the Hazard Quotients from Trespasser Exposure to Soil (0-0.5 feet bgs)
Mound Area
Pioneer AOC, Former Wilkins AFS
Shelby, OH

COPC	Hazard Quotients			
	Soil Ingestion	Dermal Contact	Inhalation	Total
<i>Organics</i>				
Benzo(a)anthracene	NA	NA	NA	---
Benzo(a)pyrene	NA	NA	NA	---
Benzo(b)fluoranthene	NA	NA	NA	---
Dibenz(a,h)anthracene	NA	NA	NA	---
Indeno(1,2,3-cd)pyrene	NA	NA	NA	---
2,3,7,8-TCDD TEQ	NA	NA	NA	---
<i>Inorganics</i>				
Aluminum	1.93E-03	1.15E-04	1.77E-04	2.22E-03
Arsenic	1.01E-02	1.80E-03	1.30E-06	1.19E-02
Chromium, total	2.04E-03	4.85E-03	2.62E-05	6.91E-03
Iron	1.36E-02	8.06E-04	1.74E-06	1.44E-02
Manganese	4.88E-03	3.32E-01	1.05E-03	3.38E-01
Mercury	2.64E-03	4.90E-05	1.18E-06	2.69E-03
Thallium	1.94E-03	1.16E-04	2.50E-07	2.06E-03
Vanadium	4.32E-03	9.88E-03	5.56E-07	1.42E-02
Total:	4.14E-02	3.49E-01	1.26E-03	3.92E-01

NA - No toxicity value available.

Table 6-33

Summary of the Cancer Risks from Construction Worker Exposure to Soil (All Depths)

Pioneer AOC, Former Wilkins AFS
Shelby, OH

COPC	Cancer Risks			
	Soil Ingestion	Dermal Contact	Inhalation	Total
<i>Organics</i>				
Benzo(a)anthracene	3.66E-09	1.43E-09	2.38E-10	5.32E-09
Benzo(a)pyrene	4.43E-08	1.73E-08	2.88E-09	6.45E-08
Benzo(b)fluoranthene	2.13E-09	8.30E-10	1.38E-10	3.10E-09
Dibenz(a,h)anthracene	7.73E-09	3.01E-09	5.02E-10	1.12E-08
Indeno(1,2,3-cd)pyrene	3.14E-09	1.22E-09	2.04E-10	4.57E-09
2,3,7,8-TCDD TEQ	9.12E-09	8.20E-10	5.92E-10	1.05E-08
<i>Inorganics</i>				
Aluminum	NC	NC	NC	---
Antimony	NC	NC	NC	---
Arsenic	2.12E-07	1.91E-08	1.39E-07	3.70E-07
Cadmium	NA	NA	1.51E-08	1.51E-08
Chromium, total	NA	NA	6.73E-07	6.73E-07
Iron	NC	NC	NC	---
Lead	NA	NA	NA	---
Manganese	NC	NC	NC	---
Mercury	NA	NA	NA	---
Thallium	NC	NC	NC	---
Vanadium	NC	NC	NC	---
Total:	2.82E-07	4.37E-08	8.31E-07	1.16E-06

NA - No toxicity value available.

NC - Not classified as a carcinogen.

Table 6-34

Summary of the Hazard Quotients from Construction Worker Exposure to Soil (All Depths)

Pioneer AOC, Former Wilkins AFS
Shelby, OH

COPC	Hazard Quotients			
	Soil Ingestion	Dermal Contact	Inhalation	Total
<i>Organics</i>				
Benzo(a)anthracene	NA	NA	NA	---
Benzo(a)pyrene	NA	NA	NA	---
Benzo(b)fluoranthene	NA	NA	NA	---
Dibenz(a,h)anthracene	NA	NA	NA	---
Indeno(1,2,3-cd)pyrene	NA	NA	NA	---
2,3,7,8-TCDD TEQ	NA	NA	NA	---
<i>Inorganics</i>				
Aluminum	1.64E-02	4.92E-04	7.61E-01	7.78E-01
Antimony	3.13E-02	6.27E-03	2.04E-03	3.97E-02
Arsenic	6.59E-02	5.94E-03	4.28E-03	7.62E-02
Cadmium	1.03E-02	1.19E-03	6.72E-04	1.22E-02
Chromium, total	1.18E-02	1.42E-02	7.66E-02	1.03E-01
Iron	1.20E-01	3.61E-03	7.82E-03	1.32E-01
Lead	NA	NA	NA	---
Manganese	3.57E-02	1.22E+00	3.89E+00	5.15E+00
Mercury	3.67E-02	3.44E-04	8.31E-03	4.53E-02
Thallium	2.45E-02	7.34E-04	1.59E-03	2.68E-02
Vanadium	3.96E-02	4.56E-02	2.57E-03	8.78E-02
Total:	3.93E-01	1.30E+00	4.76E+00	6.45E+00

NA - No toxicity value available.

Table 6-35

Summary of the Cancer Risks from Residential Exposure to Soil (All Depths)

Pioneer AOC, Former Wilkins AFS
Shelby, OH

COPC	Cancer Risks			
	Soil Ingestion	Dermal Contact	Inhalation	Total
<i>Organics</i>				
Benzo(a)anthracene	4.95E-07	2.04E-07	5.10E-11	6.99E-07
Benzo(a)pyrene	6.00E-06	2.47E-06	6.18E-10	8.47E-06
Benzo(b)fluoranthene	2.88E-07	1.19E-07	2.97E-11	4.07E-07
Dibenz(a,h)anthracene	1.05E-06	4.31E-07	1.08E-10	1.48E-06
Indeno(1,2,3-cd)pyrene	4.25E-07	1.75E-07	4.38E-11	6.00E-07
2,3,7,8-TCDD TEQ	1.23E-06	1.17E-07	1.27E-10	1.35E-06
<i>Inorganics</i>				
Aluminum	NC	NC	NC	---
Antimony	NC	NC	NC	---
Arsenic	2.87E-05	2.73E-06	2.98E-08	3.15E-05
Cadmium	NA	NA	3.25E-09	3.25E-09
Chromium, total	NA	NA	1.45E-07	1.45E-07
Iron	NC	NC	NC	---
Lead	NA	NA	NA	---
Manganese	NC	NC	NC	---
Mercury	NA	NA	NA	---
Thallium	NC	NC	NC	---
Vanadium	NC	NC	NC	---
	3.82E-05	6.24E-06	1.79E-07	4.46E-05

NC - Not classified as a carcinogen.

Table 6-36

Summary of the Hazard Quotients from Future Residential Exposure to Soil (All Depths)

Pioneer AOC, Former Wilkins AFS
Shelby, OH

COPC	Hazard Quotients							
	Child				Adult			
	Soil Ingestion	Dermal Contact	Inhalation	Total	Soil Ingestion	Dermal Contact	Inhalation	Total
<i>Organics</i>								
Benzo(a)anthracene	NA	NA	NA	---	NA	NA	NA	---
Benzo(a)pyrene	NA	NA	NA	---	NA	NA	NA	---
Benzo(b)fluoranthene	NA	NA	NA	---	NA	NA	NA	---
Dibenz(a,h)anthracene	NA	NA	NA	---	NA	NA	NA	---
Indeno(1,2,3-cd)pyrene	NA	NA	NA	---	NA	NA	NA	---
2,3,7,8-TCDD TEQ	NA	NA	NA	---	NA	NA	NA	---
<i>Inorganics</i>								
Aluminum	1.30E-01	3.64E-03	5.02E-03	1.39E-01	1.39E-02	5.55E-04	2.15E-03	1.66E-02
Antimony	2.48E-01	4.63E-02	1.34E-05	2.95E-01	2.66E-02	7.08E-03	5.76E-06	3.37E-02
Arsenic	5.22E-01	4.39E-02	2.83E-05	5.66E-01	5.60E-02	6.70E-03	1.21E-05	6.27E-02
Cadmium	8.19E-02	8.83E-03	4.43E-06	9.08E-02	8.78E-03	1.35E-03	1.90E-06	1.01E-02
Chromium, total	9.34E-02	1.05E-01	5.05E-04	1.99E-01	1.00E-02	1.60E-02	2.17E-04	2.62E-02
Iron	9.53E-01	2.67E-02	5.16E-05	9.80E-01	1.02E-01	4.07E-03	2.21E-05	1.06E-01
Lead	NA	NA	NA	---	NA	NA	NA	---
Manganese	2.83E-01	9.05E+00	2.57E-02	9.36E+00	3.03E-02	1.38E+00	1.10E-02	1.42E+00
Mercury	2.90E-01	2.54E-03	5.48E-05	2.93E-01	3.11E-02	3.88E-04	2.35E-05	3.15E-02
Thallium	1.94E-01	5.42E-03	1.05E-05	1.99E-01	2.08E-02	8.28E-04	4.49E-06	2.16E-02
Vanadium	3.13E-01	3.37E-01	1.70E-05	6.51E-01	3.36E-02	5.15E-02	7.26E-06	8.51E-02
Total:	3.11E+00	9.63E+00	3.14E-02	1.28E+01	3.33E-01	1.47E+00	1.35E-02	1.82E+00

NA - No toxicity value available.

7.0 SUMMARY AND CONCLUSIONS

This section summarizes the various aspects of the RI activities and findings and presents significant conclusions. Recommendations are offered which draw from the conclusions.

7.1 SUMMARY

The following discussion summarizes the events undertaken in the field, the results of the analyses with respect to the presence, location and migration of contaminants in the affected media, and the evaluation of the calculated and projected risk to human health and the environment.

7.1.1 Field Activities

The Pioneer AOC has been investigated as a potential source of soil and groundwater contamination following the identification of an area used for disposal and burning of demolition debris, rubbish and medical/laboratory glassware at the west end of the PCTC property. Prior to the fieldwork at Pioneer AOC, Project Work Plans (WPs) were prepared by Plexus to guide all aspects of the investigation. These included a WP, Field Sampling Plan (FSP), QAPP, and Health and Safety Plan (HASP). The fieldwork took place April 10-17, 2003.

The RI activities included:

- The installation of two background groundwater monitoring wells;
- Collection of 22 surface soil samples at the AOC and seven background surface soil samples;
- Development or redevelopment of the AOC wells and background wells;
- Purging and sampling of the wells;
- Analysis of the soil and groundwater samples;
- Monitoring of soil gas for landfill gases at 20 points at the AOC and between the AOC and the PCTC buildings;
- Survey of well and sample locations and elevations; and
- Topographic survey of the AOC.

An ecological screening field visit to the site took place on July 16, 2003.

All environmental samples were analyzed according to USEPA CLP methods for target compound list (TCL), TAL and cyanide. STL Laboratories, under contract to Plexus, performed all analyses according to LCG requirements. The data was verified according to EPA protocol and LCG requirements.

The slug test data were analyzed by AQTESOLV® software for time vs. displacement utilizing the Bouwer and Rice unconfined aquifer solution. Calculated values for K were 9.12×10^{-3} cm/sec and 6.00×10^{-3} cm/sec.

A SI was conducted at the Pioneer AOC in 2001. The results of the SI are discussed in this report in light of the RI data.

7.1.2 Nature and Extent

7.1.2.1 Soil

During the SI SVOCs were detected in surface and subsurface soils in the fill area. Surface soil samples were collected during the RI in the fill area, between the fill and the PCTC buildings and in background locations. SVOCs were detected in all of the samples collected including the background samples. The surface soil SVOC concentrations were generally higher in the fill area than outside the fill area. Total SVOC concentrations from surface soil samples in the fill area ranged from ND to 39,170 ug/kg. The total SVOC concentrations for the subsurface soil samples in the fill area ranged from ND to 214 ug/kg. Low levels of SVOCs are present in surface soil throughout the area around the AOC ranging from ND to 926 ug/kg and in the background area ranging from 52 to 693 ug/kg. The available data show that the surface soils in the AOC are impacted with SVOC compounds at levels higher than the subsurface AOC soils, surface soils from the surrounding property, and the background surface soil levels.

During the SI a dioxin compound, 2,3,7,8-TCDD, was detected above its residential soil PRG in the subsurface soil sample collected from 2 to 3 feet bgs in soil boring SB06. Five additional soil samples were collected from surface and subsurface soils in the fill area; dioxin compounds were detected in all of these samples, but not above their residential soil PRG. A background soil sample was analyzed for dioxin during the RI; dioxin compounds were detected, but none exceeded any of their residential soil PRGs. The dioxin appears to be limited in extent in the fill soils. There are no records or evidence of the burning of PCBs at the site and PCBs were not detected in the site soils. The source of the dioxin in the subsurface soil may have been the burning of plastic or other wastes in the presence of a chlorine donor.

The maximum metals concentrations were determined from the set of surface and subsurface soil sample data collected. The highest concentrations of lead, silver, chromium, copper, antimony, mercury, thallium, calcium and sodium were reported for samples collected from the fill area. Most of these were detected in WI-SS-11, a sample collected from the bottom of the drainage crossing the fill area. Many of the remaining metals maximum concentrations were detected in the sample collected within the drainage (WI-SS-09), near the pipe outfall at the southwest corner of the PCTC property, well removed from the fill area. These results may be related to the redox conditions in the soils near the pipe outfall in the drainage swale and within the ditch crossing the fill area. Arsenic was detected in every soil sample collected including the background samples. The arsenic levels in the fill material were similar to the results from the surface soil samples outside the AOC and the background samples.

VOCs, pesticides, and PCBs were not detected in significant concentrations in any of the soil samples collected from the fill area during the SI. Soil samples from the RI were not analyzed for these compounds.

7.1.2.2 Groundwater

Two rounds of groundwater samples have been collected from the three on-site wells at the Pioneer AOC. The samples were analyzed for VOCs, SVOCs, PCBs, pesticides, and total and dissolved metals for both rounds of sampling. The SI samples were also analyzed for PNAs and dioxin. Two newly installed background wells were sampled once during the RI. The background samples were analyzed for VOCs, SVOCs, PCBs, pesticides, total and dissolved metals, and dioxin.

The total and dissolved metals concentrations in the groundwater samples from the AOC were similar between the SI and RI. The highest metals concentrations were detected in the samples from MW05 in both rounds. The exception to this is manganese, which was detected in elevated concentrations in samples from MW08 in both rounds. This may be related to redox conditions at MW08 resulting in manganese staying in its dissolved phase preferentially. There is no MCL for manganese. There is a secondary drinking water standard for manganese of 50 ug/L. The manganese secondary drinking water standard was exceeded in MW08. The arsenic detected in groundwater at the site was similar in concentration and comparable to arsenic detected in background wells. Arsenic detected in MW05 exceeded the MCL of 10 ug/L in the total and dissolved samples from both rounds. Thallium exceeded its MCL sporadically in site and background groundwater samples and appears to be naturally occurring.

No VOCs, SVOCs, pesticides, PCBs, cyanide, or dioxin were detected in significant concentrations or above drinking water MCLs in the Pioneer AOC wells or in the background wells.

7.1.2.3 Soil Gas

The soil gas monitoring conducted at the site for landfill gases in April 2003 did not detect any concentrations of gases that would indicate landfill gas generation in the fill material.

7.1.3 Fate and Transport of Contaminants

The SVOCs and dioxin compounds detected in the fill soil are stable and not prone to migration. These compounds are not particularly volatile or soluble and would only be expected to be transported with the materials they are mixed with in the fill area. The metals detected in the soil in the fill area and surrounding area appear to be naturally occurring.

The manganese detected above its secondary drinking water standard in groundwater from well MW08 may be associated with the fill material, but manganese was not detected at these levels in the other on-site wells. The manganese would not be expected to migrate very far and would be adsorbed onto soil particles quickly as it moved through the aquifer. Total and dissolved arsenic was detected above its drinking water MCL in both samples from MW05. Arsenic is found in most of the groundwater samples collected, including both background samples at lower concentrations. The metals results from MW05 appear to be anomalous when compared to the other two on-site wells. MW05 went dry twice during redevelopment. MW05 went dry during purging. The low flow sampling techniques used on the other on site and background wells could not be used on MW05. MW05 did not recharge well and samples from this well were more turbid than the other wells. Five hours following purging the turbidity reading from MW05 was elevated at 505 NTU. The unfiltered metals water sample was turbid. The filtered metal sample from MW05 was brown in color indicating that fine particles suspended in the water passed through the 0.45-micron filter. Other water chemistry parameters recorded appear to be consistent between the three on-site wells. Thallium was detected in several groundwater samples above its MCL of 2 ug/L. The detections were not consistent between total and dissolved samples and thallium was above its MCL in one of the background well samples. It is suspected that the thallium detected is naturally occurring.

7.1.4 Risk Assessment

In order to quantitatively evaluate the potential risks to public health posed by chemical contamination at the Pioneer AOC a risk assessment was performed. The assessment evaluated

whether actual or possible releases of hazardous substances pose a potential threat to exposed individuals under current and hypothetical future scenarios. The overall objective was to determine whether there is a need for remedial action at the site, and if needed, to focus the evaluation of remedial action alternatives. The analysis considered actual concentrations of chemicals of concern, levels of exposure by potential receptors, and chemical toxicity, to develop estimates of potential health risk. The final risk characterization presented estimated risks associated with noncarcinogens and carcinogenic effects of the chemicals of concern based on the exposure and toxicity assessments.

The risk assessment characterizes risk for two receptors considered to represent RME scenarios: a site worker and a site trespasser. The assumptions used in characterizing these receptor populations for each pathway are conservative, and are unlikely to be exceeded, based on information available at the time this assessment was performed. The risk from the RME scenarios, which are based on conservative exposure assumptions, indicated that exposure to site COPCs did not pose unacceptable risks to the receptors evaluated.

The methods follow current EPA guidance, including Risk Assessment Guidance for Superfund (RAGS) (EPA, 2004b), and were supplemented by additional guidance. The methods account for cumulative effects of various exposure routes and contaminants.

A CSM was prepared for the Pioneer AOC (see Figure 6-1). As discussed previously, the HHRA evaluated four receptor populations: a site worker, a trespasser, construction worker, and future residents. Each receptor was assumed to come in contact with the surface soils and the contaminants they contain in the fill area and surrounding area via the inhalation, ingestion, or dermal contact exposure routes. The site worker risks were calculated based on the assumption that they come in contact with COPCs in the maintained lawn that surrounds the mound area. The trespasser risks were calculated based on the assumption that they come in contact with COPCs in the mound area. The construction worker risks were calculated based on the assumption that they would come in contact with COPCs in aggregate soil (0 to 10 feet bgs) during construction activities. The future residents risks were calculated based on the assumption that they would come in contact with COPC in aggregate soil. Conservative, health-protective exposure scenarios and assumptions were used in this evaluation of risks that would tend to overestimate actual risks. Even with this conservative approach, all risk estimates were below relevant State and EPA benchmarks for a site worker or a trespasser. The construction worker scenario resulted in a minor exceedance of the noncancer benchmark for manganese.

Residential development is not likely to occur in the future given the current and future uses of the site (industrial). For conservatism, however, a future residential scenario was evaluated to determine an upper-bound on the level of risk posed by the site. The results of the risk assessment indicate that the residential use poses unacceptable risk levels. The carcinogenic risk is from arsenic, SVOCs, and dioxin. The total risk from arsenic contributed over 70 percent of the total. Arsenic was detected in every soil sample collected including the background samples. The arsenic levels in the fill material were similar to the results from the surface soil samples outside the AOC and the background samples. The arsenic detected in groundwater at the site is similar in concentration, and comparable to, arsenic detected in background wells. All the SVOCs detected in samples collected from the AOC soil mound during the SI and RI were also detected in samples collected in surface soils from areas around the site, between the AOC and the PCTC building, and in background samples. Only one soil

sample contained dioxin above PRGs, specifically 2,3,7,8-TCDD. The sample was collected from 2 to 3 feet below the surface of the mound. The non-carcinogenic risk for residential use comes from manganese.

Exposure to groundwater was not considered a complete pathway.

A SLERA was conducted at the site and it was determined that no important ecological resources were impacted by previous site activities and, therefore, no further ERA actions are required.

7.2 CONCLUSIONS

The work completed for this RI Report was designed to meet the objectives to characterize the nature and extent of potential environmental contamination and associated risks to human health and the environment at the Pioneer AOC.

When compared to other surface soil results from the PCTC property and background locations, SVOC concentrations were elevated in the surface soils at the site. Surface soil concentrations were elevated compared to subsurface soil concentrations at the AOC as well. However, the risks to human health from exposure to these surface soils are within acceptable risk parameters for the State and EPA. As discussed above, a future residential scenario was evaluated to determine an upper-bound on the level of risk posed by the site. The results of the risk assessment indicate that the residential use poses unacceptable risk levels. Some of the risk from carcinogens to a future resident had to do with SVOCs detected in aggregate soil. This risk needs to be considered; however, the SVOCs detected in soils in the fill area were not detected in concentrations that would necessitate remedial action.

The residential risk scenario also identified a minor carcinogenic risk from dioxin (2,3,7,8-TCDD). Dioxin was only detected in one subsurface soil sample above its PRG. This sample was collected from 2 to 3 feet bgs in the mound area. The calculated risk from Dioxin was just above the 1E-06 level. This risk needs to be considered; however, the dioxin detected would not necessitate remedial action.

Metals detected in surface soils at the AOC and on the PCTC property were elevated in areas where water was known to stand and where the soils were saturated at least some of the time. These conditions may have contributed to the elevated metals concentrations in the surface soil samples collected. The highest maximum metals concentration in surface soils (0 to 6") were detected in sample WI-SS-11 from the bottom of the drainage feature crossing the southwest or up gradient side of the fill area and sample WI-SS-09 collected near the pipe outfall at the southwest corner of the PCTC property, well removed and up gradient from the fill area. Both of these locations coincide with areas where wet surface soil conditions were reported to exist during rainy periods. Elevated metals concentrations were detected in surface soils at the site, but through the risk assessment were determined not to be a risk to human health or the environment. Metals in aggregate soil (0 to 10 feet bgs) were of more concern and were found to be a risk in the construction worker scenario and a future residential scenario. All of the risk in the construction worker scenario came from manganese. As discussed above 70% of the risk from carcinogens to a future resident came from arsenic. All of the non-carcinogenic risk comes from manganese. Both manganese and arsenic may be naturally occurring in the site area.

Metals detected in the groundwater samples collected were elevated in the samples collected from MW05. Arsenic was above its MCL in all of the metals samples analyzed for MW05. Arsenic concentrations were detected in most of the wells sampled including the background wells. Arsenic is naturally occurring in groundwater in the area of the site. Manganese was above its secondary drinking water standard in MW08. Thallium was detected sporadically in groundwater, but is thought to be naturally occurring. The risk pathway from groundwater to human receptors is considered to be incomplete.

7.2.1 Data Limitations and Recommendations for Future Work

The uncertainties associated with the procedures leading to the summary and conclusions presented above have been discussed previously. The identification of uncertainties is important to the interpretation of study findings in order to evaluate the magnitude of conservatism and in order to identify significant data gaps.

The data was verified and appears to be accurate and useful for the purposes of this investigation. No data gaps were identified during the course of the RI activities. No future work at the Pioneer AOC is recommended based on the results of the SI and this RI.

Future studies may collect additional background groundwater data, specifically metals data quarterly for a year from the background wells. The results of these background groundwater metals data should then be compared to the metals data from the site wells to determine if the metals concentrations detected in groundwater at the site are within the range of naturally occurring metals concentrations.

7.2.2 Recommended Remedial Action Objectives

The detected contaminant levels do not pose a significant risk to human health. Metals detected in soil and groundwater at levels that are of concern may be naturally occurring and not the result of Department of Defense activities at the site. No risk to the environment was found at the site. Remediation at the site is not recommended.

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