240305-040519 0001

Internal Review Comments

# RESIDUAL RISK EVALUATION
# OU-4 MIAMI-ERIE CANAL AREA

## PUBLIC REVIEW
## DRAFT

**Mound Plant**
**Miamisburg, Ohio**

***Prepared for:***
**U.S. Department of Energy**

***Prepared by:***
**Science Applications International Corporation**
**Dublin, Ohio**

***Managed by:***
**BWXT of Ohio**

**April 14, 2000**

# RESIDUAL RISK EVALUATION
# OU-4 MIAMI-ERIE CANAL AREA

## PUBLIC REVIEW
## DRAFT

**Mound Plant**
**Miamisburg, Ohio**

*Prepared for:*
**U.S. Department of Energy**

*Prepared by:*
**Science Applications International Corporation**
**Dublin, Ohio**

*Managed by:*
**BWXT of Ohio**

**April 14, 2000**

## TABLE OF CONTENTS


1.0 INTRODUCTION . . . . . 1
- 1.1 Purpose Of Residual Risk Evaluation . . . . . 1
- 1.2 Scope of the Miami-Erie Canal RRE . . . . . 4
- 1.3 Organization of Report . . . . . 4

2.0 DATA COMPILATION AND EVALUATION . . . . . 5
- 2.1 Data Quality Assessment . . . . . 6
- 2.2 Environmental Media Considered and Data Availability . . . . . 6
- 2.3 Data Analysis . . . . . 7
- 2.4 Data Screening Process . . . . . 8
  - 2.4.1 Screening Constituents Based on Background . . . . . 18
  - 2.4.2 Screening Constituents Based on Guideline Values . . . . . 18
  - 2.4.3 Screening Constituents Based on Frequency of Detection . . . . . 19
  - 2.4.4 Screening Constituents Based on Essential Human Nutrients . . . . . 19
  - 2.4.5 Additional Screening Procedures . . . . . 20

3.0 EXPOSURE ASSESSMENT . . . . . 20
- 3.1 Characterization of Exposure Setting . . . . . 20
- 3.2 Identifying Exposure Pathways . . . . . 21
- 3.3 Identifying Exposure Scenarios . . . . . 22
  - 3.3.1 Recreational Adult and Child Scenarios . . . . . 22
  - 3.3.2 Residential Adult and Child Scenarios . . . . . 26
  - 3.3.3 Off Site Construction Worker Scenario . . . . . 27
- 3.4 Exposure Point Concentrations . . . . . 27
- 3.5 Human Intake Equations And Assumptions . . . . . 28

4.0 TOXICITY ASSESSMENT . . . . . 33
- 4.1 Toxicity Values for Evaluating the Dermal Pathway . . . . . 34
- 4.2 Toxicity Assessment for Lead . . . . . 34

5.0 RISK CHARACTERIZATION . . . . . 36
- 5.1 Risk Characterization Methods . . . . . 36
  - 5.1.1 Quantification of Carcinogenic Risk . . . . . 36
  - 5.1.2 Quantification of Non-carcinogenic Risk . . . . . 37
- 5.2 Risk Characterization Results . . . . . 38

6.0 UNCERTAINTY IN THE RISK ASSESSMENT . . . . . 63
- 6.1 Uncertainty in Analytical Data . . . . . 63
- 6.2 Uncertainty in Exposure Assessment . . . . . 63
- 6.3 Uncertainties Related to Toxicity Information . . . . . 64
- 6.4 Uncertainties In Risk Characterization . . . . . 66

7.0 REFERENCES . . . . . 67

## LIST OF TABLES


| | |
|---|---|
| Table 2.1 | Identification of Constituents of Potential Concern for the Recreational RRE of the Miami-Erie Canal Area |
| Table 2.2 | Identification of Constituents of Potential Concern for the Residential RRE of the Miami-Erie Canal Area |
| Table 2.3 | Identification of Constituents of Potential Concern for the Off-Site Construction Worker RRE of the Miami-Erie Canal Area |
| Table 3.1 | Exposure Assumptions for Recreation, Residential and Off-Site Construction Worker Scenarios in the Miami-Erie Canal Area |
| Table 4.1 | Toxicity Values and Chemical-Specific Parameters for Constituents of Potential Concern in the Miami-Erie Canal Area |
| Table 5.1 | Total Residual Risk for a Recreational Adult at the Miami-Erie Canal Area |
| Table 5.2 | Background Risk for a Recreational Adult at the Miami-Erie Canal Area |
| Table 5.3 | Incremental Residual Risk for a Recreational Adult at the Miami-Erie Canal Area |
| Table 5.4 | Total Residual Risk for a Recreational Child at the Miami-Erie Canal Area |
| Table 5.5 | Background Risk for a Recreational Child at the Miami-Erie Canal Area |
| Table 5.6 | Incremental Residual Risk for a Recreational Child at the Miami-Erie Canal Area |
| Table 5.7 | Total Residual Risk for a Residential Adult at the Miami-Erie Canal Area |
| Table 5.8 | Background Risk for a Residential Adult at the Miami-Erie Canal Area |
| Table 5.9 | Incremental Residual Risk for a Residential Adult at the Miami-Erie Canal Area |
| Table 5.10 | Total Residual Risk for a Residential Child at the Miami-Erie Canal Area |
| Table 5.11 | Background Risk for a Residential Child at the Miami-Erie Canal Area |
| Table 5.12 | Incremental Residual Risk for a Residential Child at the Miami-Erie Canal Area |
| Table 5.13 | Total Residual Risk for an Off-Site Construction Worker at the Miami-Erie Canal Area |
| Table 5.14 | Background Risk for an Off-Site Construction Worker at the Miami-Erie Canal Area |
| Table 5.15 | Incremental Residual Risk for an Off-Site Construction Worker at the Miami-Erie Canal Area |
| Table 5.16 | Total Miami-Erie Canal Residual Risk Evaluation Summary Table |
| Table 5.17 | Background Miami-Erie Canal Risk Evaluation Summary Table |
| Table 5.18 | Incremental Miami-Erie Canal Residual Risk Evaluation Summary Table |


## LIST OF FIGURES


| | |
|---|---|
| Figure 1.1 | Mound Plant Vicinity Map |
| Figure 1.2 | Miami-Erie Canal Area Map |
| Figure 3.1 | Conceptual Site Model for the Miami-Erie Canal RRE |


## LIST OF APPENDICES


| | |
|---|---|
| Appendix A | Miami Erie Canal Database (Provided on 3.5 inch disk provided with this report) |

## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ATSDR | Agency for Toxic Substances Disease Registry |
| ARAR | Applicable or Relevant and Appropriate |
| BVA | Great Miami Buried Valley Aquifer |
| CDC | Centers of Disease Control and Prevention |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| COPCs | constituents of potential concern |
| CSF | cancer slope factor |
| DOE | Department of Energy |
| EPA | U.S. Environmental Protection Agency |
| EPC | exposure point concentration |
| FFA | Federal Facilities Agreement |
| GV | Guideline Values |
| HEAST | Health Effects and Assessment Summary Tables |
| HI | hazard index |
| HQ | hazard quotient |
| IEUBK | Integrated Exposure Uptake Biokinetic Model for Lead in Children |
| IRIS | Integrated Risk Information System |
| LOAEL | lowest observed adverse effects level |
| NCEA | National Center for Environmental Assessment |
| NCP | National Oil and Hazardous Substances Pollution Contingency Plan |
| ND | Not detected |
| NOAEL | no observed adverse effect level |
| Ohio EPA | Ohio Environmental Protection Agency |
| OSC | On-Scene Coordinator |
| OU | Operable Unit |
| PAH | polycyclic aromatic hydrocarbon |
| PCB | polychlorinated biphenyls |
| ppm | parts per million |
| PRS | Potential Release Site |
| QAPjP | quality assurance project plan |
| RAGS | Risk Assessment Guidance for Superfund |
| RfD | reference dose factor |
| RfC | reference concentration factor |
| RME | reasonable maximum exposure |
| RRE | residual risk evaluation |
| RREM | residual risk evaluation methodology |
| SVOCs | semi-volatile organic compounds |
| TPH | total petroleum hydrocarbon |
| TIC | tentatively identified compound |
| UCL | upper confidence limit |
| VOCs | volatile organic compounds |

# Miami-Erie Canal Human Health Residual Risk Evaluation

## Executive Summary

This report was prepared using the Mound 2000 Residual Risk Evaluation Methodology (DOE 1997a)(RREM) to quantify the potential for cancer and other non-cancer health effects from long-term, low-level exposures to site-related contaminants in the Miami-Erie Canal area. A Residual Risk Evaluation (RRE) evaluates human health risks associated with residual levels of contamination remaining within an area to ensure that future users of the land will not be exposed to unacceptable contaminant levels. Residual risks were calculated for total risk, background risk and incremental risk for the most likely and most conservative scenarios for the canal property. These scenarios included current and future recreational user (adult and child), a hypothetical future resident (adult and child) and a hypothetical adult off site construction worker. These scenarios included potential exposure to surface and subsurface soil via incidental ingestion, dermal contact, inhalation of dust and volatile organic compounds and external radiation exposure.

Total, background and incremental non-cancer risks for all receptors in all scenarios were below the target hazard level. This suggests that non-carcinogenic risks are within acceptable levels. Total, background and incremental carcinogenic risks for the recreational scenario (adult and child), the residential child and the adult off site construction worker fell within the acceptable risk range of $10^{-4}$ to $10^{-6}$ for both current and future scenarios. Background carcinogenic risks for the hypothetical adult residential scenario were within the acceptable carcinogenic risk range. Total and incremental carcinogenic risk for the hypothetical adult resident slightly exceeded the acceptable risk range of $10^{-4}$ to $10^{-6}$.

Total cancer risk for the residential adult was $3.1 \times 10^{-4}$. Of this risk, $1.2 \times 10^{-4}$ or 39% was due to dermal exposure to benzo(a)pyrene. An additional $1.5 \times 10^{-4}$ or 48% of this risk is due to external exposure to radium-226. Incremental cancer risk was $2.1 \times 10^{-4}$. Of this risk, $1.2 \times 10^{-4}$ or 60% was due to dermal exposure to benzo(a)pyrene. An additional $5.0 \times 10^{-5}$ or 24% of this risk is due to external exposure to radium-226.

PAHs are ubiquitous in many environments, particularly along railroad right-of-ways, such as the one running through the canal area. Radium-226 is a naturally occurring radioisotope that is present in background soils.

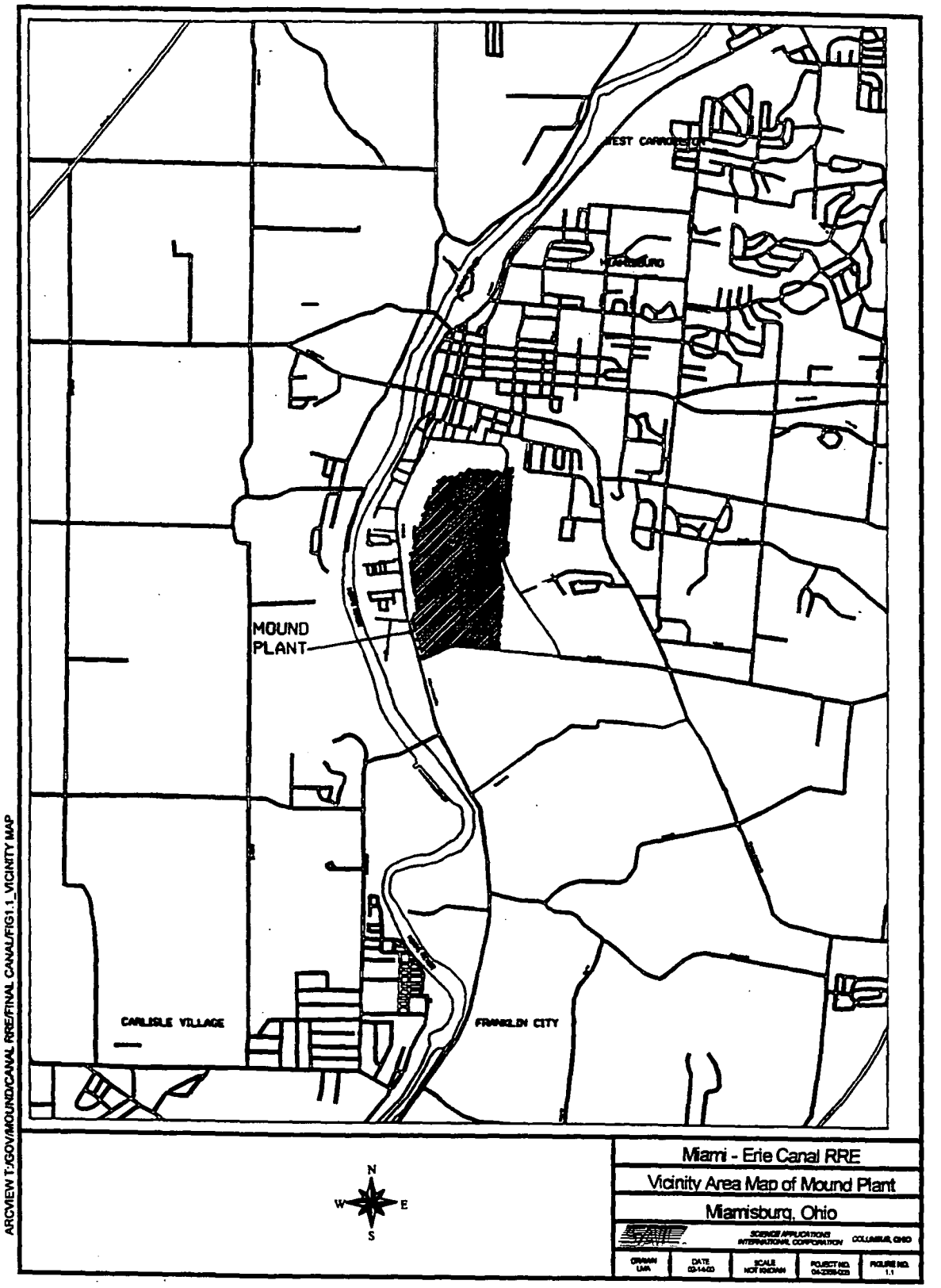
# 1.0 INTRODUCTION

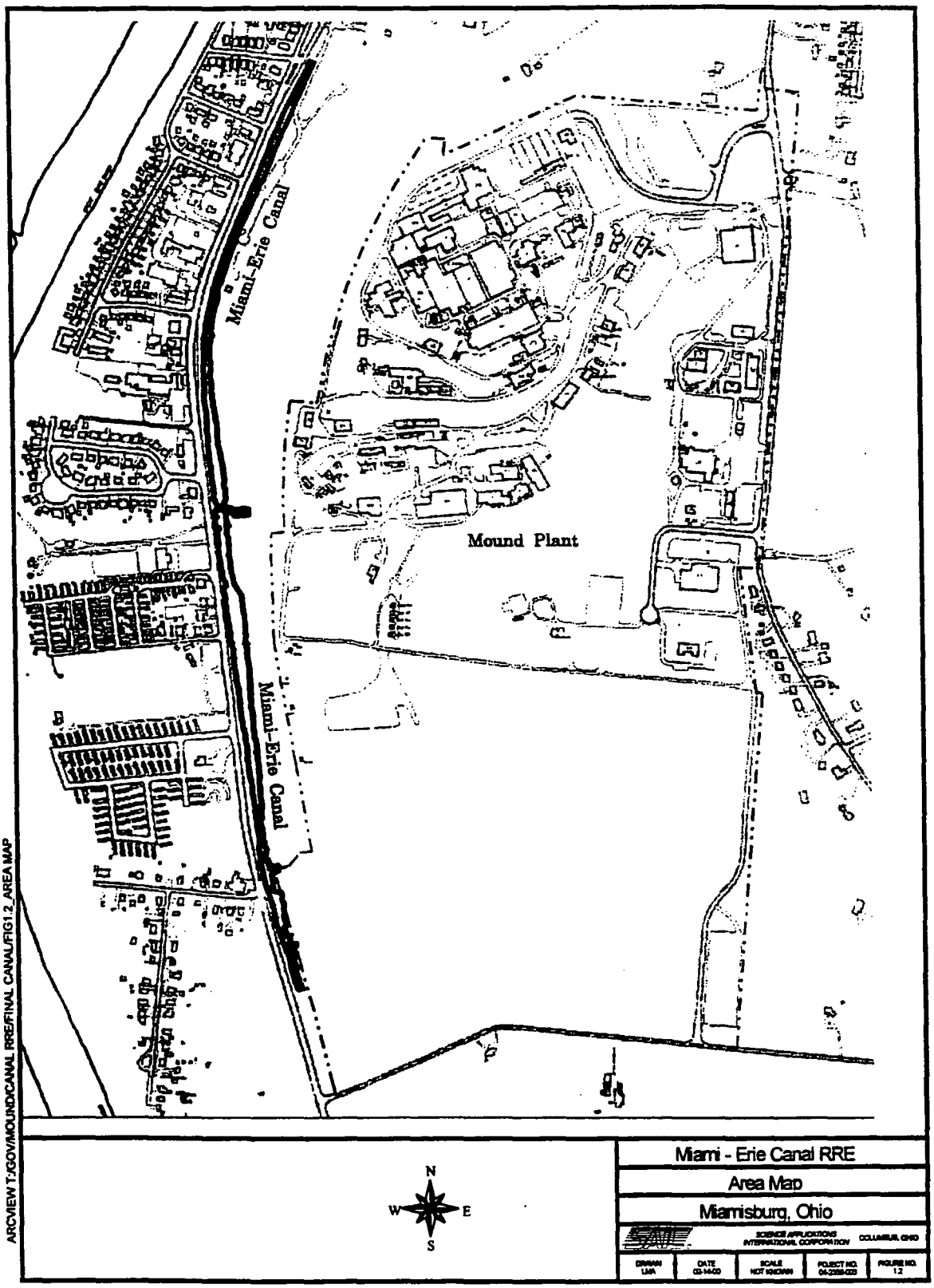
The U.S. Department of Energy's (DOE) Mound Plant is located on a 306-acre parcel of land within the City of Miamisburg, Ohio, about 10 miles southwest of Dayton, Ohio. Figure 1.1 shows the vicinity of the Mound Plant. The plant is located approximately 2,000 feet east of the Great Miami River and partially overlies the Great Miami Buried Valley Aquifer (BVA). Since 1948, Mound has operated as a research, development and production facility in support of DOE's weapons and energy programs. Mound's past weapons program mission included process development, production engineering, manufacturing, and surveillance of detonators, explosives, and nuclear components. Mound's current mission is to support DOE's efforts in environmental management and to transition the site, in cooperation with the City of Miamisburg, from a cold-war production facility to commercial or industrial use. The Miami-Erie Canal area, the subject of this report, will be returned to recreational use as a city park. A map of the Miami-Erie Canal area is included as Figure 1.2.

This report was developed using the Mound 2000 Residual Risk Evaluation Methodology (RREM) (DOE 1997a) to quantify the potential for cancer and other non-cancer health effects from long-term, low-level exposures to site-related contaminants in the canal area also known as Operable Unit 4 (OU-4). A Residual Risk Evaluation (RRE) evaluates human health risks associated with residual levels of contamination remaining within an area to ensure that future users of the land will not be exposed to contaminant levels that would pose unacceptable risks. The RRE results will be used, together with Applicable or Relevant and Appropriate Requirements (ARARs), to determine the need for additional site remediation or to demonstrate that land is ready for public use.

## 1.1 Purpose Of Residual Risk Evaluation

The objective of the Miami-Erie Canal area RRE is to assess risks associated with residual levels of contamination that exist after completion of the removal action. Although the RRE method was developed specifically for use at Mound, the method is consistent with the CERCLA baseline risk assessment method to ensure that future users of the land will not be exposed to contaminant levels that would pose unacceptable risks.


MOUND
PLANT
CARLISLE VILLAGE
FRANKLIN CITY
N
W
E
S
Miami - Erie Canal RRE
Vicinity Area Map of Mound Plant
Miamisburg, Ohio
SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
COLUMBUS, OHIO
DRAWN
DATE
SCALE
NOT KNOWN
PROJECT NO.
FIGURE NO.
1.1
ARCVIEW T:\GOV\MOUND\CANAL RRE\FINAL CANAL\FIG1.1_VICINITY MAP


Miami-Erie Canal
Mound Plant
Miami-Erie Canal
N
W
E
S
Miami - Erie Canal RRE
Area Map
Miamisburg, Ohio
SAIC
SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
COLUMBUS, OHIO
DRAWN LMA
DATE 02-14-00
SCALE NOT KNOWN
PROJECT NO. 04-2358-023
FIGURE NO. 1.2
ARCVIEW T:/GOV/MOUND/CANAL RRE/FINAL CANAL/FIG1.2_AREA MAP

## 1.2 Scope of the Miami-Erie Canal RRE

The RRE for the Miami-Erie Canal area includes an evaluation of human health risk for potential residual contamination in the area following the completion of the removal action documented in the On-Scene Coordinator (OSC) Report (DOE 1999). The canal area RRE was completed using the Mound 2000 RREM (DOE 1997a). Since the canal area is currently used for recreation purposes, residual risks were evaluated for the recreational scenario. Although residential use of the canal area is unlikely, given existing ~~land use restriction;~~ PHYSICAL CONSTRAINTS a residential risk calculation was performed to evaluate the need for additional restrictions. Since the RREM does not provide exposure assumptions or intake equations for the residential or recreational use scenarios the needed values were drawn from the "Risk Based Guideline Values, Mound Plant, Miamisburg, Ohio, March, 1997, Final Rev 4" (DOE 1997b).

Residual risks were calculated for total risk, background risk and incremental risk. Total risk was calculated using the total concentration of the constituents of potential concern (COPCs) detected in the canal area. Background risk was calculated based on background levels of the COPCs and incremental risk was calculated using the difference between total and background levels. Incremental risk can be used to assess the increase in risk above background levels due to Mound Plant operations.

## 1.3 Organization of Report

The RREM provides a framework for evaluating potential human health risks associated with residual levels of contamination. Although the RREM is similar to a traditional CERCLA baseline risk assessment, it serves a different purpose and, therefore, is not identical. The RREM consists of five elements, including:

1. identification of the contaminants to be evaluated,
2. exposure assessment,
3. toxicity assessment,
4. risk characterization,
5. and evaluation of potential cumulative risks.

The following sections describe each of these elements in more detail starting with Section 2.0, Data Compilation and Evaluation, which describes the methods used to compile Miami-Erie Canal area data and identify contaminants to be evaluated in the RRE. Section 3.0, Exposure Assessment, summarizes the

pathways through which hazardous substances may reach potential receptors and intake assumptions used to quantify exposure. In Section 4.0, Toxicity Assessment, exposure point concentrations, intake equations and toxicological reference values are presented. Information from the exposure assessment is combined with information from the toxicity assessment to characterize human health risks in Section 5.0, Risk Characterization. Section 6.0, Uncertainties, presents some of the sources of uncertainty inherent in risk assessments and in the RRE. Section 7.0, References, contains a list of all documents cited in this report.

## 2.0 DATA COMPILATION AND EVALUATION

Identification of contaminants to be carried through the RRE calculations is a multi-step process beginning with the identification of all contaminants detected in the area and then eliminating contaminants based upon a set of established screening criteria described in the RREM.

All available sampling data were compiled for use in the Miami-Erie Canal RRE. Newer data was used to supplement, rather than supersede older data except when older data described materials that had subsequently been removed from the area. In this case, the older data no longer represent site conditions and were, therefore, not used in the RRE. Sampling data obtained from the Mound Soil Screening Facility was used except in the case where a sample was split and analyzed by both the Mound Soil Screening Facility and a commercial analytical laboratory. In such cases, the value from the commercial analytical laboratory was used to take advantage of the greater precision available from the commercial analytical laboratory. Data used to characterize the Miami-Erie Canal area were drawn from the following data sets:

| DATA SET DESCRIPTION | REFERENCE |
|---|---|
| Canal Removal Action Verification Data<br>*Includes samples from South Pond, Runoff Hollow, Overflow Creek, and portions of the Plant Drainage Ditch between the plant boundary and the canal* | On-Scene Coordinator Report, OU-4 Miami-Erie Canal Removal Action, Final, June, 1999 |
| Water Park/Tennis Court Sampling Results<br>*Samples obtained in park area as part of previous investigations* | OU-9 Regional Soils Investigation Report, August 1995, Final, Revision 2<br><br>Mound Laboratory Environmental Plutonium Study 1974 (MLM-02249), September 1975 |
| Twin 60s Sediment Sampling | PRS 416 Data Package, Unpublished |

The following data sets were excluded because they represent areas remediated by removal actions.

| DATA SET DESCRIPTION | REFERENCE |
|---|---|
| Original Rogers Study | "Mound Laboratory Environmental Plutonium Study (1974). Samples from the park vicinity were included in the RRE. |
| Special Canal Sampling, SAIC 1992 | |
| Agency for Toxic Substances Disease Registry (ATSDR) | "Health Consultation, DOE Mound Plant" (1994) |

The ATSDR report included samples obtained from the park area, however, insufficient information about the analytical techniques (e.g. minimum detectable activities, sample quantitation limits) was provided to allow for data verification, so the data were not included in the RRE.

## 2.1 Data Quality Assessment

Samples were collected and analyzed according to the methods outlined in the OU9 Quality Assurance Project Plan (QAPjP) (DOE 1993a) and the OU5 QAPjP (DOE 1993b). All data used in the risk assessment have undergone Quality Assurance/Quality Control (QA/QC) evaluation and data validation in accordance with the requirements described in the OU9 QAPjP (DOE 1993a) and the OU5 QAPjP (DOE 1993b).

## 2.2 Environmental Media Considered and Data Availability

Field investigations conducted for the canal area are listed above. Samples were analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides and polychlorinated biphenyls (PCBs), dioxins/dibenzofurans, metals, common anions, total petroleum hydrocarbons (TPH), and radionuclides. Environmental media that were evaluated include surface soil (0-2 feet below land surface), subsurface soil (>2 feet below land surface), and sediment. During the canal area removal action, approximately 38,000 $yds^3$ of soil were removed. Only 16 out 15,214 analyses were run on soil collected more than two feet below land surface. Following soil removal, clean soil was brought in to backfill excavated areas so samples collected at 0-2 feet below land surface may now have an additional 1-2 feet of clean fill over them.

Although it is possible that contamination in the canal area may leach through soil to reach the BVA, for the canal area RRE it was assumed that residential, recreational and off site construction worker receptors

would drink municipally supplied water, not water obtained from the BVA. Potential risks due to exposure to BVA groundwater will be assessed prior to completion of the final Mound Record of Decision.

Canal area drainage ways contain water only during heavy rain events and therefore, are dry most of the time. Due to intermittent flow in the canal area ditches, receptors in the canal area were assumed to come into contact with sediments with the same frequency, as they would surface soils. Therefore, the exposure assumptions for soils and sediments are the same and these media have been merged into one data set for the RRE. Merging the soil and sediment data sets increased the statistical power of the data set by increasing the number of observations. Since the same exposure assumptions were used to estimate exposures to sediment and soil, combining the data sets does not reduce the overall estimate of risk but does simplify the presentation of RRE results.

## 2.3 Data Analysis

For each constituent detected in Miami-Erie Canal area soils, the 95% upper confidence limit of the mean (UCL) was calculated to estimate the concentration that receptors in the area may be exposed to. This is known as the Exposure Point Concentration or EPC. The 95% UCL was calculated in accordance with Mound 2000, Gilbert's *Statistical Methods for Environmental Pollution Monitoring* (Gilbert 1987), and the *Supplemental Guidance to RAGS: Calculating the Concentration Term* (EPA, 1992a). Before calculating the 95% UCL, the distribution of the data set was determined. If the data were found to be normally distributed, the EPC was calculated as the 95% UCL of the arithmetic mean of the data, using the Student's t-statistic (EPA 1992a). If the data were found to be log normally distributed, the EPC was calculated as the 95% UCL using the H-statistic (EPA 1992a).

The 95% UCL on the arithmetic mean for normal data sets was calculated as follows:

$$95\% \text{ UCL} = \text{Mean} + t(s/n^{1/2})$$

Where:

UCL= upper confidence limit,
t = t statistic (Table A2, Gilbert, 1987),
s = standard deviation, and
n = number of observation in the data set

The 95% UCL equation of the arithmetic mean for log-normal data sets was calculated as follows:

$$95\% \text{ UCL} = e^{\text{Mean}+H(s/(n-1)^{1/2})}$$

Where:

UCL = upper confidence limit,
H = H statistic (Table A12, Gilbert, 1987),
s = standard deviation, and
n = number of observations in the data set
e = constant

If the 95% UCL exceeded the maximum value observed in the sampling results , the maximum value was used as the EPC for that constituent (whether the data were normally or log normally distributed). For both chemical and radiological constituents "not detected" (ND) results were treated as one-half the limit of detection and included in the calculations of the mean and UCL values. Blind field duplicates were collected to assess variability in the sampling process. Duplicate samples were used in the data quality assessment but were not included in the calculation of the exposure point concentrations. If a data set had less than twenty observations (n<20) the maximum detected concentration was used as the EPC. For radionuclides, zero or negative results with no detection limits were excluded from the data set. Data qualified as "J", or estimated values at concentrations less than the detection limit, were evaluated as half the detection limit. For "J" data, which was greater than the detection limit or reported without the sample detection limit, the value was used as reported. Samples reported as ND or zero with no detection limit were not utilized in calculating a 95% UCL. Data flagged with an "R", meaning rejected, were also not used in calculating the EPC.

## 2.4 Data Screening Process

All constituents that were detected one or more times were listed in constituent summary tables and sorted by media and depth where they were detected. The constituent screening methods described below were then used to generate a final list of constituents of potential concern (COPCs). The constituent summary tables also provide maximum detected concentrations, the range of contaminant detection limits, the frequency of detection and the decision and rationale to include or exclude a constituent from further consideration in the RRE. The following section describes how COPCs were selected. Tables 2.1, 2.2 and 2.3 identify the COPCs for the recreational, residential, and off site construction worker scenarios, respectively.

**Table 2.1 Identification of Constituents of Potential Concern for the Recreational RRE of the Miami-Erie Canal Area**

| CAS Number | Chemical | Minimum Concentration | | Maximum Concentration | | Units | Location of Maximum Concentration | Detection Frequency | 95 Percent UCL | Concentration Used for Screening | Background Value | Screening Guideline Value | Ref. GV | COPC? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semi-Volatile Organic Compounds** | | | | | | | | | | | | | | |
| 91-57-6 | 2-Methylnaphthalene | 23 | J | 150 | J | UG/KG | 97VS1N23 | 25-128 | 229.00 | 150.00 | | | | YES |
| 106-44-5 | 4-Methylphenol | 64 | J | 64 | J | UG/KG | 97VN6N21 | 1-128 | 262.00 | 64.00 | | 5500000.0 | a | NO:1 |
| 83-32-9 | Acenaphthene | 20 | J | 750 | J | UG/KG | 97VN5N20 | 30-128 | 195.00 | 195.00 | | | | YES |
| 208-96-8 | Acenaphthylene | 19 | J | 650 | J | UG/KG | 97VN4L22 | 41-128 | 213.00 | 213.00 | | | | YES |
| 120-12-7 | Anthracene | 23 | J | 2300 | J | UG/KG | 97VN5N20 | 59-128 | 254.00 | 254.00 | | 330000000.0 | a | NO:3 |
| 56-55-3 | Benzo(a)anthracene | 21 | J | 7300 | | UG/KG | 97VN5N20 | 117-128 | 654.00 | 654.00 | | 35000.0 | d | NO:3 |
| 50-32-8 | Benzo(a)pyrene | 21 | J | 7900 | | UG/KG | 97VN5N20 | 111-128 | 688.00 | 688.00 | | 3500.0 | d | NO:3 |
| 205-99-2 | Benzo(b)fluoranthene | 23 | J | 7100 | | UG/KG | 97VN5N20 | 117-128 | 681.00 | 681.00 | | 35000.0 | d | NO:3 |
| 191-24-2 | Benzo(g,h,i)perylene | 22 | J | 4700 | | UG/KG | 97VN5N20 | 110-128 | 477.00 | 477.00 | | | | YES |
| 207-08-9 | Benzo(k)fluoranthene | 22 | J | 7000 | | UG/KG | 97VN5N20 | 113-128 | 669.00 | 669.00 | | 350000.0 | d | NO:3 |
| 65-85-0 | Benzoic Acid | 20 | JB | 220 | J | UG/KG | 97VS51L6 | 37-125 | 1070.00 | 220.00 | | 4400000000.0 | a | NO:3 |
| 117-81-7 | Bis(2-ethylhexyl)phthalat | 20 | JB | 44000 | D | UG/KG | 97VN35L13 | 68-128 | 1070.00 | 1070.00 | | 1800000.0 | d | NO:3 |
| 85-68-7 | Butyl Benzyl Phthalate | 20 | J | 380 | J | UG/KG | 97VS25N33 | 11-128 | 257.00 | 257.00 | | 220000000.0 | a | NO:3 |
| 86-74-8 | Carbazole | 22 | J | 930 | J | UG/KG | 97VN5N20 | 48-128 | 191.00 | 191.00 | | | | YES |
| 218-01-9 | Chrysene | 25 | J | 8100 | | UG/KG | 97VN5N20 | 120-128 | 747.00 | 747.00 | | 3500000.0 | d | NO:3 |
| 84-74-2 | Di-n-butyl Phthalate | 22 | J | 4300 | | UG/KG | 97VS20N23 | 31-128 | 368.00 | 368.00 | | 110000000.0 | a | NO:3 |
| 53-70-3 | Dibenz(a,h)anthracene | 20 | J | 1500 | J | UG/KG | 97VN21L17 | 59-128 | 240.00 | 240.00 | | 3500.0 | d | NO:3 |
| 132-64-9 | Dibenzofuran | 20 | J | 510 | J | UG/KG | 97VN5N20 | 26-128 | 195.00 | 195.00 | | | | YES |
| 84-66-2 | Diethyl Phthalate | 44 | J | 59 | J | UG/KG | 97VS20N23 | 2-128 | 262.00 | 59.00 | | | | NO:1 |
| 206-44-0 | Fluoranthene | 20 | J | 17000 | | UG/KG | 97VN5N20 | 122-128 | 1440.00 | 1440.00 | | 44000000.0 | a | NO:3 |
| 86-73-7 | Fluorene | 20 | J | 1200 | J | UG/KG | 97VN5N20 | 34-128 | 210.00 | 210.00 | | | | YES |
| 193-39-5 | Indeno(1,2,3-cd)pyrene | 20 | J | 4600 | | UG/KG | 97VN21L17 | 109-128 | 462.00 | 462.00 | | 35000.0 | d | NO:3 |
| 91-20-3 | Naphthalene | 19 | J | 140 | J | UG/KG | 97VS1N23 | 24-128 | 229.00 | 140.00 | | | | YES |
| 87-86-5 | Pentachlorophenol | 30 | J | 70 | J | UG/KG | 97VS2N22 | 2-128 | 658.00 | 70.00 | | 210000.0 | d | NO:1 |
| 85-01-8 | Phenanthrene | 21 | J | 13000 | | UG/KG | 97VN5N20 | 113-128 | 773.00 | 773.00 | | | | YES |
| 108-95-2 | Phenol | 21 | J | 270 | J | UG/KG | 97VN3L15 | 16-128 | 248.00 | 248.00 | | 660000000.0 | a | NO:3 |
| 129-00-0 | Pyrene | 28 | J | 17000 | | UG/KG | 97VN5N20 | 121-128 | 1310.00 | 1310.00 | | 33000000.0 | a | NO:3 |
| **Volatile Organic Compounds** | | | | | | | | | | | | | | |
| 107-06-2 | 1,2-Dichloroethane | 1 | J | 1 | J | UG/KG | CT | 1-3 | 3.92 | 1.00 | | 63000.0 | c | NO:3 |
| 75-09-2 | Methylene Chloride | 2 | J | 2 | J | UG/KG | CT | 1-3 | 3.34 | 2.00 | | 100000.0 | b | NO:3 |
| 108-88-3 | Toluene | 1 | J | 1 | J | UG/KG | CT | 1-3 | 3.92 | 1.00 | | 220000000.0 | b | NO:3 |

Footnotes on page 3.

Table 2.1 Identification of Constituents of Potential Concern for the Recreational RRE of the Miami-Erie Canal Area

| CAS Number | Chemical | Minimum Concentration | | Maximum Concentration | | Units | Location of Maximum Concentration | Detection Frequency | 95% UCL | Concentration Used for Screening | Background Value | Screening Guideline Value | Ref. GV | COPC? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Metals | | | | | | | | | | | | | | |
| 7429-90-5 | Aluminum | 3080.00 | | 15300.00 | | MG/KG | 97VN47L14 | 128-128 | 9890.00 | 9890.00 | 19000 | | | NO:2 |
| 7440-36-0 | Antimony | 0.45 | B | 81.10 | | MG/KG | 97VN5L2 | 31-128 | 2.15 | 2.15 | | 44.0 | a | NO:3 |
| 7440-38-2 | Arsenic | 3.70 | | 27.00 | J | MG/KG | 97VN35L13 | 128-128 | 9.50 | 9.50 | 8.6 | 33.0 | a | NO:3 |
| 7440-39-3 | Barium | 24.00 | B | 234.00 | | MG/KG | 97VRHN1 | 128-128 | 88.40 | 88.40 | 180 | 77000.0 | b | NO:2,3 |
| 7440-41-7 | Beryllium | 0.17 | B | 1.10 | B | MG/KG | 97VN47L14 | 127-128 | 0.62 | 0.62 | 1.3 | 6.0 | c | NO:2,3 |
| 7440-69-9 | Bismuth | 1.20 | | 63.9 | | MG/KG | CT | 17-128 | 3.10 | 3.10 | | | | YES |
| 7440-43-9 | Cadmium | 0.08 | B | 4.20 | | MG/KG | 97VS31N17 | 65-128 | 0.34 | 0.34 | 2.1 | 1100.0 | a | NO:2,3 |
| 7440-70-2 | Calcium | 4080.00 | | 144000.00 | | MG/KG | 97VS26N25 | 128-128 | 43200.00 | 43200.00 | 310000 | | | NO:2,4 |
| 7440-47-3 | Chromium | 4.50 | | 126.00 | | MG/KG | 97VS28N5 | 128-128 | 22.40 | 22.40 | 20 | 5500.0 | a | NO:3 |
| 7440-48-4 | Cobalt | 3.40 | B | 15.50 | | MG/KG | 97VN18L12 | 128-128 | 9.21 | 9.21 | 19 | | | NO:2 |
| 7440-50-8 | Copper | 9.90 | | 141.00 | | MG/KG | 97VS31N17 | 128-128 | 34.70 | 34.70 | 26 | | | YES |
| 57-12-5 | Cyanide | 0.36 | B | 6.80 | | MG/KG | 97VS51L6 | 6-128 | 0.30 | 0.30 | | 22000.0 | a | NO:1 |
| 7439-89-6 | Iron | 7040.00 | | 46800.00 | | MG/KG | 97VN35L13 | 128-128 | 20500.00 | 20500.00 | 35000 | | | NO:2.,4 |
| 7439-92-1 | Lead | 5.50 | | 8190.00 | | MG/KG | 97VS43N24 | 128-128 | 226.00 | 226.00 | 48 | | | YES |
| 7439-95-4 | Magnesium | 2080.00 | | 83200.00 | | MG/KG | 97VS26N25 | 128-128 | 16700.00 | 16700.00 | 40000 | | | NO:2,4 |
| 7439-96-5 | Manganese | 213.00 | | 1130.00 | | MG/KG | 97VS41N2 | 128-128 | 551.00 | 551.00 | 1400 | 130000.0 | b | NO:2,3 |
| 7439-97-6 | Mercury | 0.05 | B | 1.30 | | MG/KG | 97VS31N17 | 97-128 | 0.21 | 0.21 | | 330.0 | b | NO:3 |
| 7440-02-0 | Nickel | 7.50 | B | 31.80 | | MG/KG | 97VN35L13 | 128-128 | 19.30 | 19.30 | 32 | 22000.0 | a | NO:2,3 |
| 7440-09-7 | Potassium | 529.00 | B | 2690.00 | | MG/KG | 97VN27L15 | 128-128 | 1600.00 | 1600.00 | 1900 | | | NO:2,4 |
| 7782-49-2 | Selenium | 0.51 | B | 2.20 | | MG/KG | 97VN13L8 | 62-128 | 0.91 | 0.91 | | | | YES |
| 7440-22-4 | Silver | 0.20 | B | 11.20 | | MG/KG | 97VS19N5 | 21-128 | 0.44 | 0.44 | 1.7 | 5500.0 | a | NO:2,3 |
| 7440-23-5 | Sodium | 72.50 | B | 600.00 | B | MG/KG | 97VS48N4 | 125-128 | 180.00 | 180.00 | 240 | | | NO:2 |
| 7440-28-0 | Thallium | 0.94 | B | 3.20 | | MG/KG | 97VS55L3 | 33-128 | 0.88 | 0.88 | 0.46 | | | YES |
| 7440-62-2 | Vanadium | 8.40 | | 34.40 | | MG/KG | 97VS1AN13 | 128-128 | 22.00 | 22.00 | 25 | 7700.0 | a | NO:2,3 |
| 7440-66-6 | Zinc | 28.30 | | 481.00 | | MG/KG | 97VS43N24 | 128-128 | 91.00 | 91.00 | 140 | 330000.0 | a | NO:2,3 |

Footnotes on page 3.

**Table 2.1 Identification of Constituents of Potential Concern for the Recreational RRE of the Miami-Erie Canal Area**

| CAS Number | Chemical | Minimum Concentration | | Maximum Concentration | | Units | Location of Maximum Concentration | Detection Frequency | 95 Percent UCL | Concentration Used for Screening | Background Value | Screening Guideline Value | Ref. GV | COPC? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pesticides/PCBS** | | | | | | | | | | | | | | |
| 60-57-1 | Dieldrin | 1.100 | | 1.100 | | UG/KG | CT | 1-3 | 1.33 | 1.10 | | 1600.0 | c | NO:3 |
| 53494-70-5 | Endrin Ketone | 0.430 | J | 2.000 | | UG/KG | CT | 3-3 | 2.47 | 2.00 | | | | YES |
| 5103-74-2 | Gamma Chlordane | 0.300 | J | 0.300 | J | UG/KG | CT | 1-3 | 0.34 | 0.30 | | | | YES |
| **Radionuclides** | | | | | | | | | | | | | | |
| 10045-97-3 | Cesium-137 | 0.19 | | 0.19 | | PCI/G | CT | 1-3 | 0.25 | 0.19 | 0.42 | 0.8 | e | NO:2,3 |
| 13981-16-3 | Plutonium-238 | 0.01 | J | 715 | | PCI/G | 97VS34N9 | 683-702 | 23.00 | 23.00 | 0.13 | 110.0 | e | NO:3 |
| PU-239/240 | Plutonium-239/240 | 0.00 | | 4.17 | | PCI/G | 97VS43N16 | 412-680 | 0.10 | 0.10 | 0.18 | 100.0 | e | NO:2,3 |
| 13966-00-2 | Potassium-40 | 11.10 | | 14.90 | | PCI/G | CT | 3-3 | 16.00 | 14.90 | 37 | | | NO:2 |
| 13982-63-3 | Radium-226 | 1.84 | | 3.04 | | PCI/G | CT | 2-3 | 4.09 | 3.04 | 2 | 0.3 | e | YES |
| 10098-97-2 | Strontium-90 | 0.61 | | 7.20 | | PCI/G | CT | 3-3 | 9.22 | 7.20 | 0.72 | 570.0 | e | NO:3 |
| 14274-82-9 | Thorium-228 | 0.87 | | 7.67 | | PCI/G | 97VS19N5 | 126-126 | 1.27 | 1.27 | 1.5 | 1.7 | e | NO:2,3 |
| 14269-63-7 | Thorium-230 | 0.87 | | 7.99 | | PCI/G | 97VS8N21 | 126-126 | 1.57 | 1.57 | 1.9 | 820.0 | e | NO:2,3 |
| 7440-29-1 | Thorium-232 | 0.51 | | 2.17 | | PCI/G | 97VS47N29 | 126-126 | 1.00 | 1.00 | 1.4 | 950.0 | e | NO:2,3 |
| 10028-17-8 | Tritium | 0.05 | | 79.60 | | PCI/G | 97VS19N5 | 106-124 | 5.96 | 5.96 | 1.6 | 45000.0 | e | NO:3 |
| 13966-29-5 | Uranium-234 | 0.62 | | 1.28 | | PCI/G | 97VS17N6 | 126-126 | 0.95 | 0.95 | 1.1 | 710.0 | e | NO:2,3 |
| 15117-96-1 | Uranium-235 | 0.01 | | 0.10 | | PCI/G | 97VN31N17 | 97-126 | 0.05 | 0.50 | 0.11 | 6.6 | e | NO:3 |
| 7440-61-1 | Uranium-238 | 0.64 | | 1.62 | | PCI/G | 97VN35L13 | 126-126 | 1.00 | 1.00 | 1.2 | 31.0 | e | NO:2,3 |

a= 1/10th HI for ingestion
b= 1/10th HI for ingestion + inhalation
c= $10^{-6}$ cancer risk for ingestion + inhalation
d= $10^{-6}$ cancer risk for ingestion
e= $10^{-6}$ cancer risk for ingestion + inhalation + external
"J" = estimated quantitiy
"B" = analyte detected in associated blank

NO:1 - <5% Detects
NO:2 - <Background
NO:3 - < Screening Toxicity Value
NO:4 - Essential Human Nutrient
1.00E-06 is equivalent to 1.00 x $10^{-6}$

**Table 2.2 Identification of Constituents of Potential Concern for the Residential RRE of the Miami-Erie Canal Area**

| CAS Number | Chemical | Minimum Concentration | | Maximum Concentration | | Units | Location of Maximum Concentration | Detection Frequency | 95% UCL | Concentration Used for Screening | Background Value | Screening Guideline Value | Ref. GV | COPC? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Metals** | | | | | | | | | | | | | | |
| 7429-90-5 | Aluminum | 3080.00 | | 15300.00 | | MG/KG | 97VN47L14 | 128-128 | 9890.00 | 9890.00 | 19000 | | | NO:2 |
| 7440-36-0 | Antimony | 0.45 | B | 81.10 | | MG/KG | 97VN5L2 | 31-128 | 2.15 | 2.15 | | 11.00 | a | NO:3 |
| 7440-38-2 | Arsenic | 3.70 | | 27.00 | J | MG/KG | 97VN35L13 | 128-128 | 9.50 | 9.50 | 8.6 | 8.20 | a | YES |
| 7440-39-3 | Barium | 24.00 | B | 234.00 | | MG/KG | 97VRHN1 | 128-128 | 88.40 | 88.40 | 180 | 1900.00 | b | NO:2,3 |
| 7440-41-7 | Beryllium | 0.17 | B | 1.10 | B | MG/KG | 97VN47L14 | 127-128 | 0.62 | 0.62 | 1.3 | 0.15 | c | NO:2 |
| 7440-69-9 | Bismuth | 1.20 | | 63.9 | | MG/KG | CT | 17-128 | 3.10 | 3.10 | | | | YES |
| 7440-43-9 | Cadmium | 0.08 | B | 4.20 | | MG/KG | 97VS31N17 | 65-128 | 0.34 | 0.34 | 2.1 | 27.00 | a | NO:2,3 |
| 7440-70-2 | Calcium | 4080.00 | | 144000.00 | | MG/KG | 97VS26N25 | 128-128 | 43200.00 | 43200.00 | 310000 | | | NO:2,4 |
| 7440-47-3 | Chromium | 4.50 | | 126.00 | | MG/KG | 97VS28N5 | 128-128 | 22.40 | 22.40 | 20 | 140.00 | a | NO:3 |
| 7440-48-4 | Cobalt | 3.40 | B | 15.50 | | MG/KG | 97VN18L12 | 128-128 | 9.21 | 9.21 | 19 | | | NO:2 |
| 7440-50-8 | Copper | 9.90 | | 141.00 | | MG/KG | 97VS31N17 | 128-128 | 34.70 | 34.70 | 26 | | | YES |
| 57-12-5 | Cyanide | 0.36 | B | 6.80 | | MG/KG | 97VS51L6 | 6-128 | 0.30 | 0.30 | | 550.00 | a | NO:1 |
| 7439-89-6 | Iron | 7040.00 | | 46800.00 | | MG/KG | 97VN35L13 | 128-128 | 20500.00 | 20500.00 | 35000 | | | NO:2,4 |
| 7439-92-1 | Lead | 5.50 | | 8190.00 | | MG/KG | 97VS43N24 | 128-128 | 226.00 | 226.00 | 48 | | | YES |
| 7439-95-4 | Magnesium | 2080.00 | | 83200.00 | | MG/KG | 97VS26N25 | 128-128 | 16700.00 | 16700.00 | 40000 | | | NO:2 |
| 7439-96-5 | Manganese | 213.00 | | 1130.00 | | MG/KG | 97VS41N2 | 128-128 | 551.00 | 551.00 | 1400 | 3800.00 | b | NO:2,3 |
| 7439-97-6 | Mercury | 0.05 | B | 1.30 | | MG/KG | 97VS31N17 | 97-128 | 0.21 | 0.21 | | 8.20 | b | NO:3 |
| 7440-02-0 | Nickel | 7.50 | B | 31.80 | | MG/KG | 97VN35L13 | 128-128 | 19.30 | 19.30 | 32 | 550.00 | a | NO:2,3 |
| 7440-09-7 | Potassium | 529.00 | B | 2690.00 | | MG/KG | 97VN27L15 | 128-128 | 1600.00 | 1600.00 | 1900 | | | NO:2,4 |
| 7782-49-2 | Selenium | 0.51 | B | 2.20 | | MG/KG | 97VN13L8 | 62-128 | 0.91 | 0.91 | | | | YES |
| 7440-22-4 | Silver | 0.20 | B | 11.20 | | MG/KG | 97VS19N5 | 21-128 | 0.44 | 0.44 | 1.7 | 140.00 | a | NO:2,3 |
| 7440-23-5 | Sodium | 72.50 | B | 600.00 | B | MG/KG | 97VS48N4 | 125-128 | 180.00 | 180.00 | 240 | | | NO:2,4 |
| 7440-28-0 | Thallium | 0.94 | B | 3.20 | | MG/KG | 97VS55L3 | 33-128 | 0.88 | 0.88 | 0.46 | | | YES |
| 7440-62-2 | Vanadium | 8.40 | | 34.40 | | MG/KG | 97VS1AN13 | 128-128 | 22.00 | 22.00 | 25 | 190.00 | a | NO:2,3 |
| 7440-66-6 | Zinc | 28.30 | | 481.00 | | MG/KG | 97VS43N24 | 128-128 | 91.00 | 91.00 | 140 | 8200.00 | a | NO:2,3 |

Footnotes on page 3.

**Table 2.2 Identification of Constituents of Potential Concern for the Residential RRE of the Miami-Erie Canal Area**

| CAS Number | Chemical | Minimum Concentration | | Maximum Concentration | | Units | Location of Maximum Concentration | Detection Frequency | 95% UCL | Concentration Used for Screening | Background Value | Screening Guideline Value | Ref. GV | COPC? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semi-Volatile Organic Compounds** | | | | | | | | | | | | | | |
| 91-57-6 | 2-Methylnaphthalene | 23 | J | 150 | J | UG/KG | 97VS1N23 | 25-128 | 229.00 | 150.00 | | | | YES |
| 106-44-5 | 4-Methylphenol | 64 | J | 64 | J | UG/KG | 97VN6N21 | 1-128 | 262.00 | 64.00 | | 140.00 | a | NO:1 |
| 83-32-9 | Acenaphthene | 20 | J | 750 | J | UG/KG | 97VN5N20 | 30-128 | 195.00 | 195.00 | | | | YES |
| 208-96-8 | Acenaphthylene | 19 | J | 650 | J | UG/KG | 97VN4L22 | 41-128 | 213.00 | 213.00 | | | | YES |
| 120-12-7 | Anthracene | 23 | J | 2300 | J | UG/KG | 97VN5N20 | 59-128 | 254.00 | 254.00 | | 8200000.00 | a | NO:3 |
| 56-55-3 | Benzo(a)anthracene | 21 | J | 7300 | | UG/KG | 97VN5N20 | 117-128 | 654.00 | 654.00 | | 880.00 | d | NO:3 |
| 50-32-8 | Benzo(a)pyrene | 21 | J | 7900 | | UG/KG | 97VN5N20 | 111-128 | 688.00 | 688.00 | | 88.00 | d | YES |
| 205-99-2 | Benzo(b)fluoranthene | 23 | J | 7100 | | UG/KG | 97VN5N20 | 117-128 | 681.00 | 681.00 | | 880.00 | d | NO:3 |
| 191-24-2 | Benzo(g,h,i)perylene | 22 | J | 4700 | | UG/KG | 97VN5N20 | 110-128 | 477.00 | 477.00 | | | | YES |
| 207-08-9 | Benzo(k)fluoranthene | 22 | J | 7000 | | UG/KG | 97VN5N20 | 113-128 | 669.00 | 669.00 | | 8800.00 | d | NO:3 |
| 65-85-0 | Benzoic Acid | 20 | JB | 220 | J | UG/KG | 97VS51L6 | 37-125 | 1070.00 | 220.00 | | 110000000.00 | a | NO:3 |
| 117-81-7 | Bis(2-ethylhexyl)phthala | 20 | JB | 44000 | D | UG/KG | 97VN35L13 | 68-128 | 1070.00 | 1070.00 | | 46000.00 | d | NO:3 |
| 85-68-7 | Butyl Benzyl Phthalate | 20 | J | 380 | J | UG/KG | 97VS25N33 | 11-128 | 257.00 | 257.00 | | 5500000.00 | a | NO:3 |
| 86-74-8 | Carbazole | 22 | J | 930 | J | UG/KG | 97VN5N20 | 48-128 | 191.00 | 191.00 | | | | YES |
| 218-01-9 | Chrysene | 25 | J | 8100 | | UG/KG | 97VN5N20 | 120-128 | 747.00 | 747.00 | | 88000.00 | d | NO:3 |
| 84-74-2 | Di-n-butyl Phthalate | 22 | J | 4300 | | UG/KG | 97VS20N23 | 31-128 | 368.00 | 368.00 | | 2700000.00 | a | NO:3 |
| 53-70-3 | Dibenz(a,h)anthracene | 20 | J | 1500 | J | UG/KG | 97VN21L17 | 59-128 | 240.00 | 240.00 | | 88.00 | d | YES |
| 132-64-9 | Dibenzofuran | 20 | J | 510 | J | UG/KG | 97VN5N20 | 26-128 | 195.00 | 195.00 | | | | YES |
| 84-66-2 | Diethyl Phthalate | 44 | J | 59 | J | UG/KG | 97VS20N23 | 2-128 | 262.00 | 59.00 | | | | NO:1 |
| 206-44-0 | Fluoranthene | 20 | J | 17000 | | UG/KG | 97VN5N20 | 122-128 | 1440.00 | 1440.00 | | 1100000.00 | a | NO:3 |
| 86-73-7 | Fluorene | 20 | J | 1200 | J | UG/KG | 97VN5N20 | 34-128 | 210.00 | 210.00 | | | | YES |
| 193-39-5 | Indeno(1,2,3-cd)pyrene | 20 | J | 4600 | | UG/KG | 97VN21L17 | 109-128 | 462.00 | 462.00 | | 880.00 | d | NO:3 |
| 91-20-3 | Naphthalene | 19 | J | 140 | J | UG/KG | 97VS1N23 | 24-128 | 229.00 | 140.00 | | | | YES |
| 87-86-5 | Pentachlorophenol | 30 | J | 70 | J | UG/KG | 97VS2N22 | 2-128 | 658.00 | 70.00 | | 5300.00 | d | NO:1 |
| 85-01-8 | Phenanthrene | 21 | J | 13000 | | UG/KG | 97VN5N20 | 113-128 | 773.00 | 773.00 | | | | YES |
| 108-95-2 | Phenol | 21 | J | 270 | J | UG/KG | 97VN3L15 | 16-128 | 248.00 | 248.00 | | 16000000.00 | a | NO:3 |
| 129-00-0 | Pyrene | 28 | J | 17000 | | UG/KG | 97VN5N20 | 121-128 | 1310.00 | 1310.00 | | 820000.00 | a | NO:3 |
| **Volatile Organic Compounds** | | | | | | | | | | | | | | |
| 107-06-2 | 1,2-Dichloroethane | 1 | J | 1 | J | UG/KG | CT | 1-3 | 3.92 | 1.00 | | 1600.00 | c | NO:3 |
| 75-09-2 | Methylene Chloride | 2 | J | 2 | J | UG/KG | CT | 1-3 | 3.34 | 2.00 | | 100000.00 | b | NO:3 |
| 108-88-3 | Toluene | 1 | J | 1 | J | UG/KG | CT | 1-3 | 3.92 | 1.00 | | 25000.00 | b | NO:3 |

Footnotes on page 3.

**Table 2.2 Identification of Constituents of Potential Concern for the Residential RRE of the Miami-Erie Canal Area**

| CAS Number | Chemical | Minimum Concentration | | Maximum Concentration | | Units | Location of Maximum Concentration | Detection Frequency | 95% UCL | Concentration Used for Screening | Background Value | Screening Guideline Value | Ref. GV | COPC? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pesticides/PCBS** | | | | | | | | | | | | | | |
| 60-57-1 | Dieldrin | 1.100 | | 1.100 | | UG/KG | CT | 1-3 | 1.33 | 1.10 | | 40.00 | c | NO:3 |
| 53494-70-5 | Endrin Ketone | 0.430 | J | 2.000 | | UG/KG | CT | 3-3 | 2.47 | 2.00 | | | | YES |
| 5103-74-2 | Gamma Chlordane | 0.300 | J | 0.300 | J | UG/KG | CT | 1-3 | 0.34 | 0.30 | | | | YES |
| **Radionuclides** | | | | | | | | | | | | | | |
| 10045-97-3 | Cesium-137 | 0.19 | | 0.19 | | PCI/G | CT | 1-3 | 0.25 | 0.19 | 0.42 | 0.05 | e | NO:2 |
| 13981-16-3 | Plutonium-238 | 0.01 | J | 715.00 | | PCI/G | 97VS34N9 | 689-718 | 22.50 | 22.50 | 0.13 | 2.70 | e | YES |
| PU-239/240 | Plutonium-239/240 | 0.00 | | 4.17 | | PCI/G | 97VS43N16 | 412-680 | 0.10 | 0.10 | 0.18 | 2.50 | e | NO:2,3 |
| 13966-00-2 | Potassium-40 | 11.10 | | 14.90 | | PCI/G | CT | 3-3 | 16.00 | 14.90 | 37 | | | NO:2 |
| 13982-63-3 | Radium-226 | 1.84 | | 3.04 | | PCI/G | CT | 2-3 | 4.09 | 3.04 | 2 | 0.02 | e | YES |
| 10098-97-2 | Strontium-90 | 0.52 | | 7.20 | | PCI/G | CT | 3-3 | 9.22 | 7.20 | 0.72 | 14.00 | e | NO:3 |
| 14274-82-9 | Thorium-228 | 0.61 | | 7.67 | | PCI/G | 97VS19N5 | 126-126 | 1.27 | 1.27 | 1.5 | 0.11 | e | NO:2 |
| 14269-63-7 | Thorium-230 | 0.87 | | 7.99 | | PCI/G | 97VS8N21 | 126-126 | 1.57 | 1.57 | 1.9 | 21.00 | e | NO:2,3 |
| 7440-29-1 | Thorium-232 | 0.51 | | 2.17 | | PCI/G | 97VS47N29 | 126-126 | 1.12 | 1.00 | 1 | 24.00 | e | NO:3 |
| 10028-17-8 | Tritium | 0.05 | | 79.60 | | PCI/G | 97VS19N5 | 106-124 | 5.96 | 5.96 | 1.6 | 11000.00 | e | NO:3 |
| 13966-29-5 | Uranium-234 | 0.62 | | 1.28 | | PCI/G | 97VS17N6 | 126-126 | 0.95 | 0.95 | 1.1 | 18.00 | e | NO:2,3 |
| 15117-96-1 | Uranium-235 | 0.01 | | 0.10 | | PCI/G | 97VN31N17 | 97-126 | 0.05 | 0.05 | 0.11 | 0.41 | e | NO:2,3 |
| 7440-61-1 | Uranium-238 | 0.64 | | 1.62 | | PCI/G | 97VN35L13 | 126-126 | 1.03 | 1.03 | 1.2 | 1.80 | e | NO:2,3 |

a= 1/10th HI for ingestion
b= 1/10th HI for ingestion + inhalation
c= $10^{-6}$ cancer risk for ingestion + inhalation
d= $10^{-6}$ cancer risk for ingestion
e= $10^{-6}$ cancer risk for ingestion + inhalation + external
"J" = estimated quantitiy
"B" = analyte detected in associated blank

NO:1 - <5% Detects
NO:2 - <Background
NO:3 - < Screening Toxicity Value
NO:4 - Essential Human Nutrient
1.00E-06 is equivalent to $1.00 \times 10^{-6}$

**Table 2.3 Identification of Constituents of Potential Concern for the Off Site Construction Worker RRE of the Miami-Erie Canal Area**

| CAS Number | Chemical | Minimum Concentration | | Maximum Concentration | | Units | Location of Maximum Concentration | Detection Frequency | 95% UCL | Concentration Used for Screening | Background Value | Screening Guideline Value | Ref. GV | COPC? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Metals** | | | | | | | | | | | | | | |
| 7429-90-5 | Aluminum | 3080.00 | | 15300.00 | | MG/KG | 97VN47L14 | 128-128 | 9890.00 | 9890.00 | 19000 | | | NO:2 |
| 7440-36-0 | Antimony | 0.45 | B | 81.10 | | MG/KG | 97VN5L2 | 31-128 | 2.15 | 2.15 | | 8.50 | a | NO:3 |
| 7440-38-2 | Arsenic | 3.70 | | 27.00 | J | MG/KG | 97VN35L13 | 128-128 | 9.50 | 9.50 | 8.6 | 6.40 | a | YES |
| 7440-39-3 | Barium | 24.00 | B | 234.00 | | MG/KG | 97VRHN1 | 128-128 | 88.40 | 88.40 | 180 | 1500.00 | b | NO:2,3 |
| 7440-41-7 | Beryllium | 0.17 | B | 1.10 | B | MG/KG | 97VN47L14 | 127-128 | 0.62 | 0.62 | 1.3 | 3.50 | c | NO:2,3 |
| 7440-69-9 | Bismuth | 1.20 | | 63.9 | | MG/KG | CT | 17-128 | 3.10 | 3.10 | | | | YES |
| 7440-43-9 | Cadmium | 0.08 | B | 4.20 | | MG/KG | 97VS31N17 | 65-128 | 0.34 | 0.34 | 2.1 | 21.00 | a | NO:2,3 |
| 7440-70-2 | Calcium | 4080.00 | | 144000.00 | | MG/KG | 97VS26N25 | 128-128 | 43200.00 | 43200.00 | 310000 | | | NO:2,4 |
| 7440-47-3 | Chromium | 4.50 | | 126.00 | | MG/KG | 97VS28N5 | 128-128 | 22.40 | 22.40 | 20 | 110.00 | a | NO:3 |
| 7440-48-4 | Cobalt | 3.40 | B | 15.50 | | MG/KG | 97VN18L12 | 128-128 | 9.21 | 9.21 | 19 | | | NO:2 |
| 7440-50-8 | Copper | 9.90 | | 141.00 | | MG/KG | 97VS31N17 | 128-128 | 34.70 | 34.70 | 26 | | | YES |
| 57-12-5 | Cyanide | 0.36 | B | 6.80 | | MG/KG | 97VS51L6 | 6-128 | 0.30 | 0.30 | | 430.00 | a | NO:1 |
| 7439-89-6 | Iron | 7040.00 | | 46800.00 | | MG/KG | 97VN35L13 | 128-128 | 20500.00 | 20500.00 | 35000 | | | NO:2,4 |
| 7439-92-1 | Lead | 5.50 | | 8190.00 | | MG/KG | 97VS43N24 | 128-128 | 226.00 | 226.00 | 48 | | | YES |
| 7439-95-4 | Magnesium | 2080.00 | | 83200.00 | | MG/KG | 97VS26N25 | 128-128 | 16700.00 | 16700.00 | 40000 | | | NO:2 |
| 7439-96-5 | Manganese | 213.00 | | 1130.00 | | MG/KG | 97VS41N2 | 128-128 | 551.00 | 551.00 | 1400 | 2700.00 | b | NO:2,3 |
| 7439-97-6 | Mercury | 0.05 | B | 1.30 | | MG/KG | 97VS31N17 | 97-128 | 0.21 | 0.21 | | 6.40 | b | NO:3 |
| 7440-02-0 | Nickel | 7.50 | B | 31.80 | | MG/KG | 97VN35L13 | 128-128 | 19.30 | 19.30 | 32 | 430.00 | a | NO:2,3 |
| 7440-09-7 | Potassium | 529.00 | B | 2690.00 | | MG/KG | 97VN27L15 | 128-128 | 1600.00 | 1600.00 | 1900 | | | NO:2,4 |
| 7782-49-2 | Selenium | 0.51 | B | 2.20 | | MG/KG | 97VN13L8 | 62-128 | 0.91 | 0.91 | | | | YES |
| 7440-22-4 | Silver | 0.20 | B | 11.20 | | MG/KG | 97VS19N5 | 21-128 | 0.44 | 0.44 | 1.7 | 110.00 | a | NO:2,3 |
| 7440-23-5 | Sodium | 72.50 | B | 600.00 | B | MG/KG | 97VS48N4 | 125-128 | 180.00 | 180.00 | 240 | | | NO:2,4 |
| 7440-28-0 | Thallium | 0.94 | B | 3.20 | | MG/KG | 97VS55L3 | 33-128 | 0.88 | 0.88 | 0.46 | | | YES |
| 7440-62-2 | Vanadium | 8.40 | | 34.40 | | MG/KG | 97VS1AN13 | 128-128 | 22.00 | 22.00 | 25 | 150.00 | a | NO:2,3 |
| 7440-66-6 | Zinc | 28.30 | | 481.00 | | MG/KG | 97VS43N24 | 128-128 | 91.00 | 91.00 | 140 | 6400.00 | a | NO:2,3 |

Footnotes on page 3.

**Table 2.3 Identification of Constituents of Potential Concern for the Off Site Construction Worker RRE of the Miami-Erie Canal Area**

| CAS Number | Chemical | Minimum Concentration | | Maximum Concentration | | Units | Location of Maximum Concentration | Detection Frequency | 95% UCL | Concentration Used for Screening | Background Value | Screening Guideline Value | Ref. GV | COPC? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semi-Volatile Organic Compounds** | | | | | | | | | | | | | | |
| 91-57-6 | 2-Methylnaphthalene | 23 | J | 150 | J | UG/KG | 97VS1N23 | 25-128 | 229.00 | 150.00 | | | | YES |
| 106-44-5 | 4-Methylphenol | 64 | J | 64 | J | UG/KG | 97VN6N21 | 1-128 | 262.00 | 64.00 | | 110000.00 | a | NO:1 |
| 83-32-9 | Acenaphthene | 20 | J | 750 | J | UG/KG | 97VN5N20 | 30-128 | 195.00 | 195.00 | | | | YES |
| 208-96-8 | Acenaphthylene | 19 | J | 650 | J | UG/KG | 97VN4L22 | 41-128 | 213.00 | 213.00 | | | | YES |
| 120-12-7 | Anthracene | 23 | J | 2300 | J | UG/KG | 97VN5N20 | 59-128 | 254.00 | 254.00 | | 6400000.00 | a | NO:3 |
| 56-55-3 | Benzo(a)anthracene | 21 | J | 7300 | | UG/KG | 97VN5N20 | 117-128 | 654.00 | 654.00 | | 20000.00 | d | NO:3 |
| 50-32-8 | Benzo(a)pyrene | 21 | J | 7900 | | UG/KG | 97VN5N20 | 111-128 | 688.00 | 688.00 | | 2000.00 | d | NO:3 |
| 205-99-2 | Benzo(b)fluoranthene | 23 | J | 7100 | | UG/KG | 97VN5N20 | 117-128 | 681.00 | 681.00 | | 20000.00 | d | NO:3 |
| 191-24-2 | Benzo(g,h,i)perylene | 22 | J | 4700 | | UG/KG | 97VN5N20 | 110-128 | 477.00 | 477.00 | | | | YES |
| 207-08-9 | Benzo(k)fluoranthene | 22 | J | 7000 | | UG/KG | 97VN5N20 | 113-128 | 669.00 | 669.00 | | 200000.00 | d | NO:3 |
| 65-85-0 | Benzoic Acid | 20 | JB | 220 | J | UG/KG | 97VS51L6 | 37-125 | 1070.00 | 220.00 | | 85000000.00 | a | NO:3 |
| 117-81-7 | Bis(2-ethylhexyl)phthala | 20 | JB | 44000 | D | UG/KG | 97VN35L13 | 68-128 | 1070.00 | 1070.00 | | 430000.00 | a | NO:3 |
| 85-68-7 | Butyl Benzyl Phthalate | 20 | J | 380 | J | UG/KG | 97VS25N33 | 11-128 | 257.00 | 257.00 | | 4300000.00 | a | NO:3 |
| 86-74-8 | Carbazole | 22 | J | 930 | J | UG/KG | 97VN5N20 | 48-128 | 191.00 | 191.00 | | | | YES |
| 218-01-9 | Chrysene | 25 | J | 8100 | | UG/KG | 97VN5N20 | 120-128 | 747.00 | 747.00 | | 2000000.00 | d | NO:3 |
| 84-74-2 | Di-n-butyl Phthalate | 22 | J | 4300 | | UG/KG | 97VS20N23 | 31-128 | 368.00 | 368.00 | | 2100000.00 | a | NO:3 |
| 53-70-3 | Dibenz(a,h)anthracene | 20 | J | 1500 | J | UG/KG | 97VN21L17 | 59-128 | 240.00 | 240.00 | | 2000000.00 | d | NO:3 |
| 132-64-9 | Dibenzofuran | 20 | J | 510 | J | UG/KG | 97VN5N20 | 26-128 | 195.00 | 195.00 | | | | YES |
| 84-66-2 | Diethyl Phthalate | 44 | J | 59 | J | UG/KG | 97VS20N23 | 2-128 | 262.00 | 59.00 | | | | NO:1 |
| 206-44-0 | Fluoranthene | 20 | J | 17000 | | UG/KG | 97VN5N20 | 122-128 | 1440.00 | 1440.00 | | 850000.00 | a | NO:3 |
| 86-73-7 | Fluorene | 20 | J | 1200 | J | UG/KG | 97VN5N20 | 34-128 | 210.00 | 210.00 | | | | YES |
| 193-39-5 | Indeno(1,2,3-cd)pyrene | 20 | J | 4600 | | UG/KG | 97VN21L17 | 109-128 | 462.00 | 462.00 | | 20000.00 | d | NO:3 |
| 91-20-3 | Naphthalene | 19 | J | 140 | J | UG/KG | 97VS1N23 | 24-128 | 229.00 | 140.00 | | | | YES |
| 87-86-5 | Pentachlorophenol | 30 | J | 70 | J | UG/KG | 97VS2N22 | 2-128 | 658.00 | 70.00 | | 120000.00 | d | NO:1 |
| 85-01-8 | Phenanthrene | 21 | J | 13000 | | UG/KG | 97VN5N20 | 113-128 | 773.00 | 773.00 | | | | YES |
| 108-95-2 | Phenol | 21 | J | 270 | J | UG/KG | 97VN3L15 | 16-128 | 248.00 | 248.00 | | 13000000.00 | a | NO:3 |
| 129-00-0 | Pyrene | 28 | J | 17000 | | UG/KG | 97VN5N20 | 121-128 | 1310.00 | 1310.00 | | 640000.00 | a | NO:3 |
| **Volatile Organic Compounds** | | | | | | | | | | | | | | |
| 107-06-2 | 1,2-Dichloroethane | 1 | J | 1 | J | UG/KG | CT | 1-3 | 3.92 | 1.00 | | 55000.00 | c | NO:3 |
| 75-09-2 | Methylene Chloride | 2 | J | 2 | J | UG/KG | CT | 1-3 | 3.34 | 2.00 | | 100000.00 | b | NO:3 |
| 108-88-3 | Toluene | 1 | J | 1 | J | UG/KG | CT | 1-3 | 3.92 | 1.00 | | 25000.00 | b | NO:3 |

Footnotes on page 3.

**Table 2.3 Identification of Constituents of Potential Concern for the Off Site Construction Worker RRE of the Miami-Erie Canal Area**

| CAS Number | Chemical | Minimum Concentration | | Maximum Concentration | | Units | Location of Maximum Concentration | Detection Frequency | 95% UCL | Concentration Used for Screening | Background Value | Screening Guideline Value | Ref. GV | COPC? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pesticides/PCBS** | | | | | | | | | | | | | | |
| 60-57-1 | Dieldrin | 1.100 | | 1.100 | | UG/KG | CT | 1-3 | 1.33 | 1.10 | | 930.00 | c | NO:3 |
| 53494-70-5 | Endrin Ketone | 0.430 | J | 2.000 | | UG/KG | CT | 3-3 | 2.47 | 2.00 | | | | YES |
| 5103-74-2 | Gamma Chlordane | 0.300 | J | 0.300 | J | UG/KG | CT | 1-3 | 0.34 | 0.30 | | | | YES |
| **Radionuclides** | | | | | | | | | | | | | | |
| 10045-97-3 | Cesium-137 | 0.19 | | 0.19 | | PCI/G | CT | 1-3 | 0.25 | 0.19 | 0.42 | 2.30 | e | NO:2,3 |
| 13981-16-3 | Plutonium-238 | 0.01 | J | 715.00 | | PCI/G | 97VS34N9 | 689-718 | 22.50 | 22.50 | 0.13 | 28.00 | e | NO:3 |
| PU-239/240 | Plutonium-239/240 | 0.00 | | 4.17 | | PCI/G | 97VS43N16 | 412-680 | 0.10 | 0.10 | 0.18 | 26.00 | e | NO:2,3 |
| 13966-00-2 | Potassium-40 | 11.10 | | 14.90 | | PCI/G | CT | 3-3 | 16.00 | 14.90 | 37 | | | NO:2 |
| 13982-63-3 | Radium-226 | 1.84 | | 3.04 | | PCI/G | CT | 2-3 | 4.09 | 3.04 | 2 | 0.70 | e | YES |
| 10098-97-2 | Strontium-90 | 0.52 | | 7.20 | | PCI/G | CT | 3-3 | 9.22 | 7.20 | 0.72 | 150.00 | e | NO:3 |
| 14274-82-9 | Thorium-228 | 0.61 | | 7.67 | | PCI/G | 97VS19N5 | 126-126 | 1.27 | 1.27 | 1.5 | 4.30 | e | NO:2,3 |
| 14269-63-7 | Thorium-230 | 0.87 | | 7.99 | | PCI/G | 97VS8N21 | 126-126 | 1.57 | 1.57 | 1.9 | 220.00 | e | NO:2,3 |
| 7440-29-1 | Thorium-232 | 0.51 | | 2.17 | | PCI/G | 97VS47N29 | 126-126 | 1.12 | 1.00 | 1 | 250.00 | e | NO:3 |
| 10028-17-8 | Tritium | 0.05 | | 79.60 | | PCI/G | 97VS19N5 | 106-124 | 5.96 | 5.96 | 1.6 | 120000.00 | e | NO:3 |
| 13966-29-5 | Uranium-234 | 0.62 | | 1.28 | | PCI/G | 97VS17N6 | 126-126 | 0.95 | 0.95 | 1.1 | 190.00 | e | NO:2,3 |
| 15117-96-1 | Uranium-235 | 0.01 | | 0.10 | | PCI/G | 97VN31N17 | 97-126 | 0.05 | 0.05 | 0.11 | 17.00 | e | NO:2,3 |
| 7440-61-1 | Uranium-238 | 0.64 | | 1.62 | | PCI/G | 97VN35L13 | 126-126 | 1.03 | 1.03 | 1.2 | 55.00 | e | NO:2,3 |

a= 1/10th HI for ingestion
b= 1/10th HI for ingestion + inhalation
c= $10^{-6}$ cancer risk for ingestion + inhalation
d= $10^{-6}$ cancer risk for ingestion
e= $10^{-6}$ cancer risk for ingestion + inhalation + external
"J" = estimated quantitiy
"B" = analyte detected in associated blank

NO:1 - <5% Detects
NO:2 - <Background
NO:3 - < Screening Toxicity Value
NO:4 - Essential Human Nutrient
1.00E-06 Is equivalent to $1.00 \times 10^{-6}$

### 2.4.1 Screening Constituents Based on Background

Site-specific background concentrations described as the Upper 95% Tolerance Limit of the background sample results for each constituent have been developed for Mound Plant soils (DOE 1997a) and are presented in the RREM. Constituents with a maximum concentration detected exceeding their level in background were identified as COPCs and carried to the next step of the RRE. Constituents with maximum concentrations less than their background concentration were not carried though the RRE. If no background value was available for a particular constituent (e.g., many organic compounds), the constituent was carried through to the next step of the RRE.

In cases where the 95% UCL of the arithmetic mean fell below the maximum detected value, the 95% UCL was compared to background to determine whether the 95% UCL was below background. If the 95% UCL was below the background value for the constituent, the constituent was not identified as a COPC in the RRE. Including constituents whose 95% UCL is less than background would cause the incremental risk to be a "negative" risk. Eliminating these constituents focuses the RRE on constituents detected above background.

### 2.4.2 Screening Constituents Based on Guideline Values

Soil constituents present at concentrations that exceed background concentration were compared to Risk-Based Guideline Values (GVs) for the Mound Facility (DOE 1997b). GVs are media-specific concentrations of constituents that correspond to specific human health risk levels for specified exposure scenarios. GVs were developed for recreational, residential and off site construction worker scenarios (see DOE 1997b for the detailed derivation of Guideline Values). Recreational, residential and off site construction worker GVs, were used to screen COPCs for retention in the quantitative risk assessment.

The GVs used to screen COPCs were developed specifically for Mound, and were approved by the DOE, the U.S. EPA, and Ohio EPA. The GVs correspond to the $10^{-6}$ risk level for carcinogenic constituents and radionuclides, and to a Hazard Quotient of one for each non-carcinogen constituent. A $1 \times 10^{-6}$ risk level represents an incremental increase of one chance in one million of developing cancer as a result of exposure to the GV concentration. Since the target risk level for carcinogenic constituents is a range of $10^{-4}$ to $10^{-6}$, as specified in the NCP, screening COPCs against the GV is protective. For non-carcinogenic constituents, the Hazard Quotient (HQ), or the ratio of the intake of a single constituent to its reference dose, is used to define

acceptable risk. When multiple COPCs occur in the same area, the HQs are summed to derive a Hazard Index (HI). The target threshold for non-carcinogenic constituents is a HI of less than or equal to one. The GVs for non-carcinogenic constituents were calculated for a HI of one. To account for the possibility of more than one non-carcinogenic constituent, COPC's were screened using 1/10 the GV for non-carcinogenic constituents. Carcinogenic or radioactive constituents that exceed their GVs and non-carcinogenic constituents that exceed one-tenth of their GV were carried to the next step of the RRE.

### 2.4.3 Screening Constituents Based on Frequency of Detection

Constituents detected at concentrations above Mound background levels and above applicable GVs were next evaluated for their frequency of detection. The Risk Assessment Guidance for Superfund (RAGS) Part A (EPA, 1989) states that infrequently detected compounds may be artifacts in the data due to sampling, analytical, or other problems, and therefore may not be site-related. Compounds that were detected infrequently in all media, and not detected at high concentrations in any medium were eliminated from further consideration by the RRE. No compounds were eliminated on the basis that they were unrelated to historical operations conducted within the canal area.

Infrequent detection was defined as five percent or less. This is equivalent to one detect in 20 samples. If there were an insufficient number of samples (e.g. less than 20) to determine whether the frequency of detection is five percent or less, the contaminant was not eliminated on the basis of frequency of detection. Other relevant factors such as whether the constituent is expected to be present based on historical data or degradation products of known contaminants also was considered in the decision to include or exclude infrequently detected constituents.

### 2.4.4 Screening Constituents Based on Essential Human Nutrients

According to RAGS Part A (EPA 1989): "Chemicals that are (1) essential human nutrients, (2) present at low concentrations (i.e., only slightly elevated above naturally occurring levels), and (3) toxic only at very high doses (i.e., much higher than those that could be associated with contact at the site) need not be considered further in the quantitative risk assessment." Inorganic analytes meeting this description were not carried through the RRE. Calcium, chloride, iron, magnesium, potassium, and sodium are considered essential nutrients to humans. These compounds were detected in the canal area at levels below or slightly elevated above

background and are toxic only at very high doses. Concentrations of these compounds in on-site media would not be expected to result in intakes associated with a toxic response. Therefore, these compounds were eliminated as COPCs for the canal area.

### 2.4.5 Additional Screening Procedures

In accordance with the RREM, additional screening procedures also were used to evaluate Miami-Erie Canal area constituents. For example, in accordance with EPA's Functional Guideline for Organics (EPA 1988) if a blank contains measurable levels of a common laboratory contaminant, then the associated sample results were considered as positive results only if the concentration in the samples exceeded ten times the concentration in the blank. If the concentration of a common laboratory contaminant was less than ten times the blank concentration, the constituent was considered to be an artifact of laboratory handling and was not included in the RRE. Common laboratory contaminants include acetone, 2-butanone, methylene chloride, toluene and phthalate esters.

Given the high degree of uncertainty in both the identity and reported concentrations of tentatively identified compounds (TICs), these constituents were not carried through the RRE. Relatively few TICs were reported in the Miami-Erie Canal database and historical information does not suggest that a particular TIC should be present.

## 3.0 EXPOSURE ASSESSMENT

The goal of the RRE exposure assessment is to estimate the type and magnitude of contaminant exposures that may occur under current conditions with the area being used for recreational purposes and in the future assuming that the area is developed for residential use. The information gathered in the exposure assessment is integrated with toxicity information to characterize potential risks associated with exposure to residual contamination in the canal area.

### 3.1 Characterization of Exposure Setting

The Miami-Erie Canal area is located west of the Mound Plant between the Conrail Railroad right-of-way to the east and Dayton-Cincinnati Road to the west. The areas includes: (1) the abandoned Miami-Erie Canal; (2) Overflow Creek which connects the canal to the Great Miami River; (3) a drainage ditch from the

site boundary to the canal; (4) Runoff Hollow between the Conrail tracks and the Mound Plant; and (5) South Pond in the Miamisburg City Park. Currently, land use in the canal area is a combination of city park, Conservancy District, and railroad right-of-way.

Historic operations and accidental releases from the Mound Plant have resulted in the discharge of contamination into the Miami-Erie Canal area. This contamination consisted primarily of plutonium and tritium (DOE 1999). An underground pipeline rupture at the Mound Plant in 1969 resulted in the release of plutonium-238 in a nitric acid solution. During pipeline remediation, a rainstorm washed contaminated soil to the canal and, to a lesser extent, to Overflow Creek and the Great Miami River. Plutonium-contaminated soils were deposited as sediments in the canal. Tritium contamination of canal area soils is largely due to the pre-1970 disposal of tritiated process liquids. Some of the tritiated water released to the canal area may have infiltrated and migrated to the regional aquifer known as the Buried Valley Aquifer (BVA), however, groundwater in the canal area is currently not used.

Several investigations and one removal action have been performed in the Miami-Erie Canal area since the pipeline break in 1969. For a complete chronology of Miami-Erie Canal activities, see the OSC Report (DOE 1999). Restoration activities in the Miami-Erie Canal area have included the excavation and removal of approximately 38,000 cubic yards of soil. The removal action clean-up goal was to remove plutonium-238, with a resulting 95% UCL of the mean concentrations less than 75 pCi/g, and to remove all known spots of contamination greater than 150 pCi/g (DOE 1999). These goals were established by a focus group of stakeholders to be consistent with risk-based GVs for the recreation use scenario. The OSC report (DOE 1999) demonstrated that the verification sampling results confirm that these goals were achieved. Following completion of the Miami-Erie Canal restoration project, 1-2 feet of clean soil was brought in to replace soil that had been removed. The clean soil was graded, grass was seeded, trees were planted, and a bike path was constructed. The canal property will once again be used as a City of Miamisburg park after a DOE easement is canceled.

### 3.2 Identifying Exposure Pathways

Although many exposure pathways are possible, this RRE focuses only on the likely pathways within expected recreational land use. Pathways for residential and off site construction worker use were added to evaluate the need for ~~additional~~ land use restrictions. When identifying exposure pathways it is important to

keep in mind the four elements of an exposure pathway. An exposure pathway consists of: (1) a source of chemical release, (2) a transport media, (3) a point of potential human contact with the contaminated media, and (4) an exposure route (e.g. ingestion). If any of these elements is missing or eliminated, the pathway will be incomplete and exposure will not occur.

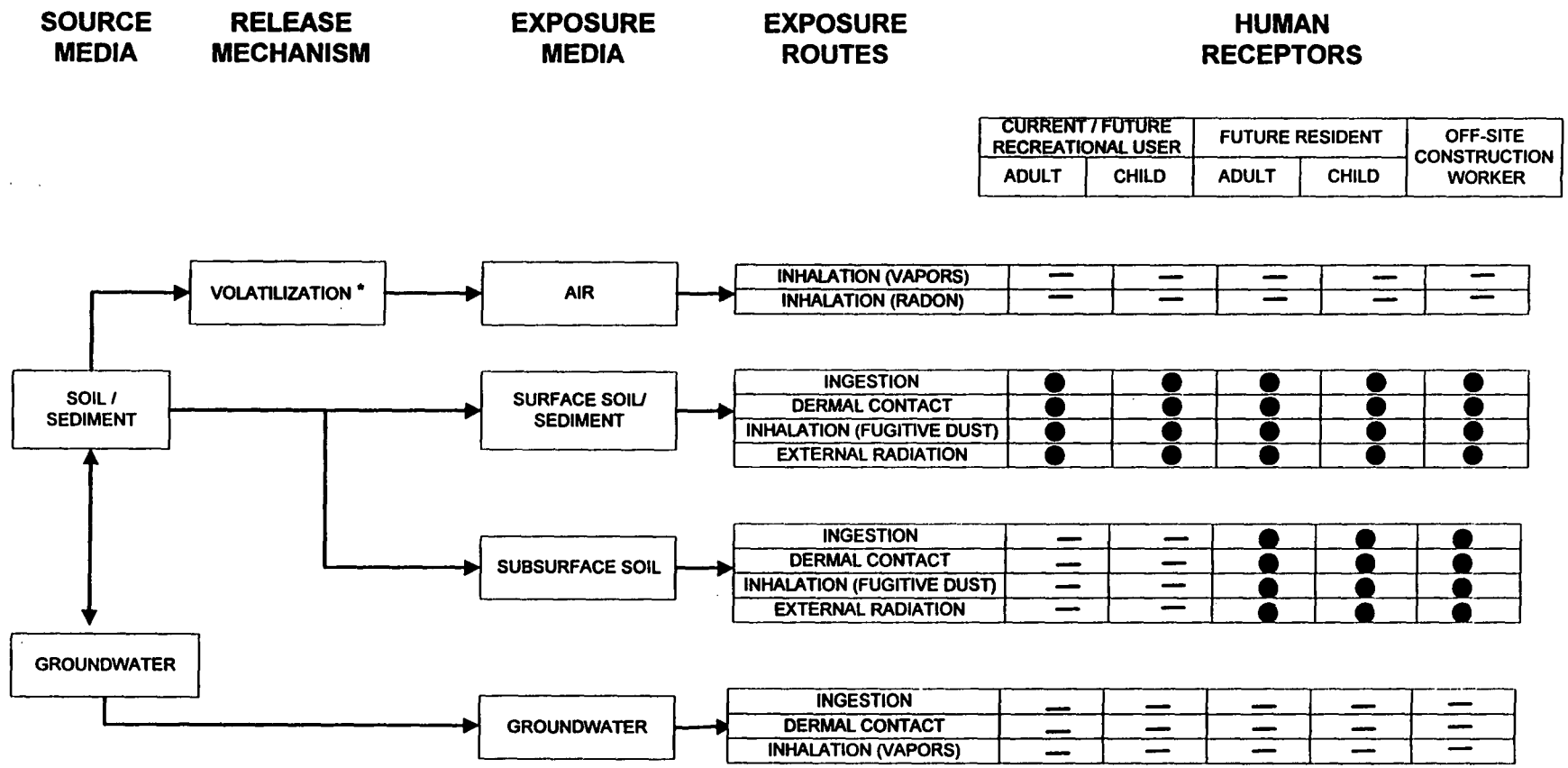
A graphical representation of the exposure pathways identified for potential receptors is included in the conceptual site model for the Miami-Erie Canal (Figure 3.1). The conceptual site model summarizes the pathways that hazardous substances may take to reach potential receptors. Exposure assumptions used to evaluate potential exposure pathways were drawn from the Mound Plant *Risk-Based Guideline Values* (DOE 1997b) and are based on the reasonable maximum exposure (RME) scenario recommended by RAGS Part A (EPA 1989). The RME scenario is a conservative depiction of potential exposure conditions intended to represent the maximum exposure conditions that one might reasonably expect to occur at the site. RME assumptions were used to characterize risk for all potential canal area receptors. Exposure assumptions used to quantify contaminant exposures are summarized in Table 3.1.

### 3.3 Identifying Exposure Scenarios

Residual contamination in the Miami-Erie Canal area was evaluated for three potential use scenarios. Residual contamination in the canal area was evaluated for recreational adults and children, for residential adults and children and for an adult off site construction worker. Recreational use is the intended use. Residential use of the canal area is unlikely, however it was included to determine whether land use restrictions were needed. The construction worker was also included to determine whether land use restrictions were needed. All three scenarios assume exposure to soil and sediment.

#### 3.3.1 Recreational Adult and Child Scenarios

Since recreational activities are planned within the canal area, recreational adults and children were identified as potential receptors. During recreational activities these receptors could be exposed to residual contamination present in soil 0-2 feet below land surface including sediment. It was assumed that recreational users would use municipally supplied water. The recreational users were assumed to be on the property four hours per day, 52 days per year over a six year period for children and over a 24 year period for adults. Adults were assumed to weigh 70-kilograms while children were assumed to weigh 15 kilograms.




● COMPLETE PATHWAY EVALUATED QUANTITATIVELY

○ COMPLETE PATHWAY EVALUATED QUALITATIVELY

— INCOMPLETE PATHWAY, NOT EVALUATED

* NO VOLATILE COPCs IN AREA

**Figure 3.1**
**Conceptual Site Model for the Miami-Erie Canal RRE**

**Table 3.1 Exposure Assumptions for Recreational and Residential Use of the Miami-Erie Canal Area**

| Parameter | Units | Recreational Adult | Recreational Child | Resident Adult | Resident Child | Off Site Construction Worker | Reference |
|---|---|---|---|---|---|---|---|
| **Medium/pathway** | | | | | | | |
| **Surface soil (0 - 2 ft.) & Sediment** | | | | | | | |
| **Incidental ingestion** | | | | | | | |
| Soil ingestion rate | mg/day | 100 | 200 | NA | NA | NA | a |
| Exposure frequency | days/year | 52 | 52 | NA | NA | NA | b |
| Exposure duration | years | 24 | 6 | NA | NA | NA | c |
| Body weight | kg | 70 | 15 | NA | NA | NA | d |
| Carcinogen averaging time | days | 25550 | 25550 | NA | NA | NA | e |
| Noncarcinogen averaging time | days | 8760 | 2190 | NA | NA | NA | e |
| Conversion Factor | kg/mg | 1.00E-06 | 1.00E-06 | NA | NA | NA | |
| **Dermal contact** | | | | | | | |
| Skin surface area available for contact | $cm^2$ | 5463 | 2115 | NA | NA | NA | f |
| Adherence factor | $mg/cm^2$ | 1 | 1 | NA | NA | NA | g |
| Exposure frequency | events/year | 52 | 52 | NA | NA | NA | b |
| Exposure duration | years | 24 | 6 | NA | NA | NA | c |
| Body weight | kg | 70 | 15 | NA | NA | NA | d |
| Carcinogen averaging time | days | 25550 | 25550 | NA | NA | NA | e |
| Noncarcinogen averaging time | days | 8760 | 2190 | NA | NA | NA | e |
| Conversion Factor | kg/mg | 1.00E-06 | 1.00E-06 | NA | NA | NA | |
| **Inhalation of VOCs and dust** | | | | | | | |
| Inhalation rate | $m^3$/day | 20 | 8.7 | NA | NA | NA | h |
| Exposure time | hours/day | 4 | 4 | NA | NA | NA | i |
| Exposure frequency | days/year | 52 | 52 | NA | NA | NA | b |
| Exposure duration | years | 24 | 6 | NA | NA | NA | c |
| Body weight | kg | 70 | 15 | NA | NA | NA | d |
| Carcinogen averaging time | days | 25550 | 25550 | NA | NA | NA | e |
| Noncarcinogen averaging time | days | 8760 | 2190 | NA | NA | NA | e |
| Conversion Factor | days/hour | 0.042 | 0.042 | NA | NA | NA | |

**Table 3.1 Exposure Assumptions for Recreational and Residential Use of the Miami-Erie Canal Area**

| Parameter | Units | Recreational Adult | Recreational Child | Resident Adult | Resident Child | Off Site Construction Worker | Reference |
|---|---|---|---|---|---|---|---|
| **Surface/Subsurface soil (0 ft - total depth) and Sediment** | | | | | | | |
| **Incidental ingestion** | | | | | | | |
| Soil ingestion rate | mg/day | NA | NA | 100 | 200 | 480 | a |
| Exposure frequency | days/year | NA | NA | 350 | 350 | 250 | b |
| Exposure duration | years | NA | NA | 24 | 6 | 1 | c |
| Body weight | kg | NA | NA | 70 | 15 | 70 | d |
| Carcinogen averaging time | days | NA | NA | 25550 | 25550 | 25550 | e |
| Noncarcinogen averaging time | days | NA | NA | 8760 | 2190 | 365 | e |
| Conversion Factor | kg/mg | NA | NA | 1.00E-06 | 1.00E-06 | 1.00E-06 | |
| **Dermal contact** | | | | | | | |
| Skin surface area available for contact | $cm^2$ | NA | NA | 5463 | 2115 | 5000 | f |
| Adherence factor | $mg/cm^2$ | NA | NA | 1 | 1 | 0.2 | g |
| Exposure frequency | events/year | NA | NA | 350 | 350 | 250 | b |
| Exposure duration | years | NA | NA | 24 | 6 | 1 | c |
| Body weight | kg | NA | NA | 70 | 15 | 70 | d |
| Carcinogen averaging time | days | NA | NA | 25550 | 25550 | 25550 | e |
| Noncarcinogen averaging time | days | NA | NA | 8760 | 2190 | 365 | e |
| Conversion Factor | kg/mg | NA | NA | 1.00E-06 | 1.00E-06 | 1.00E-06 | |
| **Inhalation of VOCs and dust** | | | | | | | |
| Inhalation rate | $m^3$/day | NA | NA | 20 | 8.7 | 20 | h |
| Exposure frequency | days/year | NA | NA | 350 | 350 | 250 | b |
| Exposure time | hours/day | 1 | 1 | 16 | 16 | 8 | i |
| Exposure duration | years | NA | NA | 24 | 6 | 1 | c |
| Body weight | kg | NA | NA | 70 | 15 | 70 | d |
| Carcinogen averaging time | days | NA | NA | 25550 | 25550 | 25550 | e |
| Noncarcinogen averaging time | days | NA | NA | 8760 | 2190 | 365 | e |
| Conversion Factor | days/hour | NA | NA | 0.042 | 0.042 | 0.042 | |

Current and future exposure scenarios for the recreational scenario are identical. Exposure pathways evaluated for the recreational user for both current and future scenarios, include:

- incidental ingestion of sediment or soil 0-2 feet below land surface;
- external exposure to ionizing radiation from radionuclides in sediment or soil 0-2 feet below land surface;
- dermal contact with contaminants in sediment or soil 0-2 feet below land surface;
- inhalation of airborne contaminated soil particulates; and
- inhalation of volatile emissions from soil.

The parameters used to evaluate these pathways and their references are provided in Table 3.1.

### 3.3.2 Residential Adult and Child Scenarios

In order to calculate risk under a residential use scenario, hypothetical residents were assumed to live at the site for 24 years and hypothetical resident children were assumed to live at the site for 6 years. Allowing for a two-week vacation, site residents have an exposure frequency of 350 days/year. During home construction, excavation for basement construction could bring subsurface soil to the land surface. Therefore, potential direct soil exposure pathways were evaluated assuming that site residents could be exposed to residual contamination present in sediment or soil at any depth. It was assumed that canal area residents would use municipally supplied water for potable supply.

There are currently no site residents, so the site resident scenario was conducted for a hypothetical future use. The exposure pathways evaluated for the future site resident include:

- incidental ingestion of sediment or soil at or below land surface;
- external exposure to ionizing radiation from radionuclides in sediment or soil at or below land surface;
- dermal contact with contaminants in sediment or soil at or below land surface;
- inhalation of airborne contaminated soil particulates; and
- inhalation of volatile emissions from soil.

The parameters used to evaluate these pathways and their references are provided in Table 3.1.

### 3.3.3 Off Site Construction Worker Scenario

Since it is reasonable to assume that construction activities could occur within the canal area, adult construction workers were identified as potential receptors. During construction activities these receptors could be exposed to residual contamination present in soil at or below land surface. Potential exposure pathways include incidental soil ingestion, external radiation exposure, and inhalation of airborne dust and vapors. Off Site Construction workers were assumed to be on the property 8 hours per day, 250 days per year over a 1-year period. Since construction workers are assumed to be adults, a body weight of 70-kilogram was used to assess exposure to chemical contaminants. It was assumed that canal area ~~residents~~ CONSTRUCTION WORKERS would use municipally supplied water for potable supply.

Current and future exposure scenarios for the construction worker scenario are identical. Exposure pathways evaluated for the construction worker for both current and future scenarios, include:

- incidental ingestion of soil at or below land surface;
- external exposure to ionizing radiation from radionuclides in soil at or below land surface;
- inhalation of airborne contaminated dust;
- inhalation of volatile emissions from soil;

The parameters used to evaluate these pathways and their references are provided in Table 3.1.

## 3.4 Exposure Point Concentrations

Exposure point concentrations (EPC) are the concentrations of contaminants available to human receptors at the point of contact. If the data were found to be normally distributed, the EPC for the RRE was calculated as the 95% UCL of the arithmetic mean of the data, using the student's t-statistic. If the data were found to be log normally distributed, the RME estimate was calculated as the 95% UCL using the H-statistic (EPA 1992a).

Only surface soil data (0-2 feet below land surface) was used to calculate the exposure point concentration for the recreational user. Recreational users are assumed to spend most of their time riding bikes or hiking and having only limited contact with surface soil or sediment. During home construction subsurface soils could be brought to land surface. Therefore the exposure point concentration for the hypothetical off site

construction worker and future site resident scenario was calculated using sediment and soil samples collected at any depth. Given the low number of subsurface samples collected, the inclusion of subsurface soil had little to no effect on EPC for the residential scenario.

### 3.5 Human Intake Equations And Assumptions

This section presents the exposure equations and assumptions used to derive contaminant-specific intake estimates for the populations and exposure pathways evaluated in the risk assessment. The use of the intake equations presented in this section is in accordance with methods presented by EPA in RAGS Part A (EPA 1989) and the RREM presented in Mound 2000 (DOE 1997a). Exposure assumptions have been developed to represent high-end RME conditions. Exposure assumptions for each of the potential receptors, and corresponding guidance or rationale used in this assessment are presented in Table 3.1.

There is a fundamental difference in the measurement of exposures from chemical contaminants as compared to radionuclide contaminants. For chemicals, exposure generally refers to the intake (e.g., inhalation, ingestion, dermal exposure) of the chemical, expressed in units of mg/kg-day. Toxicity values for chemicals are generally expressed in these terms; therefore, the product of the intake estimate with the toxicity value yields a risk value. Radionuclide intake is typically expressed in units of activity (i.e., bequerel [Bq] or curie [Ci]) rather than mass. In addition, dose has a different meaning for radionuclides than for chemicals since adverse effects are related to rate decay rather than amount or mass. For radionuclides, dose is equal to the energy imparted to a unit mass of human tissue. Despite these differences the risk due to chemical and radiological contaminants have been summed in the RRE summary tables (Table 5.16-5.18)

The approach used to estimate intake for chemical contaminants largely applies to radionuclides. However, there are a few key differences in the methods. For example, in addition to the ingestion, inhalation and direct contact pathways considered for chemical contaminants, external exposure to penetrating radiation was also evaluated for radionuclides. Equations for estimating the intake of radionuclides have been modified by omitting the body weight and averaging time from the denominator. This is done because radiation exposure assessments do not end with the calculation of intake, but use dose conversion factors to estimate dose equivalents to specified organs.

Oral and inhalation intakes are expressed as the amount of chemical at the exchange boundary (e.g., skin, lungs, intestine) that is available for absorption. These intakes are not equivalent to the absorbed dose (the amount of chemical actually absorbed into the blood stream). Dermal doses are expressed as estimates of absorbed dose. The toxicological reference values used to calculate risk have been adjusted to account for this difference; however, this discrepancy is a source of uncertainty when comparing or combining dermal doses with intakes from other exposure routes.

Exposure to soil and sediment through incidental ingestion was evaluated for recreational users under current and future land use scenarios and for future off site construction workers and residents. Intakes for the chemical contaminants in soil/sediment ingestion pathway were estimated by using the following equation:

$$Intake\ (mg/kg\text{-}day) = \frac{C_{so} \times IR \times FI \times EF \times ED \times CF}{BW \times AT}$$

Where:

| | | |
|---|---|---|
| $C_{SO}$ | = | Contaminant concentration in soil/sediment (mg/kg) |
| IR | = | Ingestion rate (mg/day) |
| FI | = | Fraction ingested from contaminated source (1.0) (unitless) |
| EF | = | Exposure frequency (days/year) |
| ED | = | Exposure duration (years) |
| CF | = | Conversion factor ($10^{-6}$ kg/mg) |
| BW | = | Body weight (kg) |
| AT | = | Averaging time for cancer and non-cancer effects (days) |

Radionuclide intakes for the soil/sediment via incidental ingestion was estimated by using the following equation:

$$Intake\ (pCi) = C_{so} \times IR \times FI \times EF \times ED \times CF$$

Where:

| | | |
|---|---|---|
| $C_{SO}$ | = | Radiological activity in soil/sediment (pCi/g) |
| IR | = | Ingestion rate (mg/day) |
| FI | = | Fraction ingested from contaminated source (1.0) (unitless) |
| EF | = | Exposure frequency (days/year) |
| ED | = | Exposure duration (years) |
| CF | = | Conversion factor ($10^{-3}$ kg/mg) |

Dermal exposure to soil and sediment was assumed to occur simultaneously with incidental ingestion exposure. Exposure to soil and sediment through dermal contact was evaluated for recreational users under current and future land use scenarios, and for future off site construction workers and residents. Soil/sediment dermal exposures were evaluated for recreational users under current and future land use scenarios. Chemical intakes for the soil/sediment via dermal exposure were estimated using the following equation:

$$Absorbed\ Dose\ (mg/kg\text{-}day) = \frac{C_{so} \times SA \times AF \times ABS \times EF \times ED \times CF}{BW \times AT}$$

Where:

| | | |
|---|---|---|
| $C_{SO}$ | = | Chemical concentration in soil/sediment (mg/kg) |
| SA | = | Skin surface area available for contact ($cm^2$/day) |
| AF | = | Soil to skin adherence factor (1) (mg/$cm^2$) |
| ABS | = | Dermal absorption factor (unitless) |
| EF | = | Exposure frequency (days/year) |
| ED | = | Exposure duration (years) |
| CF | = | Conversion factor ($10^{-6}$ kg/mg) |
| BW | = | Body weight (kg) |
| AT | = | Averaging time for cancer and non-cancer effects (days) |

Exposure to external radiation from radionuclides in soils/sediments was estimated by using the following equation:

$$Absorbed\ Dose\ (pCi/g) = Cso \times ED \times Te \times (1\text{-}Se)$$

Where:

| | | |
|---|---|---|
| $C_{SO}$ | = | Radionuclide activity in soil/sediment (pCi/g) |
| ED | = | Exposure duration (years) |
| Te | = | Gamma exposure time factor (hrs/hrs) |
| Se | = | Shielding factor (unitless) |

Unlike inhalation, ingestion, and dermal exposure, the external radiation exposure term is defined as an equivalent radionuclide concentration in soil/sediment that an onsite receptor would be exposed to for a particular exposure duration. This exposure term is adjusted for exposure time and shielding. For the canal area RRE a default shielding factor of 20% was assumed. These assumptions provide for a conservative estimate of external radiation exposure.

Intake of soil/sediment (fugitive dust) via inhalation was evaluated for recreational users under current and future land use scenarios, and for future off site construction workers and residents. The intake equation for chemical contaminants for this pathway is provided below:

$$Intake\ (mg/kg\text{-}day) = \frac{C_{so} \times IR \times ET \times EF \times ED}{PEF \times BW \times AT}$$

Where:

| | | |
|---|---|---|
| $C_{SO}$ | = | Contaminant concentration in soil/sediment (mg/kg) |
| IR | = | Inhalation rate ($m^3$/hr) |
| ET | = | Exposure time (hrs/day) |
| EF | = | Exposure frequency (days/year) |

| | | |
|---|---|---|
| ED | = | Exposure duration (years) |
| PEF | = | Particulate emission factor ($4.63 \times 10^9$ $m^3/kg$, EPA default value) |
| BW | = | Body weight (kg) |
| AT | = | Averaging time for cancer and non-cancer effects (days) |

The intake equation for radionuclide contaminants via inhalation of fugitive dust was estimated using the following equation:

$$Intake\ (pCi) = \frac{C_{so} \times IR \times ET \times EF \times ED}{PEF}$$

Where:

| | | |
|---|---|---|
| $C_{SO}$ | = | Radiological activity in soil/sediment (pCi/g) |
| IR | = | Inhalation rate ($m^3/hr$) |
| ET | = | Exposure time (hrs/day) |
| EF | = | Exposure frequency (days/year) |
| ED | = | Exposure duration (years) |
| PEF | = | Particulate emission factor ($4.28 \times 10^9$ $m^3/g$, EPA default value) |

The PEF relates the concentration of the contaminant in soil/sediment to the concentration of respirable particles in the air from fugitive dust emissions. These emissions result from wind erosion. The default value of $4.63 \times 10^9$ $m^3/kg$ was taken from RAGS, Volume I, Part B (EPA 1991b) and represents a surface with unlimited erosion potential.

Volatilization of chemical contaminants from soils/sediments may result in exposures via inhalation for recreational users; however, no volatile COPCs were identified in the canal area. Therefore, this pathway was not evaluated for chemical constituents.

## 4.0 TOXICITY ASSESSMENT

The objectives of the toxicity assessment are to identify and select toxicological values for use in estimating the significance of the exposure and to evaluate potential adverse effects associated with exposure to compounds detected in the Miami-Erie Canal area. The RRE for the canal area evaluated chronic exposures. The RRE utilized methods recommended by EPA for evaluating human cancer and non-cancer health effects resulting from exposure to the COPCs. The toxicity criteria used in the RRE were obtained from the most current update of the EPA Integrated Risk Information System (IRIS) or, if the information was not available in IRIS, the EPA Health Effects Assessment Summary Tables (HEAST). IRIS is an electronic database containing the most current descriptive and quantitative EPA regulatory information on chemical and radiological constituents. Constituent files maintained in IRIS contain information related to non-carcinogenic and carcinogenic health effects of constituents. HEAST is a published reference, updated periodically by EPA. It contains toxicity information and values for constituents from health effects documents and profiles. Other sources for toxicity information include the National Center for Environmental Assessment (NCEA) Provisional Values, ATSDR Toxicology Profiles or EPA Criteria Documents. Table 4.1 presents a summary of toxicological criteria used along with the chemical-specific characteristics used to estimate dermal absorbed dose and the concentrations present in vapors or dust.

In assessing the potential for non-cancer health effects, EPA assumes that there is a threshold below which no adverse toxic effects are expected. For example, a toxic threshold would exist if a substance had no toxic effect at a certain level of exposure, but did have a toxic effect at a higher level. EPA derives and publishes reference doses (RfDs) and reference concentrations (RfCs) for use in evaluating adverse non-carcinogenic effects. These are estimates (with uncertainty spanning an order of magnitude or greater) of daily human exposures, including sensitive sub-populations, that may go without appreciable harmless effects during a lifetime (EPA 1989). EPA derives RfDs and RfCs for humans based on estimates of the no-observable-adverse-effect-level (NOAEL) or lowest-observable-adverse-effect-level (LOAEL) observed in test organisms.

Carcinogenesis, however, is generally thought to be a phenomenon without a threshold for effect (EPA 1989). The basis for this presumption is that an extremely low level of exposure to some carcinogens may result in chromosomal or enzyme changes leading to uncontrolled cellular proliferation or cancer. EPA does not therefore estimate an effect threshold for carcinogenic chemicals. EPA uses a two-part evaluation for

carcinogens. First the constituent is assigned a weight-of-evidence classification based on both epidemiological evidence of carcinogenic effects and laboratory tests conducted with animals. Then a cancer potency factor, or slope factor (CSF), is calculated. The slope factor is a plausible upper-bound estimate of the slope of the dose-response curve in the low dose range. In risk assessment, the cancer slope factor is used to estimate the excess lifetime probability of a carcinogenic effect occurring in exposed receptors.

## 4.1 Toxicity Values for Evaluating the Dermal Pathway

Toxicological reference values are available only for the oral and inhalation pathways and the majority of these values are based on intake (i.e., administered dose) rather than an absorbed dose. Because the intake equation for the dermal contact pathway calculates absorbed dose (by incorporating a dermal absorption factor or a permeability coefficient), it is necessary to convert the administered dose toxicity value to an absorbed dose toxicity value in order to calculate risk. For the Miami-Erie Canal RRE oral administered-dose toxicity values were adjusted using compound specific gastrointestinal absorption factors. For non-carcinogens, the administered dose toxicity value (i.e., the RfD) was multiplied by the gastrointestinal absorption factor. For carcinogens, the slope factor was divided by the gastrointestinal absorption factor.

## 4.2 Toxicity Assessment for Lead

Lead was identified as a COPC in the canal area, however, lead does not have toxicological reference values. A risk-based remediation goal for lead 400 parts per million (ppm) in soil was established by EPA based on the "Interim Guidance on Establishing Soil Lead Cleanup Levels at RCRA Facilities" (EPA, 1994a). The allowable concentration of 400 ppm lead in soil is supported by USEPA's Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) (USEPA, 1994b). The IEUBK predicts that 400 ppm lead in soil could cause a 6 year old resident child (averaged across the preceding 84 months) to have a probability of no greater than 5% of a blood lead level of 10 micrograms/deciliter ($\mu$g/dL) assuming exposure to surface soil and subsurface soil brought to the land surface. In children, a blood lead level of between 10 and 15 micrograms per deciliter ($\mu$g/dL) has been associated with a level at which no adverse effects would be expected (Centers for Disease Control and Prevention [CDC], 1985). Since the residential exposure scenario is more conservative than the recreational scenario, the acceptable level of 400 ppm lead is expected to be protective under both the recreational and residential scenarios.

**Table 4.1 Toxicity Values and Chemical-Specific Parameters for Constituents of Potential Concern in the Miami-Erie Canal Area**

| | Non-Cancer | | | Cancer | | | | Dermal Exposure Parameters | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | General | | Soil |
| Chemical | Oral RFDo (mg/kg/day) | Dermal Adjusted RFDa (mg/kg/day) | Inhalation RFDi (mg/kg/day) | Oral CSFo $(mg/kg/day)^{-1}$ | Dermal Adjusted CSFa $(mg/kg/day)^{-1}$ | External Radiation $(mg/kg/day)^{-1}$ | Inhalation CSFi $(mg/kg/day)^{-1}$ | GI Factor (Unitless) | Source (Unitless) | Dermal ABS (Unitless) |
| **INORGANICS** | | | | | | | | | | |
| Arsenic | 3.00E-04 | 1.23E-04 | 5.00E-04 | 1.50E+00 | NA | NA | 1.50E+01 | 0.41 | a | 0.01 |
| Bismuth | NA | NA | NA | NA | NA | NA | NA | NA | a | 0.01 |
| Copper | 3.70E-02 | 1.11E-02 | NA | NA | NA | NA | NA | 0.3 | a | 0.01 |
| Lead | NA | NA | NA | NA | NA | NA | NA | 0.15 | a | 0.01 |
| Selenium | 5.00E-03 | 2.20E-03 | NA | NA | NA | NA | NA | 0.44 | c | 0.01 |
| Thallium | 8.00E-05 | 1.20E-05 | NA | NA | NA | NA | NA | 0.15 | a | 0.01 |
| **SVOCs** | | | | | | NA | | | | |
| 2-Methylnaphthalene | NA | NA | NA | NA | NA | NA | NA | 0.8 | | 0.3 |
| Acenaphthene | 6.00E-02 | 1.86E-02 | NA | NA | NA | NA | NA | 0.31 | a | 0.3 |
| Acenaphthylene | NA | NA | NA | NA | NA | NA | NA | 0.31 | a | 0.3 |
| Benzo(a)pyrene | NA | NA | NA | 7.30E+00 | 2.52E+00 | NA | 3.10E+00 | 0.31 | a | 0.3 |
| Benzo(ghi)perylene | NA | NA | NA | NA | NA | NA | NA | 0.31 | a | 0.3 |
| Carbazole | NA | NA | NA | 2.00E-02 | NA | NA | NA | 0.7 | a | 0.3 |
| Dibenz(a,h)anthracene | NA | NA | NA | 7.30E+00 | 1.66E+00 | NA | 3.10E+00 | 0.7 | a | 0.3 |
| Dibenzofuran | NA | NA | NA | NA | NA | NA | NA | 0.31 | b | 0.3 |
| Fluorene | 4.00E-02 | 2.00E-02 | | NA | NA | NA | NA | 0.5 | b | 0.3 |
| Naphthalene | 2.00E-02 | 1.00E-02 | 8.60E-04 | NA | NA | NA | NA | 0.5 | a | 0.3 |
| Phenanthrene | NA | NA | NA | NC | NC | NA | NC | 0.65 | a | 0.3 |
| **Pesticides/PCBs** | | | | | | | | | | |
| Edrin Ketone | NA | NA | NA | NA | NA | NA | NA | 0.5 | a | 0.3 |
| Gamma Chlordane | 5.00E-04 | 2.50E-04 | 2.00E-04 | 3.50E-01 | 1.25E-02 | NA | 3.50E-01 | 0.5 | a | 0.3 |
| **Radionuclides** | | | | | | | | | | |
| Plutonium-238 | NA | NA | NA | 2.95E-10 | NA | 2.95E-10 | 2.74E-08 | NA | | NA |
| Radium-226 | NA | NA | NA | 3.00E-10 | NA | 3.00E-10 | 2.80E-09 | NA | | NA |

a. These gastrointestinal absorption factors have been compiled by the Biomedical and Environmental Information Analysis Section (BEIAS) of the Health and Safety Research Division of Oak Ridge National Laboratory (ORNL) for use at all DOE-OR/ERD sites; the GI absorption factor for PCBs was used for each Aroclor congener.
b. Default gastrointestinal absorption factors (0.8 for VOCs, 0.5 for SVOCs, 0.2 for inorganics) were assumed if no other information could be located (EPA Region IV guidance).
c. These gastrointestinal absorption factors are taken from the Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profiles; ORNL has also listed 7% as GI abs. Factor for inorganic salts of mercury.

NA = Not Available
RfD = Reference Dose
CSF = Cancer Slope Factor
GI = Gastrointestinal
ABS = Dermal Absorption Factor

SVOCs = Semi-volatile Organic Compounds
PCBs = Polychlorinated biphenyls
VOCs = Volatile Organic Compounds
1.00E-06 is equivalent to $1.00 \times 10^{-6}$

## 5.0 RISK CHARACTERIZATION

This section presents the risk characterization for the Miami-Erie Canal area. Information from the exposure assessment (Section 3) is combined with information from a toxicity assessment (Section 4) to characterize human health risks.

### 5.1 Risk Characterization Methods

Risk characterization integrates the exposure and toxicity assessments by comparing estimates of intake or dose with appropriate toxicity values. This in turn provides an indication of the potential for adverse effects to exposed receptors. The objective of the risk characterization is to determine if exposure to contaminants associated with the site poses risks that exceed EPA target levels for human health effects. The results of the risk assessment may thus support the determination of site release or the need for site remediation.

The RRE reports the incremental risk, total risk, and risk from background for each contaminant evaluated in the Miami-Erie Canal Area. The incremental risk is the risk posed by site-related contamination above the risk posed by background environmental levels. Background risk is the risk resulting from sources other than the Mound-related residual contamination. Site-specific background values are provided in the Mound 2000 RREM (DOE 1997a). The Mound 2000 background values that correspond to the canal COPCs were used as the EPCs to determine background risk. Total risk is the sum of the background and incremental risk. This risk characterization presents a separate evaluation of non-carcinogenic and carcinogenic effects. The assessment distinguishes cancer from non-cancer effects because organisms typically respond differently following exposure to carcinogenic or non-carcinogenic agents. Quantification methods for cancer and non-cancer effects are discussed separately in the following sections.

#### 5.1.1 Quantification of Carcinogenic Risk

Cancer risks are probabilistic estimates of the excess (incremental) lifetime cancer risk for an individual specifically attributable to long term exposure to site-related chemicals. The procedure for calculating risk associated with exposure to carcinogenic compounds has been established by EPA (EPA 1989). A non-threshold, dose-response model was used to calculate a cancer slope (potency) factor for each COPC.

To derive an estimate of risk, the cancer slope factor was multiplied by the estimated chronic daily intake experienced by the exposed individual:

$$\text{Risk} = \text{CDI} \times \text{CSF}$$

Where:

| | | |
|---|---|---|
| Risk | = | High end estimate of the excess lifetime cancer risk to an individual (unitless probability) |
| CDI | = | Chronic daily intake averaged over an established period (mg/kg body weight/day) |
| CSF | = | Cancer slope factor (95% upper-bound estimate of the slope of the dose-response curve) expressed as (mg/kg body weight/day)$^{-1}$. |

To evaluate the risk of exposure to more than one carcinogenic COPC, the risk estimates for each COPC were summed to provide an overall estimate of total carcinogenic risk (EPA 1989).

$$\text{Risk}_T = \sum_{i=1}^{n} \text{Risk}_i$$

Where:

| | | |
|---|---|---|
| $\text{Risk}_T$ | = | The combined excess lifetime cancer risk across chemical carcinogens |
| $\text{Risk}_i$ | = | The risk estimate for the $i^{th}$ chemical of n chemicals under evaluation. |

### 5.1.2 Quantification of Non-carcinogenic Risk

The traditionally accepted practice of evaluating exposure to non-carcinogenic compounds has been to experimentally determine a NOAEL and to divide this by a safety factor to establish an acceptable human dose, for example, acceptable daily intake or RfD. The RfD is then compared to the average daily intake experienced by the exposed population to obtain a measure of concern for adverse non-carcinogenic effects:

$$HQ = \frac{Intake}{RfD}$$

Where:

| | | |
|---|---|---|
| HQ | = | Hazard Quotient: potential for adverse non-carcinogenic effects |
| Intake | = | Average daily intake for subchronic or chronic exposure (mg/kg body weight/day) |
| RfD | = | Acceptable intake for subchronic or chronic exposure (mg/kg body weight/day). |

To evaluate exposure to multiple non-carcinogenic COPCs the HQs for all COPCs were summed to obtain the Hazard Index (HI).

$$HI = \sum HQi$$

Where:

| | | |
|---|---|---|
| HI | = | Hazard Index |
| $HQ_i$ | = | Hazard Quotient for the $i^{th}$ chemical of n chemicals under evaluation. |

EPA has established target risk levels for use in determining the need for site remediation. For non-carcinogenic effects, EPA has set the target HQ at one. If the HQ is >1, there is the potential for adverse health effects at the given exposure/dose level, but the HQ value is not an indication of the severity of the effects. For multiple non-carcinogens, the HQs for all of the chemicals under evaluation are summed resulting in the HI. If the HI is > 1, the potential also exists for adverse health effects resulting from exposure to mixtures of chemicals. In cases where the HQ for individual substances is below 1 yet several HQs sum to greater than 1, EPA recommends segregating the compounds into groups with like or common toxicological effects and re-evaluating the potential for the various adverse health effects. In cases where HQs for individual substances are greater than 1, this step is not necessary or useful.

## 5.2 Risk Characterization Results

The following sections present the risk characterization results for the Miami-Erie Canal area by potential receptor. All of the tables for Section 5 (Tables 5.1 through 5.18) are presented at the end of the Section. Risk estimates for individual COPCs for all scenarios and pathways are presented in Tables 5.1

through 5.15. Tables 5.1 through 5.6 present risk estimates based on recreational exposure parameters, Tables 5.7 through 5.12 present risk estimates based on residential exposure parameters and Tables 5.13 through 5.15 present risk estimates based on off site construction worker exposure parameters. Residual risks were calculated based on total risk, background risk and incremental risk. Total risk was calculated using total concentration of the COPCs detected in the area. Background risk was based on background levels of the COPCs, and incremental risk was calculated using the difference between total and background levels. Incremental risk can be used to assess the increase in risk above background levels due to Mound Plant operations. Tables 5.16 through 5.18 present summaries of the results for all scenarios and pathways assessed in the RRE. In the summary tables, risk estimates that are at or above the non-cancer HI of 1 and the cancer target risk range of $10^{-6}$ are bolded. Risk estimates of zero indicate that toxicity criteria were not available for the COPC being evaluated.

**Recreational Adult**

Tables 5.1 through 5.3 present total, background and incremental risk for a recreational adult in the Miami-Erie Canal area. The total, background and incremental non-cancer risk is less than 1 indicating that non-cancer risk is at an acceptable level. Total cancer risk for a recreational adult is $9.4 \times 10^{-6}$, which falls within the target risk range of $10^{-4}$ to $10^{-6}$. The only constituent to exceed $1 \times 10^{-6}$ was radium-226. Residual risk due to radium-226 was driven by external exposure to radium-226 in soil. The majority (66%) of this risk is due to background levels ($6.2 \times 10^{-6}$). The incremental risk due to radium-226 in the canal area to a recreational adult is $3.2 \times 10^{-6}$, which again falls within the target risk range.

**Recreational Child**

Tables 5.4 through 5.6 present total, background and incremental risk for a recreational child in the Miami-Erie Canal area. The total, background and incremental non-cancer risk is less than 1 indicating that non-cancer risk is at an acceptable level. Total cancer risk for a recreational child is $2.4 \times 10^{-6}$, which falls within the target risk range of $10^{-4}$ to $10^{-6}$. The only constituent to exceed $10^{-6}$ was radium-226. Residual risk due to radium-226 was driven by external exposure to radium-226 in soil. The majority of this risk (67%) is due to background levels ($1.6 \times 10^{-6}$). The incremental risk due to radium-226 in the canal area to a recreational child is $2.1 \times 10^{-7}$, which falls below the target risk range.

## Residential Adult

Tables 5.7 through 5.9 present total, background and incremental risk for a residential adult in the Miami-Erie Canal area. The total, background, and incremental non-cancer risk, or HI, is less than 1 indicating that non-cancer risk is at an acceptable level. Total chemical and radiological cancer risk of $3.1 \times 10^{-4}$ for the residential adult exceeds the target cancer risk range of $1 \times 10^{-4}$ to $1 \times 10^{-6}$. Risk from exposure to radionuclides for a residential adult is $1.5 \times 10^{-4}$. Constituents that exceed $1 \times 10^{-6}$ include benzo(a)pyrene, dibenz(a,h)anthracene, arsenic, plutonium-238 and radium-226. Background cancer risk to a residential adult is $1.1 \times 10^{-4}$, which accounts for 34% of the total residual risk. Incremental residual cancer risk for a residential adult in the canal area is $2.1 \times 10^{-4}$, which exceeds the target risk range. 62% of the incremental risk is due to benzo(a)pyrene which is ubiquitous the environment, particularly near rail roads and roadways.

## Residential Child

Tables 5.10 through 5.12 present total, background and incremental risk for a residential child in the Miami-Erie Canal area. The total, background and incremental non-cancer risk is less than 1 indicating that non-cancer risk is at an acceptable level. Total chemical and radiological cancer risk for a residential child is $1.3 \times 10^{-4}$, which slightly exceeds the target risk range of $10^{-4}$ to $10^{-6}$. Constituents that exceed $1 \times 10^{-6}$ include benzo(a)pyrene, dibenz(a,h)anthracene, arsenic, plutonium-238 and radium-226. Background cancer risk to a residential child is $4.2 \times 10^{-5}$, which accounts for 32% of the total residual risk. Incremental residual cancer risk for a residential child in the canal area is $9.0 \times 10^{-5}$, which falls within the target risk range. 69% of the incremental risk is due to benzo(a)pyrene which is ubiquitous in the environment, particularly near rail roads and roadways.

## Off Site Construction Worker

Tables 5.12 through 5.15 present total, background and incremental risk for an off site construction worker in the Miami-Erie Canal area. The total, background and incremental non-cancer risk is less than 1 indicating that non-cancer risk is at an acceptable level. Total chemical and radiological cancer risk for an off site construction worker is $7.2 \times 10^{-6}$, which The only constituents that exceeds $1 \times 10^{-6}$ is radium-226 via external exposure. Background and incremental, chemical and radiological cancer risk to an off site

construction worker is $5.1 \times 10^{-6}$ and $2.2 \times 10^{-6}$ respectively. Both these values fall within the target risk range of $10^{-4}$ to $10^{-6}$.

**Table 5.1** **Total Residual Risk for a Recreational Adult at the Miami-Erie Canal Area**

| Constituent | EPC mg/kg | CANCER EFFECTS: Route-Specific Risk: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Cancer Risk Total | NON-CANCER EFFECTS: Route-Specific HQ: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Non-Cancer HI Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pesticides/PCBS** | | | | | | | | | | | | | |
| Endrin Ketone | 0.002 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Gamma Chlordane | 0.0003 | 7.3E-12 | 2.4E-10 | 5.7E-17 | NAP | NAP | 2.5E-10 | 1.2E-07 | 4.0E-06 | 2.4E-12 | NAP | NAP | 4.1E-06 |
| **Metals** | | | | | | | | | | | | | |
| Bismuth | 3.10 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Copper | 34.70 | NA | NA | NA | NAP | NAP | 0.0E+00 | 1.9E-04 | 3.5E-04 | NA | NAP | NAP | 5.4E-04 |
| Lead | 226.00 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Selenium | 0.91 | NA | NA | NA | NAP | NAP | 0.0E+00 | 3.7E-05 | 4.6E-05 | NA | NAP | NAP | 8.3E-05 |
| Thallium | 0.88 | NA | NA | NA | NAP | NAP | 0.0E+00 | 2.2E-03 | 8.2E-03 | NA | NAP | NAP | 1.0E-02 |
| **Semi-Volatile Organic Compounds** | | | | | | | | | | | | | |
| 2-Methylnaphthalene | 0.15 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Acenaphthene | 0.195 | NA | NA | NA | NAP | NAP | 0.0E+00 | 6.6E-07 | 3.5E-05 | NA | NAP | NAP | 3.6E-05 |
| Acenaphthylene | 0.213 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Benzo(g,h,i)perylene | 0.477 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Carbazole | 0.191 | 2.7E-10 | 1.4E-08 | NA | NAP | NAP | 1.4E-08 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Dibenzofuran | 0.195 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Fluorene | 0.21 | NA | NA | NA | NAP | NAP | 0.0E+00 | 1.1E-06 | 3.5E-05 | 0.0E+00 | NAP | NAP | 3.6E-05 |
| Naphthalene | 0.14 | NA | NA | NA | NAP | NAP | 0.0E+00 | 1.4E-06 | 4.7E-05 | 2.6E-10 | NAP | NAP | 4.8E-05 |
| Phenanthrene | 0.773 | NC | NC | NC | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| **Total Chemcial** | | 2.7E-10 | 1.4E-08 | 5.7E-17 | 0.0E+00 | 0.0E+00 | 1.5E-08 | 2.5E-03 | 8.7E-03 | 2.6E-10 | 0.0E+00 | 0.0E+00 | 1.1E-02 |
| **Radionuclides** | EPC pCi/g | | | | | | | | | | | | |
| Radium-226 | 3.04 | 1.1E-07 | NAP | 8.3E-12 | NAP | 9.3E-06 | 9.4E-06 | NAP | NAP | NAP | NAP | NAP | NAP |
| **Total Radionuclides** | | 1.1E-07 | NAP | 8.3E-12 | 0.0E+00 | 9.3E-06 | 9.4E-06 | NAP | NAP | NAP | NAP | NAP | NAP |
| **Total Overall Risk** | | 1.1E-07 | 1.4E-08 | 8.3E-12 | 0.0E+00 | 9.3E-06 | 9.4E-06 | 2.5E-03 | 8.7E-03 | 2.6E-10 | 0.0E+00 | 0.0E+00 | 1.1E-02 |

| | |
|---|---|
| EPC | Exposure point concentration |
| mg/kg | Milligram per kilogram |
| NA | Not available; insufficient toxicity data |
| NAP | Not applicable pathway; not a VOC |
| NC | Not a suspected carcinogen |
| pCi/g | Picocuries per gram |
| VOCs | Volatile organic compounds |
| 1.00E-06 | Is equivalent to $1.00 \times 10^{-6}$ |

**Table 5.2 Background Residual Risk for a Recreational Adult at the Miami-Erie Canal Area**

| Constituent | EPC mg/kg | CANCER EFFECTS: Route-Specific Risk: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Cancer Risk Total | NON-CANCER EFFECTS: Route-Specific HQ: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Non-Cancer HI Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pesticides/PCBS** | | | | | | | | | | | | | |
| Endrin Ketone | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Gamma Chlordane | | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 |
| **Metals** | | | | | | | | | | | | | |
| Bismuth | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Copper | 26 | NA | NA | NA | NAP | NAP | 0.0E+00 | 1.4E-04 | 2.6E-04 | NA | NAP | NAP | 4.0E-04 |
| Lead | 48 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Selenium | | NA | NA | NA | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | NA | NAP | NAP | 0.0E+00 |
| Thallium | 0.46 | NA | NA | NA | NAP | NAP | 0.0E+00 | 1.2E-03 | 4.3E-03 | NA | NAP | NAP | 5.4E-03 |
| **Semi-Volatile Organic Compounds** | | | | | | | | | | | | | |
| 2-Methylnaphthalene | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Acenaphthene | | NA | NA | NA | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | NA | NAP | NAP | 0.0E+00 |
| Acenaphthylene | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Benzo(g,h,i)perylene | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Carbazole | | 0.0E+00 | 0.0E+00 | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Dibenzofuran | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Fluorene | | NA | NA | NA | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 |
| Naphthalene | | NA | NA | NA | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 |
| Phenanthrene | | NC | NC | NC | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Total Chemical | | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 1.3E-03 | 4.5E-03 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 5.8E-03 |
| **Radionuclides** | EPC pCi/g | | | | | | | | | | | | |
| Radium-226 | 2 | 7.5E-08 | NAP | 5.5E-12 | NAP | 6.1E-06 | 6.2E-06 | NAP | NAP | NAP | NAP | NAP | NAP |
| Total Radionuclides | | 7.5E-08 | NAP | 5.5E-12 | NAP | 6.1E-06 | 6.2E-06 | NAP | NAP | NAP | NAP | NAP | NAP |
| **Total Overall Risk** | | 7.5E-08 | 0.0E+00 | 5.5E-12 | 0.0E+00 | 6.1E-06 | 6.2E-06 | 1.3E-03 | 4.5E-03 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 5.8E-03 |

| | |
|---|---|
| EPC | Exposure point concentration |
| mg/kg | Milligram per kilogram |
| NA | Not available; insufficient toxicity data |
| NAP | Not applicable pathway |
| NC | Not a suspected carcinogen |
| pCi/g | Picocuries per gram |
| VOCs | Volatile organic compounds |
| 1.00E-06 | Is equivalent to $1.00 \times 10^{-6}$ |

**Table 5.3** **Incremental Residual Risk for a Recreational Adult at the Miami-Erie Canal Area**

| Constituent | EPC mg/kg | CANCER EFFECTS: Route-Specific Risk: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Cancer Risk Total | NON-CANCER EFFECTS: Route-Specific HQ: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Non-Cancer HI Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pesticides/PCBS** | | | | | | | | | | | | | |
| Endrin Ketone | 0.002 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Gamma Chlordane | 0.0003 | 7.3E-12 | 2.4E-10 | 5.7E-17 | NAP | NAP | 2.5E-10 | 1.2E-07 | 4.0E-06 | 2.4E-12 | NAP | NAP | 4.1E-06 |
| **Metals** | | | | | | | | | | | | | |
| Bismuth | 3.10 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Copper | 8.70 | NA | NA | NA | NAP | NAP | 0.0E+00 | 4.8E-05 | 8.7E-05 | NA | NAP | NAP | 1.3E-04 |
| Lead | 178.00 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Selenium | 0.91 | NA | NA | NA | NAP | NAP | 0.0E+00 | 3.7E-05 | 4.6E-05 | NA | NAP | NAP | 8.3E-05 |
| Thallium | 0.42 | NA | NA | NA | NAP | NAP | 0.0E+00 | 1.1E-03 | 3.9E-03 | NA | NAP | NAP | 5.0E-03 |
| **Semi-Volatile Organic Compounds** | | | | | | | | | | | | | |
| 2-Methylnaphthalene | 0.15 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Acenaphthene | 0.195 | NA | NA | NA | NAP | NAP | 0.0E+00 | 6.6E-07 | 3.5E-05 | NA | NAP | NAP | 3.6E-05 |
| Acenaphthylene | 0.213 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Benzo(g,h,i)perylene | 0.477 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Carbazole | 0.191 | 2.7E-10 | 1.4E-08 | NA | NAP | NAP | 1.4E-08 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Dibenzofuran | 0.195 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Fluorene | 0.21 | NA | NA | NA | NAP | NAP | 0.0E+00 | 1.1E-06 | 3.5E-05 | 0.0E+00 | NAP | NAP | 3.6E-05 |
| Naphthalene | 0.14 | NA | NA | NA | NAP | NAP | 0.0E+00 | 1.4E-06 | 4.7E-05 | 2.6E-10 | NAP | NAP | 4.8E-05 |
| Phenanthrene | 0.773 | NC | NC | NC | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| **Total Chemical** | | 2.7E-10 | 1.4E-08 | 5.7E-17 | 0.0E+00 | 0.0E+00 | 1.5E-08 | 1.2E-03 | 4.1E-03 | 2.6E-10 | 0.0E+00 | 0.0E+00 | 5.3E-03 |
| Radionuclides | EPC pCi/g | | | | | | | | | | | | |
| Radium-226 | 1.04 | 3.9E-08 | NAP | 2.8E-12 | NAP | 3.2E-06 | 3.2E-06 | NAP | NAP | NAP | NAP | NAP | NAP |
| **Total Radionuclide** | | 3.9E-08 | NAP | 2.8E-12 | 0.0E+00 | 3.2E-06 | 3.2E-06 | NA | NA | NA | NAP | NAP | NAP |
| **Total Overall Risk** | | 3.9E-08 | 1.4E-08 | 2.8E-12 | 0.0E+00 | 3.2E-06 | 3.2E-06 | 1.2E-03 | 4.1E-03 | 2.6E-10 | 0.0E+00 | 0.0E+00 | 5.3E-03 |

| | |
|---|---|
| EPC | Exposure point concentration for incremental risk is total minus background |
| mg/kg | Milligram per kilogram |
| NA | Not available; insufficient toxicity data |
| NAP | Not applicable pathway |
| NC | Not a suspected carcinogen |
| pCi/g | Picocuries per gram |
| VOCs | Volatile organic compounds |
| 1.00E-06 | Is equivalent to $1.00 \times 10^{-6}$ |

**Table 5.4** **Total Residual Risk for a Recreational Child at the Miami-Erie Canal Area**

| Constituent | EPC mg/kg | CANCER EFFECTS: Route-Specific Risk: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Cancer Risk Total | NON-CANCER EFFECTS: Route-Specific HQ: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Non-Cancer HI Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pesticides/PCBS** | | | | | | | | | | | | | |
| Endrin Ketone | 0.002 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Gamma Chlordane | 0.0003 | 1.7E-11 | 1.1E-10 | 2.9E-17 | NAP | NAP | 1.3E-10 | 1.1E-06 | 7.2E-06 | 4.8E-12 | NAP | NAP | 8.4E-06 |
| **Metals** | | | | | | | | | | | | | |
| Bismuth | 3.10 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Copper | 34.70 | NA | NA | NA | NAP | NAP | 0.0E+00 | 1.8E-03 | 6.3E-04 | NA | NAP | NAP | 2.4E-03 |
| Lead | 226.00 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Selenium | 0.91 | NA | NA | NA | NAP | NAP | 0.0E+00 | 3.5E-04 | 8.3E-05 | NA | NAP | NAP | 4.3E-04 |
| Thallium | 0.88 | NA | NA | NA | NAP | NAP | 0.0E+00 | 2.1E-02 | 1.5E-02 | NA | NAP | NAP | 3.6E-02 |
| **Semi-Volatile Organic Compounds** | | | | | | | | | | | | | |
| 2-Methylnaphthalene | 0.15 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Acenaphthene | 0.195 | NA | NA | NA | NAP | NAP | 0.0E+00 | 6.2E-06 | 6.3E-05 | NA | NAP | NAP | 6.9E-05 |
| Acenaphthylene | 0.213 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Benzo(g,h,i)perylene | 0.477 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Carbazole | 0.191 | 6.2E-10 | 6.4E-09 | NA | NAP | NAP | 7.0E-09 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Dibenzofuran | 0.195 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Fluorene | 0.21 | NA | NA | NA | NAP | NAP | 0.0E+00 | 1.0E-05 | 6.3E-05 | 0.0E+00 | NAP | NAP | 7.3E-05 |
| Naphthalene | 0.14 | NA | NA | NA | NAP | NAP | 0.0E+00 | 1.3E-05 | 8.4E-05 | 5.2E-10 | NAP | NAP | 9.8E-05 |
| Phenanthrene | 0.773 | NC | NC | NC | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| **Total Chemcials** | | 6.4E-10 | 6.5E-09 | 2.9E-17 | 0.0E+00 | 0.0E+00 | 7.1E-09 | 2.3E-02 | 1.6E-02 | 5.3E-10 | 0.0E+00 | 0.0E+00 | 3.9E-02 |
| **Radionuclides** | EPC pCi/g | | | | | | | | | | | | |
| Radium-226 | 3.04 | 5.7E-08 | NAP | 9.0E-13 | NAP | 2.3E-06 | 2.4E-06 | NAP | NAP | NAP | NAP | NAP | NAP |
| **Total Radionuclides** | | 5.7E-08 | NAP | 9.0E-13 | 0.0E+00 | 2.3E-06 | 2.4E-06 | NAP | NAP | NAP | NAP | NAP | NAP |
| **Total Overall Risk** | | 5.8E-08 | 6.5E-09 | 9.0E-13 | 0.0E+00 | 2.3E-06 | 2.4E-06 | 2.3E-02 | 1.6E-02 | 5.3E-10 | 0.0E+00 | 0.0E+00 | 3.9E-02 |

| | |
|---|---|
| EPC | Exposure point concentration |
| mg/kg | Milligram per kilogram. |
| NA | Not available; insufficient toxicity data. |
| NAP | Not applicable pathway; not a VOC. |
| NC | Not a suspected carcinogen. |
| pCi/g | Picocuries per gram |
| VOCs | Volatile organic compounds. |
| 1.00E-06 | Is equivalent to $1.00 \times 10^{-6}$ |

**Table 5.5 Background Residual Risk for a Recreational Child at the Miami-Erie Canal Area**

| Constituent | EPC mg/kg | CANCER EFFECTS: Route-Specific Risk: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Cancer Risk Total | NON-CANCER EFFECTS: Route-Specific HQ: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Non-Cancer HI Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pesticides/PCBS** | | | | | | | | | | | | | |
| Endrin Ketone | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Gamma Chlordane | | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 |
| **Metals** | | | | | | | | | | | | | |
| Bismuth | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Copper | 26 | NA | NA | NA | NAP | NAP | 0.0E+00 | 1.3E-03 | 4.7E-04 | NA | NAP | NAP | 1.8E-03 |
| Lead | 48 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Selenium | | NA | NA | NA | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | NA | NAP | NAP | 0.0E+00 |
| Thallium | 0.46 | NA | NA | NA | NAP | NAP | 0.0E+00 | 1.1E-02 | 7.7E-03 | NA | NAP | NAP | 1.9E-02 |
| **Semi-Volatile Organic Compounds** | | | | | | | | | | | | | |
| 2-Methylnaphthalene | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Acenaphthene | | NA | NA | NA | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | NA | NAP | NAP | 0.0E+00 |
| Acenaphthylene | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Benzo(g,h,i)perylene | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Carbazole | | 0.0E+00 | 0.0E+00 | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Dibenzofuran | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Fluorene | | NA | NA | NA | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 |
| Naphthalene | | NA | NA | NA | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 |
| Phenanthrene | | NC | NC | NC | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| **Total Chemical** | | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 1.2E-02 | 8.2E-03 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 2.0E-02 |
| **Radionuclides** | EPC pCi/g | | | | | | | | | | | | |
| Radium-226 | 2 | 3.7E-08 | NAP | 5.9E-16 | NAP | 1.5E-06 | 1.6E-06 | NAP | NAP | NAP | NAP | NAP | NAP |
| **Total Radionuclides** | | 3.7E-08 | NAP | 5.9E-16 | NAP | 1.5E-06 | 1.6E-06 | NAP | NAP | NAP | NAP | NAP | NAP |
| **Total Overall Risk** | | 3.7E-08 | 0.0E+00 | 5.9E-16 | #VALUE! | 1.5E-06 | 1.6E-06 | 1.2E-02 | 8.2E-03 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 2.0E-02 |

| | |
|---|---|
| EPC | Exposure point concentration |
| mg/kg | Milligram per kilogram. |
| NA | Not available; insufficient toxicity data. |
| NAP | Not applicable pathway; not a VOC. |
| NC | Not a suspected carcinogen. |
| pCi/g | Picocuries per gram |
| VOCs | Volatile organic compounds. |
| 1.00E-06 | Is equivalent to $1.00 \times 10^{-6}$ |

**Table 5.6** **Incremental Residual Risk for a Recreational Child at the Miami-Erie Canal Area**

| Constituent | EPC mg/kg | CANCER EFFECTS: Route-Specific Risk: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Cancer Risk Total | NON-CANCER EFFECTS: Route-Specific HQ: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Non-Cancer HI Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pesticides/PCBS** | | | | | | | | | | | | | |
| Endrin Ketone | 0.002 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Gamma Chlordane | 0.0003 | 1.3E-11 | 8.1E-11 | 2.2E-17 | NAP | NAP | 9.4E-11 | 8.5E-07 | 5.4E-06 | 3.6E-12 | NAP | NAP | 6.3E-06 |
| **Metals** | | | | | | | | | | | | | |
| Bismuth | 3.10 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Copper | 8.70 | NA | NA | NA | NAP | NAP | 0.0E+00 | 3.3E-04 | 1.2E-04 | NA | NAP | NAP | 4.5E-04 |
| Lead | 178.00 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Selenium | 0.91 | NA | NA | NA | NAP | NAP | 0.0E+00 | 2.6E-04 | 6.2E-05 | NA | NAP | NAP | 3.2E-04 |
| Thallium | 0.42 | NA | NA | NA | NAP | NAP | 0.0E+00 | 7.5E-03 | 5.3E-03 | NA | NAP | NAP | 1.3E-02 |
| **Semi-Volatile Organic Compounds** | | | | | | | | | | | | | |
| 2-Methylnaphthalene | 0.15 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Acenaphthene | 0.195 | NA | NA | NA | NAP | NAP | 0.0E+00 | 4.6E-06 | 4.7E-05 | NA | NAP | NAP | 5.2E-05 |
| Acenaphthylene | 0.213 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Benzo(g,h,i)perylene | 0.477 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Carbazole | 0.191 | 4.7E-10 | 4.8E-09 | NA | NAP | NAP | 5.2E-09 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Dibenzofuran | 0.195 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Fluorene | 0.21 | NA | NA | NA | NAP | NAP | 0.0E+00 | 7.5E-06 | 4.7E-05 | 0.0E+00 | NAP | NAP | 5.5E-05 |
| Naphthalene | 0.14 | NA | NA | NA | NAP | NAP | 0.0E+00 | 1.0E-05 | 6.3E-05 | 3.9E-10 | NAP | NAP | 7.3E-05 |
| Phenanthrene | 0.773 | NC | NC | NC | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| **Total Chemical** | | 4.8E-10 | 4.9E-09 | 2.2E-17 | 0.0E+00 | 0.0E+00 | 5.3E-09 | 8.1E-03 | 5.6E-03 | 4.0E-10 | 0.0E+00 | 0.0E+00 | 1.4E-02 |
| **Radionuclides** | EPC pCi/g | | | | | | | | | | | | |
| Radium-226 | 1.04 | 1.9E-08 | NAP | 3.1E-13 | NAP | 7.9E-07 | 8.1E-07 | NAP | NAP | NAP | NAP | NAP | NAP |
| **Total Radionuclide** | | 1.9E-08 | NAP | 3.1E-13 | 0.0E+00 | 7.9E-07 | 8.1E-07 | NA | NA | NA | NAP | NA | NAP |
| **Total Overall Risk** | | 2.0E-08 | 4.9E-09 | 3.1E-13 | 0.0E+00 | 7.9E-07 | 8.2E-07 | 8.1E-03 | 5.6E-03 | 4.0E-10 | 0.0E+00 | 0.0E+00 | 1.4E-02 |

| | |
|---|---|
| EPC | Exposure point concentration for incremental risk is total minus background |
| mg/kg | Milligram per kilogram |
| NA | Not available; insufficient toxicity data |
| NAP | Not applicable pathway |
| NC | Not a suspected carcinogen |
| pCi/g | Picocuries per gram |
| VOCs | Volatile organic compounds |
| 1.00E-06 | Is equivalent to $1.00 \times 10^{-6}$ |

**Table 5.7** **Total Residual Risk for a Residential Adult at the Miami-Erie Canal Area**

| Constituent | EPC mg/kg | CANCER EFFECTS: Route-Specific Risk: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Cancer Risk Total | NON-CANCER EFFECTS: Route-Specific HQ: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Non-Cancer HI Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semi-Volatile Organic Compounds** | | | | | | | | | | | | | |
| 2-Methylnaphthalene | 0.15 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Acenaphthene | 0.195 | NA | NA | NA | NAP | NAP | 0.0E+00 | 4.5E-06 | 2.4E-04 | NA | NAP | NAP | 2.4E-04 |
| Acenaphthylene | 0.213 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Benzo(a)pyrene | 0.688 | 2.4E-06 | 1.2E-04 | 4.7E-11 | NAP | NAP | 1.3E-04 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Benzo(g,h,i)perylene | 0.477 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Carbazole | 0.191 | 1.8E-09 | 4.2E-08 | NA | NAP | NAP | 4.4E-08 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Dibenz(a,h)anthracene | 0.24 | 8.2E-07 | 1.9E-05 | 1.6E-11 | NAP | NAP | 2.0E-05 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Dibenzofuran | 0.195 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Fluorene | 0.21 | NA | NA | NA | NAP | NAP | 0.0E+00 | 7.2E-06 | 2.4E-04 | 0.0E+00 | NAP | NAP | 2.4E-04 |
| Naphthalene | 0.14 | NA | NA | NA | NAP | NAP | 0.0E+00 | 9.6E-06 | 3.1E-04 | 1.0E-08 | NAP | NAP | 3.2E-04 |
| Phenanthrene | 0.773 | NC | NC | NC | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| **Pesticides** | | | | | | | | | | | | | |
| Endrin Ketone | 0.002 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Gamma Chlordane | 0.0003 | 4.9E-11 | 1.6E-09 | 2.3E-15 | NAP | NAP | 1.7E-09 | 8.2E-07 | 2.7E-05 | 9.6E-11 | NAP | NAP | 2.8E-05 |
| **Metals** | | | | | | | | | | | | | |
| Arsenic | 9.5 | 6.7E-06 | 8.9E-06 | 3.1E-09 | NAP | NAP | 1.6E-05 | 4.3E-02 | 5.8E-02 | 1.2E-06 | NAP | NAP | 1.0E-01 |
| Bismuth | 3.1 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Copper | 34.7 | NA | NA | NA | NAP | NAP | 0.0E+00 | 1.3E-03 | 2.3E-03 | NA | NAP | NAP | 3.6E-03 |
| Lead | 226 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Selenium | 0.91 | NA | NA | NA | NAP | NAP | 0.0E+00 | 2.5E-04 | 3.1E-04 | NA | NAP | NAP | 5.6E-04 |
| Thallium | 0.88 | NA | NA | NA | NAP | NAP | 0.0E+00 | 1.5E-02 | 5.5E-02 | NA | NAP | NAP | 7.0E-02 |
| **Total Chemical** | | 9.9E-06 | 1.5E-04 | 3.2E-09 | NAP | NAP | 1.6E-04 | 6.0E-02 | 1.2E-01 | 1.2E-06 | 0.0E+00 | 0.0E+00 | 1.8E-01 |
| **Radionuclides** | EPC pCi/g | | | | | | | | | | | | |
| Plutonium-238 | 22.5 | 5.6E-06 | NA | 2.4E-08 | NAP | 3.1E-09 | 5.6E-06 | NA | NA | NA | NAP | NA | 0.0E+00 |
| Radium-226 | 3.04 | 7.7E-07 | 0.0E+00 | 3.3E-10 | NAP | 1.5E-04 | 1.5E-04 | NA | NA | NA | NAP | NA | 0.0E+00 |
| **Total Radionuclide** | | 6.3E-06 | 0.0E+00 | 2.5E-08 | NAP | 1.5E-04 | 1.5E-04 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| **Overall Total Risk** | | 1.6E-05 | 1.5E-04 | 2.8E-08 | NAP | 1.5E-04 | 3.2E-04 | 6.0E-02 | 1.2E-01 | 1.2E-06 | NAP | 0.0E+00 | 1.8E-01 |

| | |
|---|---|
| EPC | Exposure point concentration |
| mg/kg | Milligram per kilogram |
| NA | Not available; insufficient toxicity data |
| NAP | Not applicable pathway |
| NC | Not a suspected carcinogen |
| pCi/g | Picocuries per gram |
| VOCs | Volatile organic compounds |
| 1.00E-06 | Is equivalent to $1.00 \times 10^{-6}$ |

**Table 5.8 Background Residual Risk for a Residential Adult at the Miami-Erie Canal Area**

| Constituent | EPC mg/kg | CANCER EFFECTS: Route-Specific Risk: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Cancer Risk Total | NON-CANCER EFFECTS: Route-Specific HQ: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Non-Cancer HI Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semi-Volatile Organic Compounds** | | | | | | | | | | | | | |
| 2-Methylnaphthalene | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Acenaphthene | | NA | NA | NA | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | NA | NAP | NAP | 0.0E+00 |
| Acenaphthylene | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Benzo(a)pyrene | | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Benzo(g,h,i)perylene | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Carbazole | | 0.0E+00 | 0.0E+00 | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Dibenz(a,h)anthracene | | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Dibenzofuran | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Fluorene | | NA | NA | NA | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 |
| Naphthalene | | NA | NA | NA | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 |
| Phenanthrene | | NC | NC | NC | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| **Pesticides** | | | | | | | | | | | | | |
| Endrin Ketone | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Gamma Chlordane | | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 |
| **Metals** | | | | | | | | | | | | | |
| Arsenic | 8.6 | 6.1E-06 | 8.1E-06 | 2.8E-09 | NAP | NAP | 1.4E-05 | 3.9E-02 | 5.2E-02 | 1.1E-06 | NAP | NAP | 9.2E-02 |
| Bismuth | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Copper | 26 | NA | NA | NA | NAP | NAP | 0.0E+00 | 9.6E-04 | 1.8E-03 | NA | NAP | NAP | 2.7E-03 |
| Lead | 48 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Selenium | | NA | NA | NA | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | NA | NAP | NAP | 0.0E+00 |
| Thallium | 0.46 | NA | NA | NA | NAP | NAP | 0.0E+00 | 7.9E-03 | 2.9E-02 | NA | NAP | NAP | 3.7E-02 |
| **Total Chemical** | | 6.1E-06 | 8.1E-06 | 2.8E-09 | 0.0E+00 | 0.0E+00 | 1.4E-05 | 4.8E-02 | 8.3E-02 | 1.1E-06 | 0.0E+00 | 0.0E+00 | 1.3E-01 |
| **Radionuclides** | EPC pCi/g | | | | | | | | | | | | |
| Plutonium-238 | 0.13 | 3.2E-08 | NA | 1.4E-10 | NAP | 1.8E-11 | 3.2E-08 | NA | NA | NA | NAP | NA | 0.0E+00 |
| Radium-226 | 2 | 5.0E-07 | 0.0E+00 | 2.2E-10 | NAP | 9.6E-05 | 9.7E-05 | NA | NA | NA | NAP | NA | 0.0E+00 |
| **Total Radionuclide** | | 5.4E-07 | 0.0E+00 | 3.6E-10 | NAP | 9.6E-05 | 9.7E-05 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| **Overall Total Risk** | | 6.6E-06 | 8.1E-06 | 3.2E-09 | NAP | 9.6E-05 | 1.1E-04 | 4.8E-02 | 8.3E-02 | 1.1E-06 | 0.0E+00 | 0.0E+00 | 1.3E-01 |

| | |
|---|---|
| EPC | Exposure point concentration |
| mg/kg | Milligram per kilogram |
| NA | Not available; insufficient toxicity data |
| NAP | Not applicable pathway |
| NC | Not a suspected carcinogen |
| pCi/g | Picocuries per gram |
| VOCs | Volatile organic compounds |
| 1.00E-06 | Is equivalent to $1.00 \times 10^{-6}$ |

**Table 5.9 Incremental Residual Risk for a Residential Adult at the Miami-Erie Canal Area**

| Constituent | EPC mg/kg | CANCER EFFECTS: Route-Specific Risk: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Cancer Risk Total | NON-CANCER EFFECTS: Route-Specific HQ: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Non-Cancer HI Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semi-Volatile Organic Compounds** | | | | | | | | | | | | | |
| 2-Methylnaphthalene | 0.15 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Acenaphthene | 0.195 | NA | NA | NA | NAP | NAP | 0.0E+00 | 4.5E-06 | 2.4E-04 | NA | NAP | NAP | 2.4E-04 |
| Acenaphthylene | 0.213 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Benzo(a)pyrene | 0.688 | 2.4E-06 | 1.2E-04 | 4.7E-11 | NAP | NAP | 1.3E-04 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Benzo(g,h,i)perylene | 0.477 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Carbazole | 0.191 | 1.8E-09 | 4.2E-08 | NA | NAP | NAP | 4.4E-08 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Dibenz(a,h)anthracene | 0.24 | 8.2E-07 | 1.9E-05 | 1.6E-11 | NAP | NAP | 2.0E-05 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Dibenzofuran | 0.195 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Fluorene | 0.21 | NA | NA | NA | NAP | NAP | 0.0E+00 | 7.2E-06 | 2.4E-04 | 0.0E+00 | NAP | NAP | 2.4E-04 |
| Naphthalene | 0.14 | NA | NA | NA | NAP | NAP | 0.0E+00 | 9.6E-06 | 3.1E-04 | 1.0E-08 | NAP | NAP | 3.2E-04 |
| Phenanthrene | 0.773 | NC | NC | NC | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| **Pesticides** | | | | | | | | | | | | | |
| Endrin Ketone | 0.002 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Gamma Chlordane | 0.0003 | 4.9E-11 | 1.6E-09 | 2.3E-15 | NAP | NAP | 1.7E-09 | 8.2E-07 | 2.7E-05 | 9.6E-11 | NAP | NAP | 2.8E-05 |
| **Metals** | | | | | | | | | | | | | |
| Arsenic | 0.9 | 6.3E-07 | 8.4E-07 | 3.0E-10 | NAP | NAP | 1.5E-06 | 4.1E-03 | 5.5E-03 | 1.2E-07 | NAP | NAP | 9.6E-03 |
| Bismuth | 3.1 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Copper | 8.7 | NA | NA | NA | NAP | NAP | 0.0E+00 | 3.2E-04 | 5.9E-04 | NA | NAP | NAP | 9.1E-04 |
| Lead | 178 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Selenium | 0.91 | NA | NA | NA | NAP | NAP | 0.0E+00 | 2.5E-04 | 3.1E-04 | NA | NAP | NAP | 5.6E-04 |
| Thallium | 0.88 | NA | NA | NA | NAP | NAP | 0.0E+00 | 1.5E-02 | 5.5E-02 | NA | NAP | NAP | 7.0E-02 |
| **Total Chemical** | | 3.8E-06 | 1.4E-04 | 3.6E-10 | 0.0E+00 | 0.0E+00 | 1.5E-04 | 2.0E-02 | 6.2E-02 | 1.3E-07 | 0.0E+00 | 0.0E+00 | 8.2E-02 |
| **Radionuclides** | EPC pCi/g | | | | | | | | | | | | |
| Plutonium-238 | 22.37 | 5.5E-06 | NA | 2.4E-08 | NAP | 3.1E-09 | 5.6E-06 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Radium-226 | 1.04 | 2.6E-07 | 0.0E+00 | 1.1E-10 | NAP | 5.0E-05 | 5.0E-05 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| **Total Radionuclide** | | 5.8E-06 | 0.0E+00 | 2.4E-08 | NAP | 5.0E-05 | 5.6E-05 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| **Overall Total Risk** | | 9.6E-06 | 1.4E-04 | 2.5E-08 | NAP | 5.0E-05 | 2.0E-04 | 2.0E-02 | 6.2E-02 | 1.3E-07 | NAP | NAP | 8.2E-02 |

| | |
|---|---|
| EPC | Exposure point concentration, incremental value is total minus background |
| mg/kg | Milligram per kilogram |
| NA | Not available; insufficient toxicity data |
| NAP | Not applicable pathway |
| NC | Not a suspected carcinogen |
| pCi/g | Picocuries per gram |
| VOCs | Volatile organic compounds |
| 1.00E-06 | is equivalent to $1.00 \times 10^{-6}$ |

**Table 5.10** **Total Residual Risk for a Residential Child at the Miami-Erie Canal Area**

| Constituent | EPC mg/kg | CANCER EFFECTS: Route-Specific Risk: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Cancer Risk Total | NON-CANCER EFFECTS: Route-Specific HQ: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Non-Cancer HI Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semi-Volatile Organic Compounds** | | | | | | | | | | | | | |
| 2-Methylnaphthalene | 0.15 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Acenaphthene | 0.195 | NA | NA | NA | NAP | NAP | 0.0E+00 | 4.2E-05 | 4.3E-04 | NA | NAP | NAP | 4.7E-04 |
| Acenaphthylene | 0.213 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Benzo(a)pyrene | 0.688 | 5.5E-06 | 5.6E-05 | 2.4E-11 | NAP | NAP | 6.2E-05 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Benzo(g,h,i)perylene | 0.477 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Carbazole | 0.191 | 4.2E-09 | 1.9E-08 | NA | NAP | NAP | 2.3E-08 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Dibenz(a,h)anthracene | 0.24 | 1.9E-06 | 8.7E-06 | 8.3E-12 | NAP | NAP | 1.1E-05 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Dibenzofuran | 0.195 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Fluorene | 0.21 | NA | NA | NA | NAP | NAP | 0.0E+00 | 6.7E-05 | 4.3E-04 | 0.0E+00 | NAP | NAP | 4.9E-04 |
| Naphthalene | 0.14 | NA | NA | NA | NAP | NAP | 0.0E+00 | 8.9E-05 | 5.7E-04 | 2.1E-08 | NAP | NAP | 6.6E-04 |
| Phenanthrene | 0.773 | NC | NC | NC | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| **Pesticides** | | | | | | | | | | | | | |
| Endrin Ketone | 0.002 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Gamma Chlordane | 0.0003 | 1.2E-10 | 7.3E-10 | 1.2E-15 | NAP | NAP | 8.5E-10 | 7.7E-06 | 4.9E-05 | 1.9E-10 | NAP | NAP | 5.6E-05 |
| **Metals** | | | | | | | | | | | | | |
| Arsenic | 9.5 | 1.6E-05 | 4.0E-06 | 1.6E-09 | NAP | NAP | 2.0E-05 | 4.0E-01 | 1.0E-01 | 2.5E-06 | NAP | NAP | 5.1E-01 |
| Bismuth | 3.1 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Copper | 34.7 | NA | NA | NA | NAP | NAP | 0.0E+00 | 1.2E-02 | 4.2E-03 | NA | NAP | NAP | 1.6E-02 |
| Lead | 226 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Selenium | 0.91 | NA | NA | NA | NAP | NAP | 0.0E+00 | 2.3E-03 | 5.6E-04 | NA | NAP | NAP | 2.9E-03 |
| Thallium | 0.88 | NA | NA | NA | NAP | NAP | 0.0E+00 | 1.4E-01 | 9.9E-02 | NA | NAP | NAP | 2.4E-01 |
| **Total Chemical** | | 2.3E-05 | 6.9E-05 | 1.6E-09 | NAP | NAP | 9.2E-05 | 5.6E-01 | 2.1E-01 | 2.5E-06 | NAP | NAP | 7.7E-01 |
| Radionuclides | EPC pCi/g | | | | | | | | | | | | |
| Plutonium-238 | 22.5 | 2.8E-06 | NA | 2.6E-09 | NAP | 7.9E-10 | 2.8E-06 | NA | NA | NA | NA | NA | 0.0E+00 |
| Radium-226 | 3.04 | 3.8E-07 | 0.0E+00 | 3.6E-11 | NAP | 3.7E-05 | 3.7E-05 | NA | NA | NA | NA | NA | 0.0E+00 |
| **Total Radionuclide** | | 3.2E-06 | 0.0E+00 | 2.7E-09 | NAP | 3.7E-05 | 4.0E-05 | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 |
| **Overall Total Risk** | | 2.6E-05 | 6.9E-05 | 4.3E-09 | NAP | 3.7E-05 | 1.3E-04 | 5.6E-01 | 2.1E-01 | 2.5E-06 | NAP | NAP | 7.7E-01 |

| | |
|---|---|
| EPC | Exposure point concentration |
| mg/kg | Milligram per kilogram |
| NA | Not available; insufficient toxicity data |
| NAP | Not applicable pathway |
| NC | Not a suspected carcinogen |
| pCi/g | Picocuries per gram |
| VOCs | Volatile organic compounds |
| 1.00E-06 | Is equivalent to $1.00 \times 10^{-6}$ |

**Table 5.11 esidential Child at the Miami-Erie Canal Area**

| Constituent | EPC mg/kg | CANCER EFFECTS: Route-Specific Risk: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Cancer Risk Total | NON-CANCER EFFECTS: Route-Specific HQ: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Non-Cancer HI Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semi-Volatile Organic Compounds** | | | | | | | | | | | | | |
| 2-Methylnaphthalene | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Acenaphthene | | NA | NA | NA | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | NA | NAP | NAP | 0.0E+00 |
| Acenaphthylene | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Benzo(a)pyrene | | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Benzo(g,h,i)perylene | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Carbazole | | 0.0E+00 | 0.0E+00 | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Dibenz(a,h)anthracene | | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Dibenzofuran | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Fluorene | | NA | NA | NA | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 |
| Naphthalene | | NA | NA | NA | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 |
| Phenanthrene | | NC | NC | NC | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| **Pesticides** | | | | | | | | | | | | | |
| Endrin Ketone | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Gamma Chlordane | | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 |
| **Metals** | | | | | | | | | | | | | |
| Arsenic | 8.6 | 1.4E-05 | 3.6E-06 | 1.4E-09 | NAP | NAP | 1.8E-05 | 3.7E-01 | 9.5E-02 | 2.2E-06 | NAP | NAP | 4.6E-01 |
| Bismuth | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Copper | 26 | NA | NA | NA | NAP | NAP | 0.0E+00 | 9.0E-03 | 3.2E-03 | NA | NAP | NAP | 1.2E-02 |
| Lead | 48 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Selenium | | NA | NA | NA | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | NA | NAP | NAP | 0.0E+00 |
| Thallium | 0.46 | NA | NA | NA | NAP | NAP | 0.0E+00 | 7.4E-02 | 5.2E-02 | NA | NAP | NAP | 1.3E-01 |
| **Total Chemical** | | 1.4E-05 | 3.6E-06 | 1.4E-09 | 0.0E+00 | 0.0E+00 | 1.8E-05 | 4.5E-01 | 1.5E-01 | 2.2E-06 | 0.0E+00 | 0.0E+00 | 6.0E-01 |
| **Radionuclides** | EPC pCi/g | | | | | | | | | | | | |
| Plutonium-238 | 0.13 | 1.6E-08 | NA | 1.5E-11 | NAP | 4.5E-12 | 1.6E-08 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Radium-226 | 2 | 2.5E-07 | 0.0E+00 | 2.4E-11 | NAP | 2.4E-05 | 2.4E-05 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| **Total Radionuclide** | | 2.7E-07 | 0.0E+00 | 3.9E-11 | NAP | 2.4E-05 | 2.4E-05 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| **Overall Total Risk** | | 1.4E-05 | 3.6E-06 | 1.5E-09 | NAP | 2.4E-05 | 4.2E-05 | 4.5E-01 | 1.5E-01 | 2.2E-06 | NAP | NAP | 6.0E-01 |

| | |
|---|---|
| EPC | Exposure point concentration |
| mg/kg | Milligram per kilogram |
| NA | Not available; insufficient toxicity data |
| NAP | Not applicable pathway |
| NC | Not a suspected carcinogen |
| pCi/g | Picocuries per gram |
| VOCs | Volatile organic compounds |
| 1.00E-06 | Is equivalent to $1.00 \times 10^{-6}$ |

**Table 5.12 Incremental Residual Risk for a Residential Child at the Miami-Erie Canal Area** **Incremental**

| Constituent | EPC mg/kg | CANCER EFFECTS: Route-Specific Risk: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Cancer Risk Total | NON-CANCER EFFECTS: Route-Specific HQ: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Non-Cancer HI Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semi-Volatile Organic Compounds** | | | | | | | | | | | | | |
| 2-Methylnaphthalene | 0.15 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Acenaphthene | 0.195 | NA | NA | NA | NAP | NAP | 0.0E+00 | 4.2E-05 | 4.3E-04 | NA | NAP | NAP | 4.7E-04 |
| Acenaphthylene | 0.213 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Benzo(a)pyrene | 0.688 | 5.5E-06 | 5.6E-05 | 2.4E-11 | NAP | NAP | 6.2E-05 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Benzo(g,h,i)perylene | 0.477 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Carbazole | 0.191 | 4.2E-09 | 1.9E-08 | NA | NAP | NAP | 2.3E-08 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Dibenz(a,h)anthracene | 0.24 | 1.9E-06 | 8.7E-06 | 8.3E-12 | NAP | NAP | 1.1E-05 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Dibenzofuran | 0.195 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Fluorene | 0.21 | NA | NA | NA | NAP | NAP | 0.0E+00 | 6.7E-05 | 4.3E-04 | 0.0E+00 | NAP | NAP | 4.9E-04 |
| Naphthalene | 0.14 | NA | NA | NA | NAP | NAP | 0.0E+00 | 8.9E-05 | 5.7E-04 | 2.1E-08 | NAP | NAP | 6.6E-04 |
| Phenanthrene | 0.773 | NC | NC | NC | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| **Pesticides** | | | | | | | | | | | | | |
| Endrin Ketone | 0.002 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Gamma Chlordane | 0.0003 | 1.2E-10 | 7.3E-10 | 1.2E-15 | NAP | NAP | 8.5E-10 | 7.7E-06 | 4.9E-05 | 1.9E-10 | NAP | NAP | 5.6E-05 |
| **Metals** | | | | | | | | | | | | | |
| Arsenic | 0.9 | 1.5E-06 | 3.8E-07 | 1.5E-10 | NAP | NAP | 1.9E-06 | 3.8E-02 | 9.9E-03 | 2.3E-07 | NAP | NAP | 4.8E-02 |
| Bismuth | 3.1 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Copper | 8.7 | NA | NA | NA | NAP | NAP | 0.0E+00 | 3.0E-03 | 1.1E-03 | NA | NAP | NAP | 4.1E-03 |
| Lead | 178 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Selenium | 0.91 | NA | NA | NA | NAP | NAP | 0.0E+00 | 2.3E-03 | 5.6E-04 | NA | NAP | NAP | 2.9E-03 |
| Thallium | 0.88 | NA | NA | NA | NAP | NAP | 0.0E+00 | 1.4E-01 | 9.9E-02 | NA | NAP | NAP | 2.4E-01 |
| **Total Chemical** | | 8.9E-06 | 6.5E-05 | 1.8E-10 | 0.0E+00 | 0.0E+00 | 7.4E-05 | 1.8E-01 | 1.1E-01 | 2.6E-07 | 0.0E+00 | 0.0E+00 | 3.0E-01 |
| **Radionuclides** | EPC pCi/g | | | | | | | | | | | | |
| Plutonium-238 | 22.37 | 2.8E-06 | NA | 2.6E-09 | NAP | 7.8E-10 | 2.8E-06 | NA | NA | NA | NAP | NA | 0.0E+00 |
| Radium-226 | 1.04 | 1.3E-07 | 0.0E+00 | 1.2E-11 | NAP | 1.3E-05 | 1.3E-05 | NA | NA | NA | NAP | NA | 0.0E+00 |
| **Total Radionuclide** | | 2.9E-06 | 0.0E+00 | 2.6E-09 | NAP | 1.3E-05 | 1.6E-05 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| **Overall Total Risk** | | 1.2E-05 | 6.5E-05 | 2.8E-09 | NAP | 1.3E-05 | 9.0E-05 | 1.8E-01 | 1.1E-01 | 2.6E-07 | NAP | NAP | 3.0E-01 |

| | |
|---|---|
| EPC | Exposure point *concentration*, *incremental* value is total minus background |
| mg/kg | Milligram per kilogram |
| NA | Not available; insufficient toxicity data |
| NAP | Not applicable pathway |
| NC | Not a suspected carcinogen |
| pCi/g | Picocuries per gram |
| VOCs | Volatile organic compounds |
| 1.00E-06 | Is equivalent to $1.00 \times 10^{-6}$ |

**Table 5.13 Total Residual Risk for an Off Site Construction Worker at the Miami-Erie Canal Area**

| Constituent | EPC mg/kg | CANCER EFFECTS: Route-Specific Risk: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Cancer Risk Total | NON-CANCER EFFECTS: Route-Specific HQ: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Non-Cancer HI Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semi-Volatile Organic Compounds** | | | | | | | | | | | | | |
| 2-Methylnaphthalene | 0.15 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Acenaphthene | 0.195 | NA | NA | NA | NAP | NAP | 0.0E+00 | 1.5E-05 | 3.1E-05 | NA | NAP | NAP | 4.6E-05 |
| Acenaphthylene | 0.213 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Benzo(g,h,i)perylene | 0.477 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Carbazole | 0.191 | 2.6E-10 | 2.3E-10 | NA | NAP | NAP | 4.9E-10 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Dibenzofuran | 0.195 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Fluorene | 0.21 | NA | NA | NA | NAP | NAP | 0.0E+00 | 2.5E-05 | 3.1E-05 | 0.0E+00 | NAP | NAP | 5.5E-05 |
| Naphthalene | 0.14 | NA | NA | NA | NAP | NAP | 0.0E+00 | 3.3E-05 | 4.1E-05 | 7.4E-09 | NAP | NAP | 7.4E-05 |
| Phenanthrene | 0.773 | NC | NC | NC | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| **Pesticides** | | | | | | | | | | | | | |
| Endrin Ketone | 0.002 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Gamma Chlordane | 0.0003 | 7.0E-12 | 8.8E-12 | 6.9E-17 | NAP | NAP | 1.6E-11 | 2.8E-06 | 3.5E-06 | 6.9E-11 | NAP | NAP | 6.3E-06 |
| **Metals** | | | | | | | | | | | | | |
| Arsenic | 9.5 | 9.6E-07 | 4.9E-08 | 9.3E-11 | NAP | NAP | 1.0E-06 | 1.5E-01 | 7.6E-03 | 8.7E-07 | NAP | NAP | 1.6E-01 |
| Bismuth | 3.1 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Copper | 34.7 | NA | NA | NA | NAP | NAP | 0.0E+00 | 4.4E-03 | 3.1E-04 | NA | NAP | NAP | 4.7E-03 |
| Lead | 226 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Selenium | 0.91 | NA | NA | NA | NAP | NAP | 0.0E+00 | 8.5E-04 | 4.0E-05 | NA | NAP | NAP | 9.0E-04 |
| Thallium | 0.88 | NA | NA | NA | NAP | NAP | 0.0E+00 | 5.2E-02 | 7.2E-03 | NA | NAP | NAP | 5.9E-02 |
| **Total Chemical** | | 9.6E-07 | 4.9E-08 | 9.3E-11 | 0.0E+00 | 0.0E+00 | 1.0E-06 | 2.1E-01 | 1.5E-02 | 8.8E-07 | 0.0E+00 | 0.0E+00 | 2.2E-01 |
| **Radionuclides** | EPC pCi/g | | | | | | | | | | | | |
| Radium-226 | 3.04 | 1.1E-07 | 0.0E+00 | 9.9E-12 | NAP | 6.1E-06 | 6.2E-06 | NA | NA | NA | NAP | NA | 0.0E+00 |
| **Total Radionuclide** | | 1.1E-07 | 0.0E+00 | 9.9E-12 | NAP | 6.1E-06 | 6.2E-06 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| **Overall Total Risk** | | 1.1E-06 | 4.9E-08 | 1.0E-10 | 0.0E+00 | 6.1E-06 | 7.2E-06 | 2.1E-01 | 1.5E-02 | 8.8E-07 | 0.0E+00 | 0.0E+00 | 2.2E-01 |

| | |
|---|---|
| EPC | Exposure point concentration |
| mg/kg | Milligram per kilogram |
| NA | Not available; insufficient toxicity data |
| NAP | Not applicable pathway |
| NC | Not a suspected carcinogen |
| pCi/g | Picocuries per gram |
| VOCs | Volatile organic compounds |
| 1.00E-06 | Is equivalent to $1.00 \times 10^{-6}$ |

**Table 5.14 Background Residual Risk for an Offsite construction Worker at the Miami-Erie Canal Area**

| Constituent | EPC mg/kg | CANCER EFFECTS: Route-Specific Risk: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Cancer Risk Total | NON-CANCER EFFECTS: Route-Specific HQ: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Non-Cancer HI Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semi-Volatile Organic Compounds** | | | | | | | | | | | | | |
| 2-Methylnaphthalene | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Acenaphthene | | NA | NA | NA | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | NA | NAP | NAP | 0.0E+00 |
| Acenaphthylene | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Benzo(g,h,i)perylene | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Carbazole | | 0.0E+00 | 0.0E+00 | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Dibenzofuran | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Fluorene | | NA | NA | NA | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 |
| Naphthalene | | NA | NA | NA | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 |
| Phenanthrene | | NC | NC | NC | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| **Pesticides** | | | | | | | | | | | | | |
| Endrin Ketone | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Gamma Chlordane | | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | NAP | NAP | 0.0E+00 |
| **Metals** | | | | | | | | | | | | | |
| Arsenic | 8.6 | 8.7E-07 | 4.4E-08 | 8.4E-11 | NAP | NAP | 9.1E-07 | 1.3E-01 | 6.8E-03 | 7.9E-07 | NAP | NAP | 1.4E-01 |
| Bismuth | | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Copper | 26 | NA | NA | NA | NAP | NAP | 0.0E+00 | 3.3E-03 | 2.3E-04 | NA | NAP | NAP | 3.5E-03 |
| Lead | 48 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Selenium | | NA | NA | NA | NAP | NAP | 0.0E+00 | 0.0E+00 | 0.0E+00 | NA | NAP | NAP | 0.0E+00 |
| Thallium | 0.46 | NA | NA | NA | NAP | NAP | 0.0E+00 | 2.7E-02 | 3.8E-03 | NA | NAP | NAP | 3.1E-02 |
| **Total Chemical** | | 8.7E-07 | 4.4E-08 | 8.4E-11 | 0.0E+00 | 0.0E+00 | 9.1E-07 | 1.6E-01 | 1.1E-02 | 7.9E-07 | 0.0E+00 | 0.0E+00 | 1.8E-01 |
| **Radionuclides** | EPC pCi/g | | | | | | | | | | | | |
| Radium-226 | 2 | 7.2E-08 | 0.0E+00 | 6.5E-12 | NAP | 4.0E-06 | 4.1E-06 | NA | NA | NA | NAP | NA | 0.0E+00 |
| **Total Radionuclide** | | 7.2E-08 | 0.0E+00 | 6.5E-12 | NAP | 4.0E-06 | 4.1E-06 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| **Overall Total Risk** | | 9.4E-07 | 4.4E-08 | 9.1E-11 | 0.0E+00 | 4.0E-06 | 5.0E-06 | 1.6E-01 | 1.1E-02 | 7.9E-07 | 0.0E+00 | 0.0E+00 | 1.8E-01 |

| | |
|---|---|
| EPC | Exposure point concentration |
| mg/kg | Milligram per kilogram |
| NA | Not available; insufficient toxicity data |
| NAP | Not applicable pathway |
| NC | Not a suspected carcinogen |
| pCi/g | Picocuries per gram |
| VOCs | Volatile organic compounds |
| 1.00E-06 | Is equivalent to $1.00 \times 10^{-6}$ |

**Table 5.15 Incremental Residual Risk for an Offsite Construction Worker at the Miami-Erie Canal Area**

| Constituent | EPC mg/kg | CANCER EFFECTS: Route-Specific Risk: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Cancer Risk Total | NON-CANCER EFFECTS: Route-Specific HQ: Oral | Dermal | Inhalation Dust | Inhalation VOCs | External | Non-Cancer HI Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semi-Volatile Organic Compounds** | | | | | | | | | | | | | |
| 2-Methylnaphthalene | 0.15 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Acenaphthene | 0.195 | NA | NA | NA | NAP | NAP | 0.0E+00 | 1.5E-05 | 3.1E-05 | NA | NAP | NAP | 4.6E-05 |
| Acenaphthylene | 0.213 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Benzo(g,h,i)perylene | 0.477 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Carbazole | 0.191 | 2.6E-10 | 2.3E-10 | NA | NAP | NAP | 4.9E-10 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Dibenzofuran | 0.195 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Fluorene | 0.21 | NA | NA | NA | NAP | NAP | 0.0E+00 | 2.5E-05 | 3.1E-05 | 0.0E+00 | NAP | NAP | 5.5E-05 |
| Naphthalene | 0.14 | NA | NA | NA | NAP | NAP | 0.0E+00 | 3.3E-05 | 4.1E-05 | 7.4E-09 | NAP | NAP | 7.4E-05 |
| Phenanthrene | 0.773 | NC | NC | NC | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| **Pesticides** | | | | | | | | | | | | | |
| Endrin Ketone | 0.002 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Gamma Chlordane | 0.0003 | 7.0E-12 | 8.8E-12 | 6.9E-17 | NAP | NAP | 1.6E-11 | 2.8E-06 | 3.5E-06 | 6.9E-11 | NAP | NAP | 6.3E-06 |
| **Metals** | | | | | | | | | | | | | |
| Arsenic | 0.9 | 9.1E-08 | 4.6E-09 | 8.8E-12 | NAP | NAP | 9.5E-08 | 1.4E-02 | 7.2E-04 | 8.2E-08 | NAP | NAP | 1.5E-02 |
| Bismuth | 3.1 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Copper | 8.7 | NA | NA | NA | NAP | NAP | 0.0E+00 | 1.1E-03 | 7.7E-05 | NA | NAP | NAP | 1.2E-03 |
| Lead | 178 | NA | NA | NA | NAP | NAP | 0.0E+00 | NA | NA | NA | NAP | NAP | 0.0E+00 |
| Selenium | 0.91 | NA | NA | NA | NAP | NAP | 0.0E+00 | 8.5E-04 | 4.0E-05 | NA | NAP | NAP | 9.0E-04 |
| Thallium | 0.88 | NA | NA | NA | NAP | NAP | 0.0E+00 | 5.2E-02 | 7.2E-03 | NA | NAP | NAP | 5.9E-02 |
| **Total Chemical** | | 9.1E-08 | 4.8E-09 | 8.8E-12 | 0.0E+00 | 0.0E+00 | 9.6E-08 | 6.8E-02 | 8.1E-03 | 9.0E-08 | 0.0E+00 | 0.0E+00 | 7.6E-02 |
| | EPC pCi/g | | | | | | | | | | | | |
| **Radionuclides** | | | | | | | | | | | | | |
| Radium-226 | 1.04 | 3.7E-08 | 0.0E+00 | 3.4E-12 | NAP | 2.1E-06 | 2.1E-06 | NA | NA | NA | NAP | NA | 0.0E+00 |
| **Total Radionuclide** | | 3.7E-08 | 0.0E+00 | 3.4E-12 | NAP | 2.1E-06 | 2.1E-06 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| **Overall Total Risk** | | 1.3E-07 | 4.8E-09 | 1.2E-11 | 0.0E+00 | 2.1E-06 | 2.2E-06 | 6.8E-02 | 8.1E-03 | 9.0E-08 | 0.0E+00 | 0.0E+00 | 7.6E-02 |

| | |
|---|---|
| EPC | Exposure point concentration, incremental value is total *minus* background |
| mg/kg | Milligram per kilogram |
| NA | Not available; insufficient toxicity data |
| NAP | Not applicable pathway |
| NC | Not a suspected carcinogen |
| pCi/g | Picocuries per gram |
| VOCs | Volatile organic compounds |
| 1.00E-06 | Is equivalent to $1.00 \times 10^{-6}$ |

**Table 5.16 Total Residual Risk for the Miami-Erie Canal Area Summary Table**

| Scenario and Receptor | Media | Constituents | Pathway | Total Noncarcinogen Risk HI | Total Carcinogenic Risk ELCR |
|---|---|---|---|---|---|
| Resident Adult Scenario | Soil (all sample depths) | Chemical | Ingestion | 6.0E-02 | **9.9E-06** |
| | | | Dermal | 1.2E-01 | **1.5E-04** |
| | | | Inhalation of Dust | 1.2E-06 | 3.2E-09 |
| | | | Inhalation of VOCs | 0.0E+00 | 0.0E+00 |
| | | | TOTAL | 1.8E-01 | **1.6E-04** |
| | | Radionuclides | Ingestion | NAP | **6.3E-06** |
| | | | Inhalation of Dust | NAP | 2.5E-08 |
| | | | External | NAP | **1.5E-04** |
| | | | TOTAL | NAP | **1.5E-04** |
| | | Chemical & Radionuclide Total | | 1.8E-01 | **3.1E-04** |
| Resident Child Scenario | Soil (all sample depths) | Chemical | Ingestion | 5.6E-01 | **2.3E-05** |
| | | | Dermal | 2.1E-01 | **6.9E-05** |
| | | | Inhalation of Dust | 2.5E-06 | 1.6E-09 |
| | | | Inhalation of VOCs | 0.0E+00 | 0.0E+00 |
| | | | TOTAL | 7.7E-01 | **9.2E-05** |
| | | Radionuclides | Ingestion | NAP | **3.2E-06** |
| | | | Inhalation of Dust | NAP | 2.7E-09 |
| | | | External | NAP | **3.7E-05** |
| | | | TOTAL | NAP | **4.0E-05** |
| | | Chemical & Radionuclide Total | | 7.7E-01 | **1.3E-04** |
| Recreational Adult Scenario | Soil (0-2 ft bls) | Chemical | Ingestion | 2.5E-03 | 2.7E-10 |
| | | | Dermal | 8.6E-03 | 1.4E-08 |
| | | | Inhalation of Dust | 1.0E-09 | 2.2E-16 |
| | | | Inhalation of VOCs | 0.0E+00 | 0.0E+00 |
| | | | TOTAL | 1.1E-02 | 1.5E-08 |
| | | Radionuclides | Ingestion | NAP | 1.1E-07 |
| | | | Inhalation of Dust | NAP | 3.2E-11 |
| | | | External | NAP | **9.3E-06** |
| | | | TOTAL | NAP | **9.4E-06** |
| | | Chemical & Radionuclide Total | | 1.1E-02 | **9.4E-06** |
| Recreational Child Scenario | Soil (0-2 ft bls) | Chemical | Ingestion | 2.3E-02 | 6.4E-10 |
| | | | Dermal | 1.6E-02 | 6.5E-09 |
| | | | Inhalation of Dust | 3.2E-09 | 1.7E-16 |
| | | | Inhalation of VOCs | 0.0E+00 | 0.0E+00 |
| | | | TOTAL | 3.9E-02 | 7.1E-09 |
| | | Radionuclides | Ingestion | NAP | 5.7E-08 |
| | | | Inhalation of Dust | NAP | 5.4E-12 |
| | | | External | NAP | **2.3E-06** |
| | | | TOTAL | NAP | **2.4E-06** |
| | | Chemical & Radionuclide Total | | 3.9E-02 | **2.4E-06** |

**Table 5.16 Total Residual Risk for the Miami-Erie Canal Area Summary Table**

| Scenario and Receptor | Media | Constituents | Pathway | Total Noncarcinogen Risk HI | Total Carcinogenic Risk ELCR |
|---|---|---|---|---|---|
| Off Site Construction Worker Scenario | Soil (0-10 ft bls) | Chemical | Ingestion | 2.1E-01 | 9.6E-07 |
| | | | Dermal | 1.5E-02 | 4.9E-08 |
| | | | Inhalation of Dust | 8.8E-07 | 9.3E-11 |
| | | | Inhalation of VOCs | 0.0E+00 | 0.0E+00 |
| | | | TOTAL | 2.2E-01 | 1.0E-06 |
| | | Radionuclides | Ingestion | NAP | 1.1E-07 |
| | | | Inhalation of Dust | NAP | 9.9E-12 |
| | | | External | NAP | **6.1E-06** |
| | | | TOTAL | NAP | **6.2E-06** |
| | | Chemical & Radionuclide Total | | 2.2E-01 | **7.2E-06** |

HI values which exceed the target risk level of one and ELCR values which exceed $10^{-6}$ presented in bold text.

1E-01 is equivalent to $1.00 \times 10^{-1}$

**Table 5.17 Background Residual Risk for the Miami-Erie Canal Area Summary Table**

| Scenario and Receptor | Media | Constituents | Pathway | Background Noncarcinogen Risk HI | Background Carcinogenic Risk ELCR |
|---|---|---|---|---|---|
| | | | | | |
| Resident Adult Scenario | Soil (all sample depths) | Chemical | Ingestion | 4.8E-02 | **6.1E-06** |
| | | | Dermal | 8.3E-02 | **8.1E-06** |
| | | | Inhalation of Dust | 1.1E-06 | 2.8E-09 |
| | | | Inhalation of VOCs | 0.0E+00 | 0.0E+00 |
| | | | TOTAL | 1.3E-01 | **1.4E-05** |
| | | | | | |
| | | Radionuclides | Ingestion | NAP | 5.4E-07 |
| | | | Inhalation of Dust | NAP | 3.6E-10 |
| | | | External | NAP | **9.6E-05** |
| | | | TOTAL | NAP | **9.7E-05** |
| | | Chemical & Radionuclide Total | | 1.3E-01 | **1.1E-04** |
| | | | | | |
| Resident Child Scenario | Soil (all sample depths) | Chemical | Ingestion | 4.5E-01 | **1.4E-05** |
| | | | Dermal | 1.5E-01 | **3.6E-06** |
| | | | Inhalation of Dust | 2.2E-06 | 1.4E-09 |
| | | | Inhalation of VOCs | 0.0E+00 | 0.0E+00 |
| | | | TOTAL | 6.0E-01 | **1.8E-05** |
| | | | | | |
| | | Radionuclides | Ingestion | NAP | 2.7E-07 |
| | | | Inhalation of Dust | NAP | 3.9E-11 |
| | | | External | NAP | **2.4E-05** |
| | | | TOTAL | NAP | **2.4E-05** |
| | | Chemical & Radionuclide Total | | 6.0E-01 | **4.2E-05** |
| | | | | | |
| Recreatonal Adult Scenario | Soil (0-2 ft bls) | Chemical | Ingestion | 1.3E-03 | 0.0E+00 |
| | | | Dermal | 4.5E-03 | 0.0E+00 |
| | | | Inhalation of Dust | 0.0E+00 | 0.0E+00 |
| | | | Inhalation of VOCs | 0.0E+00 | 0.0E+00 |
| | | | TOTAL | 5.8E-03 | 0.0E+00 |
| | | | | | |
| | | Radionuclides | Ingestion | NAP | 7.5E-08 |
| | | | Inhalation of Dust | NAP | 2.1E-11 |
| | | | External | NAP | **6.1E-06** |
| | | | TOTAL | NAP | **6.2E-06** |
| | | Chemical & Radionuclide Total | | 5.8E-03 | **6.2E-06** |
| | | | | | |
| Recreational Child Scenario | Soil (0-2 ft bls) | Chemical | Ingestion | 1.3E-03 | 0.0E+00 |
| | | | Dermal | 4.5E-03 | 0.0E+00 |
| | | | Inhalation of Dust | 0.0E+00 | 0.0E+00 |
| | | | Inhalation of VOCs | 0.0E+00 | 0.0E+00 |
| | | | TOTAL | 5.8E-03 | 0.0E+00 |
| | | | | | |
| | | Radionuclides | Ingestion | NAP | 7.5E-08 |
| | | | Inhalation of Dust | NAP | 2.1E-11 |
| | | | External | NAP | **1.5E-06** |
| | | | TOTAL | NAP | **1.6E-06** |
| | | Chemical & Radionuclide Total | | 5.8E-03 | **1.6E-06** |

**Table 5.17 Background Residual Risk for the Miami-Erie Canal Area Summary Table**

| Scenario and Receptor | Media | Constituents | Pathway | Background Noncarcinogen Risk HI | Background Carcinogenic Risk ELCR |
|---|---|---|---|---|---|
| | | | | | |
| Off Site Construction Worker Scenario | Soil (0-10 ft bls) | Chemical | Ingestion | 1.6E-01 | 8.7E-07 |
| | | | Dermal | 1.1E-02 | 4.4E-08 |
| | | | Inhalation of Dust | 7.9E-07 | 8.4E-11 |
| | | | Inhalation of VOCs | 0.0E+00 | 0.0E+00 |
| | | | TOTAL | 1.8E-01 | 9.1E-07 |
| | | | | | |
| | | Radionuclides | Ingestion | NAP | 7.2E-08 |
| | | | Inhalation of Dust | NAP | 6.5E-12 |
| | | | External | NAP | **4.0E-06** |
| | | | TOTAL | NAP | **4.1E-06** |
| | | Chemical & Radionuclide Total | | 1.8E-01 | **5.1E-06** |

HI values which exceed the target risk level of one and ELCR values which exceed $10^{-6}$ presented in bold text.

1E-01 is equivalent to $1.00 \times 10^{-1}$

**Table 5.18 Incremental Residual Risk for the Miami-Erie Canal Area Summary Table**

| Scenario and Receptor | Media | Constituents | Pathway | Incremental Noncarcinogen Risk HI | Incremental Carcinogenic Risk ELCR |
|---|---|---|---|---|---|
| | | | | | |
| Resident Adult Scenario | Soil (all sample depths) | Chemical | Ingestion | 2.0E-02 | **3.8E-06** |
| | | | Dermal | 6.2E-02 | **1.4E-04** |
| | | | Inhalation of Dust | 1.3E-07 | 3.6E-10 |
| | | | Inhalation of VOCs | 0.0E+00 | 0.0E+00 |
| | | | TOTAL | 8.2E-02 | **1.5E-04** |
| | | | | | |
| | | Radionuclides | Ingestion | NAP | **5.8E-06** |
| | | | Inhalation of Dust | NAP | 2.4E-08 |
| | | | External | NAP | **5.0E-05** |
| | | | TOTAL | NAP | **5.6E-05** |
| | | Chemical & Radionuclide Total | | 8.2E-02 | **2.1E-04** |
| | | | | | |
| Resident Child Scenario | Soil (all sample depths) | Chemical | Ingestion | 1.8E-01 | **8.9E-06** |
| | | | Dermal | 1.1E-01 | **6.5E-05** |
| | | | Inhalation of Dust | 2.6E-07 | 1.8E-10 |
| | | | Inhalation of VOCs | 0.0E+00 | 0.0E+00 |
| | | | TOTAL | 3.0E-01 | **7.4E-05** |
| | | | | | |
| | | Radionuclides | Ingestion | NAP | **2.9E-06** |
| | | | Inhalation of Dust | NAP | 2.6E-09 |
| | | | External | NAP | **1.3E-05** |
| | | | TOTAL | NAP | **1.6E-05** |
| | | Chemical & Radionuclide Total | | 3.0E-01 | **9.0E-05** |
| | | | | | |
| Recreational Adult Scenario | Soil (0-2 ft bls) | Chemical | Ingestion | 1.2E-03 | 2.7E-10 |
| | | | Dermal | 4.1E-03 | 1.4E-08 |
| | | | Inhalation of Dust | 1.0E-09 | 2.2E-16 |
| | | | Inhalation of VOCs | 0.0E+00 | 0.0E+00 |
| | | | TOTAL | 5.3E-03 | 1.5E-08 |
| | | | | | |
| | | Radionuclides | Ingestion | NAP | 3.9E-08 |
| | | | Inhalation of Dust | NAP | 1.1E-11 |
| | | | External | NAP | **3.2E-06** |
| | | | TOTAL | NAP | **3.2E-06** |
| | | Chemical & Radionuclide Total | | 5.3E-03 | **3.2E-06** |
| | | | | | |
| Recreational Child Scenario | Soil (0-2 ft bls) | Chemical | Ingestion | 8.1E-03 | 4.8E-10 |
| | | | Dermal | 5.6E-03 | 4.9E-09 |
| | | | Inhalation of Dust | 2.4E-09 | 1.3E-16 |
| | | | Inhalation of VOCs | 0.0E+00 | 0.0E+00 |
| | | | TOTAL | 1.4E-02 | 5.3E-09 |
| | | | | | |
| | | Radionuclides | Ingestion | NAP | 1.9E-08 |
| | | | Inhalation of Dust | NAP | 1.8E-12 |
| | | | External | NAP | 7.9E-07 |
| | | | TOTAL | NAP | 8.1E-07 |
| | | Chemical & Radionuclide Total | | 1.4E-02 | **8.1E-07** |

**Table 5.18 Incremental Residual Risk for the Miami-Erie Canal Area Summary Table**

| Scenario and Receptor | Media | Constituents | Pathway | Incremental Noncarcinogen Risk HI | Incremental Carcinogenic Risk ELCR |
|---|---|---|---|---|---|
| Off Site Construction Worker Scenario | Soil (0-10 ft bls) | Chemical | Ingestion | 6.8E-02 | 9.1E-08 |
| | | | Dermal | 8.1E-03 | 4.8E-09 |
| | | | Inhalation of Dust | 9.0E-08 | 8.8E-12 |
| | | | Inhalation of VOCs | 0.0E+00 | 0.0E+00 |
| | | | TOTAL | 7.6E-02 | 9.6E-08 |
| | | Radionuclides | Ingestion | NAP | 3.7E-08 |
| | | | Inhalation of Dust | NAP | 3.4E-12 |
| | | | External | NAP | **2.1E-06** |
| | | | TOTAL | NAP | **2.1E-06** |
| | | Chemical & Radionuclide Total | | 7.6E-02 | **2.2E-06** |

HI values which exceed the target risk level of one and ELCR values which exceed $10^{-6}$ presented in bold text.

1E-01 is equivalent to $1.00 \times 10^{-1}$

## 6.0 UNCERTAINTY IN THE RISK ASSESSMENT

In the following section, an evaluation is presented of the sources of uncertainty in the Miami-Erie Canal area RRE and the relative influence of these sources on the results of the evaluation. Uncertainty is inherent in the selection of input parameters and in every step of the risk assessment process. Risk assessment of contaminated sites must not be viewed as yielding single value, invariant results. Rather, the results of risk assessment are estimates that span a range of possible values, and which must be understood only in light of the assumptions and methods used in the evaluation.

The results of the RRE are presented in terms of the potential for adverse effects based upon a number of conservative assumptions. The tendency to be conservative is an effort to err toward protecting health. Uncertainty can be found at all phases in the risk assessment: in the analytical data, the exposure assessment, the toxicity assessment, and the risk characterization. Where uncertainty does exist, the RRE uses conservative assumptions to ensure that the outcome will be protective.

### 6.1 Uncertainty in Analytical Data

Uncertainty is introduced to the RRE when sample locations are selected and when samples are collected and analyzed. In the RRE, the long-term exposure concentrations were upper estimates of site concentrations (e.g., maximum detect or 95% UCL); therefore, a conservative bias to overestimate potential exposure has been incorporated into the risk estimates. The uncertainty associated with the statistical analysis of environmental data is low, with little introduction of bias. However, it is possible that contaminated areas of the canal were not sampled. This is unlikely given the extent of sampling conducted.

### 6.2 Uncertainty in Exposure Assessment

Exposure assessment may introduce considerable uncertainty in the risk assessment process. The RREM presents exposure and intake calculations based on EPA procedures that were used in the Miami-Erie Canal RRE. Exposure assumption values were also used to develop site-specific risk-based guideline values for the Mound Plant which were approved by Ohio EPA and EPA. Exposure assumptions are based on speculation regarding potential land use, assumptions concerning contaminant fate and transport, and receptor

behavior. The uncertainty associated with the exposure assumptions used in the risk assessment is low to moderate, and most likely overestimates the actual risks.

A major source of uncertainty in the Miami-Erie Canal RRE involves external exposure to gamma-emitting radionuclides. External exposure refers to the irradiation of tissues by radiations emitted by radionuclides located outside the body either dispersed in air, on skin surfaces, or deposited on ground surfaces. Gamma and x-rays are the most penetrating of the emitted radiations and comprise the primary contribution to radiation dose from external exposures. The calculation of risk from external radiation exposure assumes that any gamma-emitting radionuclide in soil is uniformly distributed in soil. The calculation of external radiation exposure risk includes a gamma shielding factor ($S_e$) to account for attenuation of radiation by structures, terrain or engineered barriers. $S_e$ is expressed as a fractional value between 0 and 1, representing the possible risk reduction range from 0% to 100% due to shield. The Miami-Erie Canal RRE used a default value of 0.2 or 20% shielding for both the recreational and residential scenarios. This is a conservative value which does not account for 1-2 feet of clean fill material that was placed over excavated areas. Calculations done using RESRAD Version 5.621 and verified with Microshield Version 4.21 show that the reduction in dose from a gamma source by applying soil covers of various depths would be on the order of a 99% reduction or 99% shielding with 2 feet of soil cover (SAIC 1997). Calculations showing the shielding of external gamma dose, from a soil cover, are included in Appendix A. It is likely that clean fill in the canal area does provide shielding from gamma radiation resulting in lower risk than what is presented here.

### 6.3 Uncertainties Related to Toxicity Information

Although EPA approved toxicity values were used for the RRE a significant amount of uncertainty may surround these values. Identification of the sources of this uncertainty enables the risk assessor to establish the degree of confidence associated with the toxicity measures.

Uncertainty is inherent within the toxicity assessment and is primarily due to differences in study design, species, sex, routes of exposure, or dose-response relationships. A major source of uncertainty involves using toxicity values based on experimental studies that substantially differ from typical human exposure scenarios. The derivation of the toxicity values must take into account such differences as 1) using dose-response information from animal studies to predict effects in humans, 2) extrapolating dose-response

information from high-dose studies to predict adverse health effects from low doses, 3) using data from short-term studies to predict chronic effects, and 4) extrapolating from uniform animal populations to variable human populations.

The cancer slope factors in particular are based on studies that may differ greatly from realistic situations. Experimental cancer bioassays typically expose animals to very high levels of chemicals (i.e., the maximum tolerated dose) for their entire lifetime. After appropriate studies have been identified, the slope factor is calculated as the upper 95th percent confidence limit of the slope of the dose-response curve. This introduces conservatism into the risk assessment. In addition, carcinogens are assumed to be human carcinogens regardless of EPA's weight-of-evidence classification.

The derivation of reference doses involves the use of animal studies. Uncertainty factors ranging from 1 to 1,000 are incorporated into the reference dose to provide an extra level of health protection. The factors used depend on the type of study from which the value has been derived (e.g., animal or human, chronic or acute, study design). The scientific basis for this practice is somewhat subjective. In general, high uncertainty factors are meant to bias the results conservatively so that exposures at the reference dose level will not result in adverse health effects.

Toxicity values derived from oral administered dose studies have been converted to absorbed dose toxicity values for use in evaluating the dermal contact pathway. This is considered a more accurate approach than using unadjusted oral toxicity values for the dermal pathway. Uncertainty is introduced in the use of the gastrointestinal absorption factors. Limited information is available on the gastrointestinal absorption of some analytes and many have no information at all. In addition, no adjustments have been made for the medium of exposure (e.g., when the medium of exposure in the site differs from the medium of exposure assumed by the toxicity value). The uncertainty associated with using the absorbed dose toxicity values for the dermal pathway is moderate and the bias unknown.

There are some chemicals for which no toxicity value exists and for which little information is available. Therefore, a quantitative risk estimate cannot be calculated for these chemicals. For example, many chemicals are not evaluated for the inhalation pathway because of limited inhalation-based toxicological information. The lack of toxicity information for some chemicals contributes to the underestimation of risks.

Cancer and non-cancer risks are summed in the risk characterization process (separately for carcinogens and non-carcinogens) to estimate potential risks associated with the simultaneous exposure to multiple chemicals. In the case of carcinogens, this gives carcinogens with a class B or class C weight-of-evidence the same weight as carcinogens with a class A weight-of-evidence. It also equally weights slope factors derived from animal data with those derived from human data. Uncertainties in the combined risks are also compounded because RfDs and cancer slope factors do not have equal accuracy or levels of confidence and are not based on the same severity of effect.

## 6.4 Uncertainties In Risk Characterization

Uncertainties in any phase of the risk analysis are reflected in the risk estimates. Some uncertainty is associated with the summation of risks and HQs for multiple chemical contaminants. As stated in RAGS (EPA 1989), "The assumption of dose additivity ignores possible synergisms or antagonisms among chemicals, and assumes similarity in mechanisms of action and metabolism." However, summing risks and HQs for multiple substances in this risk assessment provides a conservative estimate.

## 7.0 REFERENCES


Centers of Disease Control and Prevention (CDC), 1985. Preventing Lead Poisoning in Children, U.S. Department of Health and Human Services, Atlanta Georgia.

DOE (United States Department of Energy) 1975. Mound Laboratory Environmental Plutonium Study 1974 (MLM-02249), September 1975

DOE 1974. Mound Laboratory Environmental Plutonium Study. Samples from the park vicinity included in the RRE

DOE 1992. Special Canal Sampling, SAIC 1992

DOE 1993a. OU9 Quality Assurance Project Plan

DOE 1993b. OU5 Quality Assurance Project Plan

DOE 1994. "Health Consultation, DOE Mound Plant" (1994)

DOE 1995. OU-9 Regional Soils Investigation Report, August 1995, Final, Revision 2

DOE 1997a. Mound 2000 Residual Risk Evaluation Methodology, Mound Plant, Miamisburg, Ohio. Final, Revision 0. January 1997

DOE 1997b. Risk-Based Guideline Values, Mound Plant, Miamisburg, Ohio. Prepared by Hazardous Waste Remedial Actions Program managed by Lockheed Martin Energy Systems, Inc. March 1997.

DOE 1999. On-Scene Coordinators Report, OU-4 Miami-Erie Canal Removal Action, Mound Plant Miamisburg, Ohio. Final (Revision 0) June 1999.

EPA. 1998d. *RCRA QAPP Instructions*, USEPA Region 5, Chicago, IL, April 1998 revision. http://www.epa.gov/reg5rcra/wptdiv/cars/cars.htm

EPA 1990. "National Oil and Hazardous Substances Pollution Contingency Plan," Final Rule, FR Vol. 55, No. 46, March 8, 1990, available from U.S. Government Printing Office, Washington, D.C.

EPA 1989. "Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Part A, Interim Final," EPA, Office of Emergency and Remedial Response, Washington, DC.

EPA 1991a. "Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors, Interim Final," OSWER Directive 9285.6-03, EPA, Office of Emergency and Remedial Response, Washington, DC.

EPA 1991b. "Risk Assessment Guidance for Superfund, Vol. I: Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals," OSWER Directive 9285.7-01B, Office of Emergency and Remedial Response, Washington, D.C.

EPA 1992a. "Supplemental Guidance to RAGS: Calculating the Concentration Term," PB92-963373, May 1992. EPA, Office of Emergency and Remedial Response Toxics Integration Branch, Washington, DC.

EPA 1992b. "Dermal Exposure Assessment: Principles and Applications," EPA/600/8-91/011b, Office of Health and Environmental Assessment, Washington, DC.

EPA 1992c. "Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual Supplemental Guidance Dermal Risk Assessment Interim Guidance," EPA, Office of Emergency and Remedial Response Toxics Integration Branch, Washington, DC.

EPA 1994a. Interim Guidance on Establishing Soil Lead Cleanup Levels at RCRA Facilities. Office of Solid Waste and Emergency Response. OSWER Directive #93SS.4-12. Washington D.C.

EPA 1994b. Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children. Office of Emergency and Remedial Response. Washington, D.C. EPA/S40/R-93/081, PB93963610

EPA 1995. "Health Effects Assessment Summary Tables," OHEA ECAO-CIN-909, Office of Research and Development and Office of Emergency and Remedial Response, Washington, D.C.

EPA 1996a. *Radiation Exposure and Risks Assessment Manual (RERAM), Risk Assessment Using Radionuclide Slope Factors*, EPA 402-R-96-016, Air and Radiation, June.

EPA 1996f. Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil. December.

EPA 1997. "Exposure Factors Handbook," Volumes I, II, and III, EPA/600/P-95/002Fa-c, EPA, Office of Research and Development, Washington, DC.

EPA 2000. Integrated Risk Information System (IRIS), National Center for Environmental Assessment, U.S. Environmental Protection Agency, 26 West Martin Luther King Drive, MS-190, Cincinnati, Ohio 45268. (513) 569-7254.

Gilbert, R.O. 1987. Statistical Methods for Environmental Pollution Monitoring. Van Nostrand Reinhold, New York.

PRS 416 Data Package, Unpublished

SAIC 1997. Memo to George Stephens from Genia McDuffee. July 10, 1997on the subject of Shielding of External Gamma Dose from a Soil Cover.

# RESIDUAL RISK EVALUATION
# OU-4 MIAMI-ERIE CANAL AREA

## PUBLIC REVIEW
## DRAFT

**Mound Plant**
**Miamisburg, Ohio**

***Prepared for:***
**U.S. Department of Energy**

***Prepared by:***
**Science Applications International Corporation**
**Dublin, Ohio**

***Managed by:***
**BWXT of Ohio**

**April 14, 2000**

App A title page

## TABLE OF CONTENTS


1.0 INTRODUCTION . . . . . 1
- 1.1 Purpose Of Residual Risk Evaluation . . . . . 1
- 1.2 Scope of the Miami-Erie Canal RRE . . . . . 4
- 1.3 Organization of Report . . . . . 4

2.0 DATA COMPILATION AND EVALUATION . . . . . 5
- 2.1 Data Quality Assessment . . . . . 6
- 2.2 Environmental Media Considered and Data Availability . . . . . 6
- 2.3 Data Analysis . . . . . 7
- 2.4 Data Screening Process . . . . . 8
  - 2.4.1 Screening Constituents Based on Background . . . . . 18
  - 2.4.2 Screening Constituents Based on Guideline Values . . . . . 18
  - 2.4.3 Screening Constituents Based on Frequency of Detection . . . . . 19
  - 2.4.4 Screening Constituents Based on Essential Human Nutrients . . . . . 19
  - 2.4.5 Additional Screening Procedures . . . . . 20

3.0 EXPOSURE ASSESSMENT . . . . . 20
- 3.1 Characterization of Exposure Setting . . . . . 20
- 3.2 Identifying Exposure Pathways . . . . . 21
- 3.3 Identifying Exposure Scenarios . . . . . 22
  - 3.3.1 Recreational Adult and Child Scenarios . . . . . 22
  - 3.3.2 Residential Adult and Child Scenarios . . . . . 26
  - 3.3.3 Off Site Construction Worker Scenario . . . . . 27
- 3.4 Exposure Point Concentrations . . . . . 27
- 3.5 Human Intake Equations And Assumptions . . . . . 28

4.0 TOXICITY ASSESSMENT . . . . . 33
- 4.1 Toxicity Values for Evaluating the Dermal Pathway . . . . . 34
- 4.2 Toxicity Assessment for Lead . . . . . 34

5.0 RISK CHARACTERIZATION . . . . . 36
- 5.1 Risk Characterization Methods . . . . . 36
  - 5.1.1 Quantification of Carcinogenic Risk . . . . . 36
  - 5.1.2 Quantification of Non-carcinogenic Risk . . . . . 37
- 5.2 Risk Characterization Results . . . . . 38

6.0 UNCERTAINTY IN THE RISK ASSESSMENT . . . . . 63
- 6.1 Uncertainty in Analytical Data . . . . . 63
- 6.2 Uncertainty in Exposure Assessment . . . . . 63
- 6.3 Uncertainties Related to Toxicity Information . . . . . 64
- 6.4 Uncertainties In Risk Characterization . . . . . 66

7.0 REFERENCES . . . . . 67

## LIST OF TABLES


| | |
|---|---|
| Table 2.1 | Identification of Constituents of Potential Concern for the Recreational RRE of the Miami-Erie Canal Area |
| Table 2.2 | Identification of Constituents of Potential Concern for the Residential RRE of the Miami-Erie Canal Area |
| Table 2.3 | Identification of Constituents of Potential Concern for the Off-Site Construction Worker RRE of the Miami-Erie Canal Area |
| Table 3.1 | Exposure Assumptions for Recreation, Residential and Off-Site Construction Worker Scenarios in the Miami-Erie Canal Area |
| Table 4.1 | Toxicity Values and Chemical-Specific Parameters for Constituents of Potential Concern in the Miami-Erie Canal Area |
| Table 5.1 | Total Residual Risk for a Recreational Adult at the Miami-Erie Canal Area |
| Table 5.2 | Background Risk for a Recreational Adult at the Miami-Erie Canal Area |
| Table 5.3 | Incremental Residual Risk for a Recreational Adult at the Miami-Erie Canal Area |
| Table 5.4 | Total Residual Risk for a Recreational Child at the Miami-Erie Canal Area |
| Table 5.5 | Background Risk for a Recreational Child at the Miami-Erie Canal Area |
| Table 5.6 | Incremental Residual Risk for a Recreational Child at the Miami-Erie Canal Area |
| Table 5.7 | Total Residual Risk for a Residential Adult at the Miami-Erie Canal Area |
| Table 5.8 | Background Risk for a Residential Adult at the Miami-Erie Canal Area |
| Table 5.9 | Incremental Residual Risk for a Residential Adult at the Miami-Erie Canal Area |
| Table 5.10 | Total Residual Risk for a Residential Child at the Miami-Erie Canal Area |
| Table 5.11 | Background Risk for a Residential Child at the Miami-Erie Canal Area |
| Table 5.12 | Incremental Residual Risk for a Residential Child at the Miami-Erie Canal Area |
| Table 5.13 | Total Residual Risk for an Off-Site Construction Worker at the Miami-Erie Canal Area |
| Table 5.14 | Background Risk for an Off-Site Construction Worker at the Miami-Erie Canal Area |
| Table 5.15 | Incremental Residual Risk for an Off-Site Construction Worker at the Miami-Erie Canal Area |
| Table 5.16 | Total Miami-Erie Canal Residual Risk Evaluation Summary Table |
| Table 5.17 | Background Miami-Erie Canal Risk Evaluation Summary Table |
| Table 5.18 | Incremental Miami-Erie Canal Residual Risk Evaluation Summary Table |


## LIST OF FIGURES


| | |
|---|---|
| Figure 1.1 | Mound Plant Vicinity Map |
| Figure 1.2 | Miami-Erie Canal Area Map |
| Figure 3.1 | Conceptual Site Model for the Miami-Erie Canal RRE |


## LIST OF APPENDICES


| | |
|---|---|
| Appendix A | Miami Erie Canal Database (Provided on 3.5 inch disk provided with this report) |

## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ATSDR | Agency for Toxic Substances Disease Registry |
| ARAR | Applicable or Relevant and Appropriate |
| BVA | Great Miami Buried Valley Aquifer |
| CDC | Centers of Disease Control and Prevention |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| COPCs | constituents of potential concern |
| CSF | cancer slope factor |
| DOE | Department of Energy |
| EPA | U.S. Environmental Protection Agency |
| EPC | exposure point concentration |
| FFA | Federal Facilities Agreement |
| GV | Guideline Values |
| HEAST | Health Effects and Assessment Summary Tables |
| HI | hazard index |
| HQ | hazard quotient |
| IEUBK | Integrated Exposure Uptake Biokinetic Model for Lead in Children |
| IRIS | Integrated Risk Information System |
| LOAEL | lowest observed adverse effects level |
| NCEA | National Center for Environmental Assessment |
| NCP | National Oil and Hazardous Substances Pollution Contingency Plan |
| ND | Not detected |
| NOAEL | no observed adverse effect level |
| Ohio EPA | Ohio Environmental Protection Agency |
| OSC | On-Scene Coordinator |
| OU | Operable Unit |
| PAH | polycyclic aromatic hydrocarbon |
| PCB | polychlorinated biphenyls |
| ppm | parts per million |
| PRS | Potential Release Site |
| QAPjP | quality assurance project plan |
| RAGS | Risk Assessment Guidance for Superfund |
| RfD | reference dose factor |
| RfC | reference concentration factor |
| RME | reasonable maximum exposure |
| RRE | residual risk evaluation |
| RREM | residual risk evaluation methodology |
| SVOCs | semi-volatile organic compounds |
| TPH | total petroleum hydrocarbon |
| TIC | tentatively identified compound |
| UCL | upper confidence limit |
| VOCs | volatile organic compounds |

# Miami-Erie Canal Human Health Residual Risk Evaluation

## Executive Summary

This report was prepared using the Mound 2000 Residual Risk Evaluation Methodology (DOE 1997a)(RREM) to quantify the potential for cancer and other non-cancer health effects from long-term, low-level exposures to site-related contaminants in the Miami-Erie Canal area. A Residual Risk Evaluation (RRE) evaluates human health risks associated with residual levels of contamination remaining within an area to ensure that future users of the land will not be exposed to unacceptable contaminant levels. Residual risks were calculated for total risk, background risk and incremental risk for the most likely and most conservative scenarios for the canal property. These scenarios included current and future recreational user (adult and child), a hypothetical future resident (adult and child) and a hypothetical adult off site construction worker. These scenarios included potential exposure to surface and subsurface soil via incidental ingestion, dermal contact, inhalation of dust and volatile organic compounds and external radiation exposure.

Total, background and incremental non-cancer risks for all receptors in all scenarios were below the target hazard level. This suggests that non-carcinogenic risks are within acceptable levels. Total, background and incremental carcinogenic risks for the recreational scenario (adult and child), the residential child and the adult off site construction worker fell within the acceptable risk range of $10^{-4}$ to $10^{-6}$ for both current and future scenarios. Background carcinogenic risks for the hypothetical adult residential scenario were within the acceptable carcinogenic risk range. Total and incremental carcinogenic risk for the hypothetical adult resident slightly exceeded the acceptable risk range of $10^{-4}$ to $10^{-6}$.

Total cancer risk for the residential adult was $3.1 \times 10^{-4}$. Of this risk, $1.2 \times 10^{-4}$ or 39% was due to dermal exposure to benzo(a)pyrene. An additional $1.5 \times 10^{-4}$ or 48% of this risk is due to external exposure to radium-226. Incremental cancer risk was $2.1 \times 10^{-4}$. Of this risk, $1.2 \times 10^{-4}$ or 60% was due to dermal exposure to benzo(a)pyrene. An additional $5.0 \times 10^{-5}$ or 24% of this risk is due to external exposure to radium-226.

PAHs are ubiquitous in many environments, particularly along railroad right-of-ways, such as the one running through the canal area. Radium-226 is a naturally occurring radioisotope that is present in background soils.

# 1.0 INTRODUCTION

The U.S. Department of Energy's (DOE) Mound Plant is located on a 306-acre parcel of land within the City of Miamisburg, Ohio, about 10 miles southwest of Dayton, Ohio. Figure 1.1 shows the vicinity of the Mound Plant. The plant is located approximately 2,000 feet east of the Great Miami River and partially overlies the Great Miami Buried Valley Aquifer (BVA). Since 1948, Mound has operated as a research, development and production facility in support of DOE's weapons and energy programs. Mound's past weapons program mission included process development, production engineering, manufacturing, and surveillance of detonators, explosives, and nuclear components. Mound's current mission is to support DOE's efforts in environmental management and to transition the site, in cooperation with the City of Miamisburg, from a cold-war production facility to commercial or industrial use. The Miami-Erie Canal area, the subject of this report, will be returned to recreational use as a city park. A map of the Miami-Erie Canal area is included as Figure 1.2.

This report was developed using the Mound 2000 Residual Risk Evaluation Methodology (RREM) (DOE 1997a) to quantify the potential for cancer and other non-cancer health effects from long-term, low-level exposures to site-related contaminants in the canal area also known as Operable Unit 4 (OU-4). A Residual Risk Evaluation (RRE) evaluates human health risks associated with residual levels of contamination remaining within an area to ensure that future users of the land will not be exposed to contaminant levels that would pose unacceptable risks. The RRE results will be used, together with Applicable or Relevant and Appropriate Requirements (ARARs), to determine the need for additional site remediation or to demonstrate that land is ready for public use.

## 1.1 Purpose Of Residual Risk Evaluation

The objective of the Miami-Erie Canal area RRE is to assess risks associated with residual levels of contamination that exist after completion of the removal action. Although the RRE method was developed specifically for use at Mound, the method is consistent with the CERCLA baseline risk assessment method to ensure that future users of the land will not be exposed to contaminant levels that would pose unacceptable risks.

## 1.2 Scope of the Miami-Erie Canal RRE

The RRE for the Miami-Erie Canal area includes an evaluation of human health risk for potential residual contamination in the area following the completion of the removal action documented in the On-Scene Coordinator (OSC) Report (DOE 1999). The canal area RRE was completed using the Mound 2000 RREM (DOE 1997a). Since the canal area is currently used for recreation purposes, residual risks were evaluated for the recreational scenario. Although residential use of the canal area is unlikely, given existing land use restriction, a residential risk calculation was performed to evaluate the need for additional restrictions. Since the RREM does not provide exposure assumptions or intake equations for the residential or recreational use scenarios the needed values were drawn from the "Risk Based Guideline Values, Mound Plant, Miamisburg, Ohio, March, 1997, Final Rev 4" (DOE 1997b).

Residual risks were calculated for total risk, background risk and incremental risk. Total risk was calculated using the total concentration of the constituents of potential concern (COPCs) detected in the canal area. Background risk was calculated based on background levels of the COPCs and incremental risk was calculated using the difference between total and background levels. Incremental risk can be used to assess the increase in risk above background levels due to Mound Plant operations.

## 1.3 Organization of Report

The RREM provides a framework for evaluating potential human health risks associated with residual levels of contamination. Although the RREM is similar to a traditional CERCLA baseline risk assessment, it serves a different purpose and, therefore, is not identical. The RREM consists of five elements, including:

1. identification of the contaminants to be evaluated,
2. exposure assessment,
3. toxicity assessment,
4. risk characterization,
5. and evaluation of potential cumulative risks.

The following sections describe each of these elements in more detail starting with Section 2.0, Data Compilation and Evaluation, which describes the methods used to compile Miami-Erie Canal area data and identify contaminants to be evaluated in the RRE. Section 3.0, Exposure Assessment, summarizes the

pathways through which hazardous substances may reach potential receptors and intake assumptions used to quantify exposure. In Section 4.0, Toxicity Assessment, exposure point concentrations, intake equations and toxicological reference values are presented. Information from the exposure assessment is combined with information from the toxicity assessment to characterize human health risks in Section 5.0, Risk Characterization. Section 6.0, Uncertainties, presents some of the sources of uncertainty inherent in risk assessments and in the RRE. Section 7.0, References, contains a list of all documents cited in this report.

## 2.0 DATA COMPILATION AND EVALUATION

Identification of contaminants to be carried through the RRE calculations is a multi-step process beginning with the identification of all contaminants detected in the area and then eliminating contaminants based upon a set of established screening criteria described in the RREM.

All available sampling data were compiled for use in the Miami-Erie Canal RRE. Newer data was used to supplement, rather than supersede older data except when older data described materials that had subsequently been removed from the area. In this case, the older data no longer represent site conditions and were, therefore, not used in the RRE. Sampling data obtained from the Mound Soil Screening Facility was used except in the case where a sample was split and analyzed by both the Mound Soil Screening Facility and a commercial analytical laboratory. In such cases, the value from the commercial analytical laboratory was used to take advantage of the greater precision available from the commercial analytical laboratory. Data used to characterize the Miami-Erie Canal area were drawn from the following data sets:

| DATA SET DESCRIPTION | REFERENCE |
|---|---|
| Canal Removal Action Verification Data<br>*Includes samples from South Pond, Runoff Hollow, Overflow Creek, and portions of the Plant Drainage Ditch between the plant boundary and the canal* | On-Scene Coordinator Report, OU-4 Miami-Erie Canal Removal Action, Final, June, 1999 |
| Water Park/Tennis Court Sampling Results<br>*Samples obtained in park area as part of previous investigations* | OU-9 Regional Soils Investigation Report, August 1995, Final, Revision 2<br><br>Mound Laboratory Environmental Plutonium Study 1974 (MLM-02249), September 1975 |
| Twin 60s Sediment Sampling | PRS 416 Data Package, Unpublished |

The following data sets were excluded because they represent areas remediated by removal actions.

| DATA SET DESCRIPTION | REFERENCE |
|---|---|
| Original Rogers Study | "Mound Laboratory Environmental Plutonium Study (1974). Samples from the park vicinity were included in the RRE. |
| Special Canal Sampling, SAIC 1992 | |
| Agency for Toxic Substances Disease Registry (ATSDR) | "Health Consultation, DOE Mound Plant" (1994) |

The ATSDR report included samples obtained from the park area, however, insufficient information about the analytical techniques (e.g. minimum detectable activities, sample quantitation limits) was provided to allow for data verification, so the data were not included in the RRE.

## 2.1 Data Quality Assessment

Samples were collected and analyzed according to the methods outlined in the OU9 Quality Assurance Project Plan (QAPjP) (DOE 1993a) and the OU5 QAPjP (DOE 1993b). All data used in the risk assessment have undergone Quality Assurance/Quality Control (QA/QC) evaluation and data validation in accordance with the requirements described in the OU9 QAPjP (DOE 1993a) and the OU5 QAPjP (DOE 1993b).

## 2.2 Environmental Media Considered and Data Availability

Field investigations conducted for the canal area are listed above. Samples were analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides and polychlorinated biphenyls (PCBs), dioxins/dibenzofurans, metals, common anions, total petroleum hydrocarbons (TPH), and radionuclides. Environmental media that were evaluated include surface soil (0-2 feet below land surface), subsurface soil (>2 feet below land surface), and sediment. During the canal area removal action, approximately 38,000 $yds^3$ of soil were removed. Only 16 out 15,214 analyses were run on soil collected more than two feet below land surface. Following soil removal, clean soil was brought in to backfill excavated areas so samples collected at 0-2 feet below land surface may now have an additional 1-2 feet of clean fill over them.

Although it is possible that contamination in the canal area may leach through soil to reach the BVA, for the canal area RRE it was assumed that residential, recreational and off site construction worker receptors

would drink municipally supplied water, not water obtained from the BVA. Potential risks due to exposure to BVA groundwater will be assessed prior to completion of the final Mound Record of Decision.

Canal area drainage ways contain water only during heavy rain events and therefore, are dry most of the time. Due to intermittent flow in the canal area ditches, receptors in the canal area were assumed to come into contact with sediments with the same frequency, as they would surface soils. Therefore, the exposure assumptions for soils and sediments are the same and these media have been merged into one data set for the RRE. Merging the soil and sediment data sets increased the statistical power of the data set by increasing the number of observations. Since the same exposure assumptions were used to estimate exposures to sediment and soil, combining the data sets does not reduce the overall estimate of risk but does simplify the presentation of RRE results.

## 2.3 Data Analysis

For each constituent detected in Miami-Erie Canal area soils, the 95% upper confidence limit of the mean (UCL) was calculated to estimate the concentration that receptors in the area may be exposed to. This is known as the Exposure Point Concentration or EPC. The 95% UCL was calculated in accordance with Mound 2000, Gilbert's *Statistical Methods for Environmental Pollution Monitoring* (Gilbert 1987), and the *Supplemental Guidance to RAGS: Calculating the Concentration Term* (EPA, 1992a). Before calculating the 95% UCL, the distribution of the data set was determined. If the data were found to be normally distributed, the EPC was calculated as the 95% UCL of the arithmetic mean of the data, using the Student's t-statistic (EPA 1992a). If the data were found to be log normally distributed, the EPC was calculated as the 95% UCL using the H-statistic (EPA 1992a).

The 95% UCL on the arithmetic mean for normal data sets was calculated as follows:

$$95\% \text{ UCL} = \text{Mean} + t(s/n^{1/2})$$

Where:

UCL= upper confidence limit,
t = t statistic (Table A2, Gilbert, 1987),
s = standard deviation, and
n = number of observation in the data set

The 95% UCL equation of the arithmetic mean for log-normal data sets was calculated as follows:

$$95\% \text{ UCL} = e^{\text{Mean}+H(s/(n-1)^{1/2})}$$

Where:

UCL = upper confidence limit,
H = H statistic (Table A12, Gilbert, 1987),
s = standard deviation, and
n = number of observations in the data set
e = constant

If the 95% UCL exceeded the maximum value observed in the sampling results , the maximum value was used as the EPC for that constituent (whether the data were normally or log normally distributed). For both chemical and radiological constituents "not detected" (ND) results were treated as one-half the limit of detection and included in the calculations of the mean and UCL values. Blind field duplicates were collected to assess variability in the sampling process. Duplicate samples were used in the data quality assessment but were not included in the calculation of the exposure point concentrations. If a data set had less than twenty observations (n<20) the maximum detected concentration was used as the EPC. For radionuclides, zero or negative results with no detection limits were excluded from the data set. Data qualified as "J", or estimated values at concentrations less than the detection limit, were evaluated as half the detection limit. For "J" data, which was greater than the detection limit or reported without the sample detection limit, the value was used as reported. Samples reported as ND or zero with no detection limit were not utilized in calculating a 95% UCL. Data flagged with an "R", meaning rejected, were also not used in calculating the EPC.

## 2.4 Data Screening Process

All constituents that were detected one or more times were listed in constituent summary tables and sorted by media and depth where they were detected. The constituent screening methods described below were then used to generate a final list of constituents of potential concern (COPCs). The constituent summary tables also provide maximum detected concentrations, the range of contaminant detection limits, the frequency of detection and the decision and rationale to include or exclude a constituent from further consideration in the RRE. The following section describes how COPCs were selected. Tables 2.1, 2.2 and 2.3 identify the COPCs for the recreational, residential, and off site construction worker scenarios, respectively.

### 2.4.1 Screening Constituents Based on Background

Site-specific background concentrations described as the Upper 95% Tolerance Limit of the background sample results for each constituent have been developed for Mound Plant soils (DOE 1997a) and are presented in the RREM. Constituents with a maximum concentration detected exceeding their level in background were identified as COPCs and carried to the next step of the RRE. Constituents with maximum concentrations less than their background concentration were not carried though the RRE. If no background value was available for a particular constituent (e.g., many organic compounds), the constituent was carried through to the next step of the RRE.

In cases where the 95% UCL of the arithmetic mean fell below the maximum detected value, the 95% UCL was compared to background to determine whether the 95% UCL was below background. If the 95% UCL was below the background value for the constituent, the constituent was not identified as a COPC in the RRE. Including constituents whose 95% UCL is less than background would cause the incremental risk to be a "negative" risk. Eliminating these constituents focuses the RRE on constituents detected above background.

### 2.4.2 Screening Constituents Based on Guideline Values

Soil constituents present at concentrations that exceed background concentration were compared to Risk-Based Guideline Values (GVs) for the Mound Facility (DOE 1997b). GVs are media-specific concentrations of constituents that correspond to specific human health risk levels for specified exposure scenarios. GVs were developed for recreational, residential and off site construction worker scenarios (see DOE 1997b for the detailed derivation of Guideline Values). Recreational, residential and off site construction worker GVs, were used to screen COPCs for retention in the quantitative risk assessment.

The GVs used to screen COPCs were developed specifically for Mound, and were approved by the DOE, the U.S. EPA, and Ohio EPA. The GVs correspond to the $10^{-6}$ risk level for carcinogenic constituents and radionuclides, and to a Hazard Quotient of one for each non-carcinogen constituent. A $1 \times 10^{-6}$ risk level represents an incremental increase of one chance in one million of developing cancer as a result of exposure to the GV concentration. Since the target risk level for carcinogenic constituents is a range of $10^{-4}$ to $10^{-6}$, as specified in the NCP, screening COPCs against the GV is protective. For non-carcinogenic constituents, the Hazard Quotient (HQ), or the ratio of the intake of a single constituent to its reference dose, is used to define

acceptable risk. When multiple COPCs occur in the same area, the HQs are summed to derive a Hazard Index (HI). The target threshold for non-carcinogenic constituents is a HI of less than or equal to one. The GVs for non-carcinogenic constituents were calculated for a HI of one. To account for the possibility of more than one non-carcinogenic constituent, COPC's were screened using 1/10 the GV for non-carcinogenic constituents. Carcinogenic or radioactive constituents that exceed their GVs and non-carcinogenic constituents that exceed one-tenth of their GV were carried to the next step of the RRE.

### 2.4.3 Screening Constituents Based on Frequency of Detection

Constituents detected at concentrations above Mound background levels and above applicable GVs were next evaluated for their frequency of detection. The Risk Assessment Guidance for Superfund (RAGS) Part A (EPA, 1989) states that infrequently detected compounds may be artifacts in the data due to sampling, analytical, or other problems, and therefore may not be site-related. Compounds that were detected infrequently in all media, and not detected at high concentrations in any medium were eliminated from further consideration by the RRE. No compounds were eliminated on the basis that they were unrelated to historical operations conducted within the canal area.

Infrequent detection was defined as five percent or less. This is equivalent to one detect in 20 samples. If there were an insufficient number of samples (e.g. less than 20) to determine whether the frequency of detection is five percent or less, the contaminant was not eliminated on the basis of frequency of detection. Other relevant factors such as whether the constituent is expected to be present based on historical data or degradation products of known contaminants also ~~was~~ were considered in the decision to include or exclude infrequently detected constituents.

### 2.4.4 Screening Constituents Based on Essential Human Nutrients

According to RAGS Part A (EPA 1989): "Chemicals that are (1) essential human nutrients, (2) present at low concentrations (i.e., only slightly elevated above naturally occurring levels), and (3) toxic only at very high doses (i.e., much higher than those that could be associated with contact at the site) need not be considered further in the quantitative risk assessment." Inorganic analytes meeting this description were not carried through the RRE. Calcium, chloride, iron, magnesium, potassium, and sodium are considered essential nutrients to humans. These compounds were detected in the canal area at levels below or slightly elevated above

background and are toxic only at very high doses. Concentrations of these compounds in on-site media would not be expected to result in intakes associated with a toxic response. Therefore, these compounds were eliminated as COPCs for the canal area.

### 2.4.5 Additional Screening Procedures

In accordance with the RREM, additional screening procedures also were used to evaluate Miami-Erie Canal area constituents. For example, in accordance with EPA's Functional Guideline for Organics (EPA 1988) if a blank contains measurable levels of a common laboratory contaminant, then the associated sample results were considered as positive results only if the concentration in the samples exceeded ten times the concentration in the blank. If the concentration of a common laboratory contaminant was less than ten times the blank concentration, the constituent was considered to be an artifact of laboratory handling and was not included in the RRE. Common laboratory contaminants include acetone, 2-butanone, methylene chloride, toluene and phthalate esters.

Given the high degree of uncertainty in both the identity and reported concentrations of tentatively identified compounds (TICs), these constituents were not carried through the RRE. Relatively few TICs were reported in the Miami-Erie Canal database and historical information does not suggest that a particular TIC should be present.

## 3.0 EXPOSURE ASSESSMENT

The goal of the RRE exposure assessment is to estimate the type and magnitude of contaminant exposures that may occur under current conditions with the area being used for recreational purposes and in the future assuming that the area is developed for residential use. The information gathered in the exposure assessment is integrated with toxicity information to characterize potential risks associated with exposure to residual contamination in the canal area.

### 3.1 Characterization of Exposure Setting

The Miami-Erie Canal area is located west of the Mound Plant between the Conrail Railroad right-of-way to the east and Dayton-Cincinnati Road to the west. The area includes: (1) the abandoned Miami-Erie Canal; (2) Overflow Creek which connects the canal to the Great Miami River; (3) a drainage ditch from the

site boundary to the canal; (4) Runoff Hollow between the Conrail tracks and the Mound Plant; and (5) South Pond in the Miamisburg City Park. Currently, land use in the canal area is a combination of city park, Conservancy District, and railroad right-of-way.

Historic operations and accidental releases from the Mound Plant have resulted in the discharge of contamination into the Miami-Erie Canal area. This contamination consisted primarily of plutonium and tritium (DOE 1999). An underground pipeline rupture at the Mound Plant in 1969 resulted in the release of plutonium-238 in a nitric acid solution. During pipeline remediation, a rainstorm washed contaminated soil to the canal and, to a lesser extent, to Overflow Creek and the Great Miami River. Plutonium-contaminated soils were deposited as sediments in the canal. Tritium contamination of canal area soils is largely due to the pre-1970 disposal of tritiated process liquids. Some of the tritiated water released to the canal area may have infiltrated and migrated to the regional aquifer known as the Buried Valley Aquifer (BVA), however, groundwater in the canal area is currently not used.

Several investigations and one removal action have been performed in the Miami-Erie Canal area since the pipeline break in 1969. For a complete chronology of Miami-Erie Canal activities, see the OSC Report (DOE 1999). Restoration activities in the Miami-Erie Canal area have included the excavation and removal of approximately 38,000 cubic yards of soil. The removal action clean-up goal was to remove plutonium-238, with a resulting 95% UCL of the mean concentrations less than 75 pCi/g, and to remove all known spots of contamination greater than 150 pCi/g (DOE 1999). These goals were established by a focus group of stakeholders to be consistent with risk-based GVs for the recreation use scenario. The OSC report (DOE 1999) demonstrated that the verification sampling results confirm that these goals were achieved. Following completion of the Miami-Erie Canal restoration project, 1-2 feet of clean soil was brought in to replace soil that had been removed. The clean soil was graded, grass was seeded, trees were planted, and a bike path was constructed. The canal property will once again be used as a City of Miamisburg park after a DOE easement is canceled.

### 3.2 Identifying Exposure Pathways

Although many exposure pathways are possible, this RRE focuses only on the likely pathways within expected recreational land use. Pathways for residential and off site construction worker use were added to evaluate the need for additional land use restrictions. When identifying exposure pathways it is important to

keep in mind the four elements of an exposure pathway. An exposure pathway consists of: (1) a source of chemical release, (2) a transport media, (3) a point of potential human contact with the contaminated media, and (4) an exposure route (e.g. ingestion). If any of these elements is missing or eliminated, the pathway will be incomplete and exposure will not occur.

A graphical representation of the exposure pathways identified for potential receptors is included in the conceptual site model for the Miami-Erie Canal (Figure 3.1). The conceptual site model summarizes the pathways that hazardous substances may take to reach potential receptors. Exposure assumptions used to evaluate potential exposure pathways were drawn from the Mound Plant *Risk-Based Guideline Values* (DOE 1997b) and are based on the reasonable maximum exposure (RME) scenario recommended by RAGS Part A (EPA 1989). The RME scenario is a conservative depiction of potential exposure conditions intended to represent the maximum exposure conditions that one might reasonably expect to occur at the site. RME assumptions were used to characterize risk for all potential canal area receptors. Exposure assumptions used to quantify contaminant exposures are summarized in Table 3.1.

Risk Assessment Guidance for Superfund

### 3.3 Identifying Exposure Scenarios

Residual contamination in the Miami-Erie Canal area was evaluated for three potential use scenarios. Residual contamination in the canal area was evaluated for recreational adults and children, for residential adults and children and for an adult off site construction worker. Recreational use is the intended use. Residential use of the canal area is unlikely, however it was included to determine whether land use restrictions were needed. The construction worker was also included to determine whether land use restrictions were needed. All three scenarios assume exposure to soil and sediment.

#### 3.3.1 Recreational Adult and Child Scenarios

Since recreational activities are planned within the canal area, recreational adults and children were identified as potential receptors. During recreational activities these receptors could be exposed to residual contamination present in soil 0-2 feet below land surface including sediment. It was assumed that recreational users would use municipally supplied water. The recreational users were assumed to be on the property four hours per day, 52 days per year over a six year period for children and over a 24 year period for adults. Adults were assumed to weigh 70-kilograms while children were assumed to weigh 15 kilograms.

Current and future exposure scenarios for the recreational scenario are identical. Exposure pathways evaluated for the recreational user for both current and future scenarios, include:

- incidental ingestion of sediment or soil 0-2 feet below land surface;
- external exposure to ionizing radiation from radionuclides in sediment or soil 0-2 feet below land surface;
- dermal contact with contaminants in sediment or soil 0-2 feet below land surface;
- inhalation of airborne contaminated soil particulates; and
- inhalation of volatile emissions from soil.

The parameters used to evaluate these pathways and their references are provided in Table 3.1.

### 3.3.2 Residential Adult and Child Scenarios

In order to calculate risk under a residential use scenario, hypothetical residents were assumed to live at the site for 24 years and hypothetical resident children were assumed to live at the site for 6 years. Allowing for a two-week vacation, site residents have an exposure frequency of 350 days/year. During home construction, excavation for basement construction could bring subsurface soil to the land surface. Therefore, potential direct soil exposure pathways were evaluated assuming that site residents could be exposed to residual contamination present in sediment or soil at any depth. It was assumed that canal area residents would use municipally supplied water for potable supply.

There are currently no site residents, so the site resident scenario was conducted for a hypothetical future use. The exposure pathways evaluated for the future site resident include:

- incidental ingestion of sediment or soil at or below land surface;
- external exposure to ionizing radiation from radionuclides in sediment or soil at or below land surface;
- dermal contact with contaminants in sediment or soil at or below land surface;
- inhalation of airborne contaminated soil particulates; and
- inhalation of volatile emissions from soil.

The parameters used to evaluate these pathways and their references are provided in Table 3.1.

### 3.3.3 Off Site Construction Worker Scenario

Since it is reasonable to assume that construction activities could occur within the canal area, adult construction workers were identified as potential receptors. During construction activities these receptors could be exposed to residual contamination present in soil at or below land surface. Potential exposure pathways include incidental soil ingestion, external radiation exposure, and inhalation of airborne dust and vapors. Off Site Construction workers were assumed to be on the property 8 hours per day, 250 days per year over a 1-year period. Since construction workers are assumed to be adults, a body weight of 70-kilogram was used to assess exposure to chemical contaminants. It was assumed that canal area residents would use municipally supplied water for potable supply.

Current and future exposure scenarios for the construction worker scenario are identical. Exposure pathways evaluated for the construction worker for both current and future scenarios, include:

- incidental ingestion of soil at or below land surface;
- external exposure to ionizing radiation from radionuclides in soil at or below land surface;
- inhalation of airborne contaminated dust;
- inhalation of volatile emissions from soil;

The parameters used to evaluate these pathways and their references are provided in Table 3.1.

## 3.4 Exposure Point Concentrations

Exposure point concentrations (EPC) are the concentrations of contaminants available to human receptors at the point of contact. If the data were found to be normally distributed, the EPC for the RRE was calculated as the 95% UCL of the arithmetic mean of the data, using the student's t-statistic. If the data were found to be log normally distributed, the RME estimate was calculated as the 95% UCL using the H-statistic (EPA 1992a). A detailed description of these calculations can be found in Section 2.3.

Only surface soil data (0-2 feet below land surface) ~~was~~ were used to calculate the exposure point concentration for the recreational user. Recreational users are assumed to ~~spend most of their time riding bikes or hiking and~~ have ~~having~~ only limited contact with surface soil or sediment. During home construction subsurface soils could be brought to land surface. Therefore the exposure point concentration for the hypothetical off site

construction worker and future site resident scenario was calculated using sediment and soil samples collected at any depth. Given the low number of subsurface samples collected, the inclusion of subsurface soil had little to no effect on EPC for the residential scenario.

### 3.5 Human Intake Equations And Assumptions

This section presents the exposure equations and assumptions used to derive contaminant-specific intake estimates for the populations and exposure pathways evaluated in the risk assessment. The use of the intake equations presented in this section is in accordance with methods presented by EPA in RAGS Part A (EPA 1989) and the RREM presented in Mound 2000 (DOE 1997a). Exposure assumptions have been developed to represent high-end RME conditions. Exposure assumptions for each of the potential receptors, and corresponding guidance or rationale used in this assessment are presented in Table 3.1.

There is a fundamental difference in the measurement of exposures from chemical contaminants as compared to radionuclide contaminants. For chemicals, exposure generally refers to the intake (e.g., inhalation, ingestion, dermal exposure) of the chemical, expressed in units of mg/kg-day. Toxicity values for chemicals are generally expressed in these terms; therefore, the product of the intake estimate with the toxicity value yields a risk value. Radionuclide intake is typically expressed in units of activity (i.e., bequerel [Bq] or curie [Ci]) rather than mass. In addition, dose has a different meaning for radionuclides than for chemicals since adverse effects are related to ~~rate~~ decay rather than amount or mass. For radionuclides, dose is equal to the energy imparted to a unit mass of human tissue. Despite these differences the risk due to chemical and radiological contaminants have been summed in the RRE summary tables (Table 5.16-5.18)

The approach used to estimate intake for chemical contaminants largely applies to radionuclides. However, there are a few key differences in the methods. For example, in addition to the ingestion, inhalation and direct contact pathways considered for chemical contaminants, external exposure to penetrating radiation was also evaluated for radionuclides. Equations for estimating the intake of radionuclides have been modified by omitting the body weight and averaging time from the denominator. This is done because radiation exposure assessments do not end with the calculation of intake, but use dose conversion factors to estimate dose equivalents to specified organs.

Oral and inhalation intakes are expressed as the amount of chemical at the exchange boundary (e.g., skin, lungs, intestine) that is available for absorption. These intakes are not equivalent to the absorbed dose (the amount of chemical actually absorbed into the blood stream). Dermal doses are expressed as estimates of absorbed dose. The toxicological reference values used to calculate risk have been adjusted to account for this difference; however, this discrepancy is a source of uncertainty when comparing or combining dermal doses with intakes from other exposure routes.

Exposure to soil and sediment through incidental ingestion was evaluated for recreational users under current and future land use scenarios and for future off site construction workers and residents. Intakes for the chemical contaminants in soil/sediment ingestion pathway were estimated by using the following equation:

$$Intake\ (mg/kg\text{-}day) = \frac{C_{so} \times IR \times FI \times EF \times ED \times CF}{BW \times AT}$$

Where:

| | | |
|---|---|---|
| $C_{SO}$ | = | Contaminant concentration in soil/sediment (mg/kg) |
| IR | = | Ingestion rate (mg/day) |
| FI | = | Fraction ingested from contaminated source (1.0) (unitless) |
| EF | = | Exposure frequency (days/year) |
| ED | = | Exposure duration (years) |
| CF | = | Conversion factor ($10^{-6}$ kg/mg) |
| BW | = | Body weight (kg) |
| AT | = | Averaging time for cancer and non-cancer effects (days) |

Radionuclide intakes for the soil/sediment via incidental ingestion was estimated by using the following equation:

$$Intake\ (pCi) = C_{so} \times IR \times FI \times EF \times ED \times CF$$

Where:

| | | |
|---|---|---|
| $C_{SO}$ | = | Radiological activity in soil/sediment (pCi/g) |
| IR | = | Ingestion rate (mg/day) |
| FI | = | Fraction ingested from contaminated source (1.0) (unitless) |
| EF | = | Exposure frequency (days/year) |
| ED | = | Exposure duration (years) |
| CF | = | Conversion factor ($10^{-3}$ kg/mg) |

Dermal exposure to soil and sediment was assumed to occur simultaneously with incidental ingestion exposure. Exposure to soil and sediment through dermal contact was evaluated for recreational users under current and future land use scenarios, and for future off site construction workers and residents. Soil/sediment dermal exposures were evaluated for recreational users under current and future land use scenarios. Chemical intakes for the soil/sediment via dermal exposure were estimated using the following equation:

$$Absorbed\ Dose\ (mg/kg\text{-}day) = \frac{C_{so} \times SA \times AF \times ABS \times EF \times ED \times CF}{BW \times AT}$$

Where:

| | | |
|---|---|---|
| $C_{SO}$ | = | Chemical concentration in soil/sediment (mg/kg) |
| SA | = | Skin surface area available for contact ($cm^2$/day) |
| AF | = | Soil to skin adherence factor (1) (mg/$cm^2$) |
| ABS | = | Dermal absorption factor (unitless) |
| EF | = | Exposure frequency (days/year) |
| ED | = | Exposure duration (years) |
| CF | = | Conversion factor ($10^{-6}$ kg/mg) |
| BW | = | Body weight (kg) |
| AT | = | Averaging time for cancer and non-cancer effects (days) |

Exposure to external radiation from radionuclides in soils/sediments was estimated by using the following equation:

$$Absorbed\ Dose\ (pCi/g) = Cso \times ED \times Te \times (1\text{-}Se)$$

Where:

| | | |
|---|---|---|
| $C_{SO}$ | = | Radionuclide activity in soil/sediment (pCi/g) |
| ED | = | Exposure duration (years) |
| Te | = | Gamma exposure time factor (hrs/hrs) |
| Se | = | Shielding factor (unitless) |

Unlike inhalation, ingestion, and dermal exposure, the external radiation exposure term is defined as an equivalent radionuclide concentration in soil/sediment that an onsite receptor would be exposed to for a particular exposure duration. This exposure term is adjusted for exposure time and shielding. For the canal area RRE a default shielding factor of 20% was assumed. These assumptions provide for a conservative estimate of external radiation exposure.

Intake of soil/sediment (fugitive dust) via inhalation was evaluated for recreational users under current and future land use scenarios, and for future off site construction workers and residents. The intake equation for chemical contaminants for this pathway is provided below:

$$Intake\ (mg/kg\text{-}day) = \frac{C_{so} \times IR \times ET \times EF \times ED}{PEF \times BW \times AT}$$

Where:

| | | |
|---|---|---|
| $C_{SO}$ | = | Contaminant concentration in soil/sediment (mg/kg) |
| IR | = | Inhalation rate ($m^3$/hr) |
| ET | = | Exposure time (hrs/day) |
| EF | = | Exposure frequency (days/year) |

| | | |
|---|---|---|
| ED | = | Exposure duration (years) |
| PEF | = | Particulate emission factor (4.63 x $10^9$ $m^3$/kg, EPA default value) |
| BW | = | Body weight (kg) |
| AT | = | Averaging time for cancer and non-cancer effects (days) |

The intake equation for radionuclide contaminants via inhalation of fugitive dust was estimated using the following equation:

$$Intake\ (pCi) = \frac{C_{so} \times IR \times ET \times EF \times ED}{PEF}$$

Where:

| | | |
|---|---|---|
| $C_{SO}$ | = | Radiological activity in soil/sediment (pCi/g) |
| IR | = | Inhalation rate ($m^3$/hr) |
| ET | = | Exposure time (hrs/day) |
| EF | = | Exposure frequency (days/year) |
| ED | = | Exposure duration (years) |
| PEF | = | Particulate emission factor (4.63 ~~4.28~~ x $10^9$ $m^3$/g, EPA default value) |

The PEF relates the concentration of the contaminant in soil/sediment to the concentration of respirable particles in the air from fugitive dust emissions. These emissions result from wind erosion. The default value of 4.63 x $10^9$ $m^3$/kg was taken from RAGS, Volume I, Part B (EPA 1991b) and represents a surface with unlimited erosion potential.

Volatilization of chemical contaminants from soils/sediments may result in exposures via inhalation for recreational users; however, no volatile COPCs were identified in the canal area. Therefore, this pathway was not evaluated for chemical constituents.

## 4.0 TOXICITY ASSESSMENT

The objectives of the toxicity assessment are to identify and select toxicological values for use in estimating the significance of the exposure and to evaluate potential adverse effects associated with exposure to compounds detected in the Miami-Erie Canal area. The RRE for the canal area evaluated chronic exposures. The RRE utilized methods recommended by EPA for evaluating human cancer and non-cancer health effects resulting from exposure to the COPCs. The toxicity criteria used in the RRE were obtained from the most current update of the EPA Integrated Risk Information System (IRIS) or, if the information was not available in IRIS, the EPA Health Effects Assessment Summary Tables (HEAST). IRIS is an electronic database containing the most current descriptive and quantitative EPA regulatory information on chemical and radiological constituents. Constituent files maintained in IRIS contain information related to non-carcinogenic and carcinogenic health effects of constituents. HEAST is a published reference, updated periodically by EPA. It contains toxicity information and values for constituents from health effects documents and profiles. Other sources for toxicity information include the National Center for Environmental Assessment (NCEA) Provisional Values, ATSDR Toxicology Profiles or EPA Criteria Documents. Table 4.1 presents a summary of toxicological criteria used along with the chemical-specific characteristics used to estimate dermal absorbed dose and the concentrations present in vapors or dust.

In assessing the potential for non-cancer health effects, EPA assumes that there is a threshold below which no adverse toxic effects are expected. For example, a toxic threshold would exist if a substance had no toxic effect at a certain level of exposure, but did have a toxic effect at a higher level. EPA derives and publishes reference doses (RfDs) and reference concentrations (RfCs) for use in evaluating adverse non-carcinogenic effects. These are estimates (with uncertainty spanning an order of magnitude or greater) of daily human exposures, including sensitive sub-populations, that may go without appreciable harmless effects during a lifetime (EPA 1989). EPA derives RfDs and RfCs for humans based on estimates of the no-observable-adverse-effect-level (NOAEL) or lowest-observable-adverse-effect-level (LOAEL) observed in test organisms.

Carcinogenesis, however, is generally thought to be a phenomenon without a threshold for effect (EPA 1989). The basis for this presumption is that an extremely low level of exposure to some carcinogens may result in chromosomal or enzyme changes leading to uncontrolled cellular proliferation or cancer. EPA does not therefore estimate an effect threshold for carcinogenic chemicals. EPA uses a two-part evaluation for

carcinogens. First the constituent is assigned a weight-of-evidence classification based on both epidemiological evidence of carcinogenic effects and laboratory tests conducted with animals. Then a cancer potency factor, or slope factor (CSF), is calculated. The slope factor is a plausible upper-bound estimate of the slope of the dose-response curve in the low dose range. In risk assessment, the cancer slope factor is used to estimate the excess lifetime probability of a carcinogenic effect occurring in exposed receptors.

## 4.1 Toxicity Values for Evaluating the Dermal Pathway

Toxicological reference values are available only for the oral and inhalation pathways and the majority of these values are based on intake (i.e., administered dose) rather than an absorbed dose. Because the intake equation for the dermal contact pathway calculates absorbed dose (by incorporating a dermal absorption factor or a permeability coefficient), it is necessary to convert the administered dose toxicity value to an absorbed dose toxicity value in order to calculate risk. For the Miami-Erie Canal RRE oral administered-dose toxicity values were adjusted using compound specific gastrointestinal absorption factors. For non-carcinogens, the administered dose toxicity value (i.e., the RfD) was multiplied by the gastrointestinal absorption factor. For carcinogens, the slope factor was divided by the gastrointestinal absorption factor.

## 4.2 Toxicity Assessment for Lead

Lead was identified as a COPC in the canal area, however, lead does not have toxicological reference values. A risk-based remediation goal for lead 400 parts per million (ppm) in soil was established by EPA based on the "Interim Guidance on Establishing Soil Lead Cleanup Levels at RCRA Facilities" (EPA, 1994a). The allowable concentration of 400 ppm lead in soil is supported by USEPA's Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) (USEPA, 1994b). The IEUBK predicts that 400 ppm lead in soil could cause a 6 year old resident child (averaged across the preceding 84 months) to have a probability of no greater than 5% of a blood lead level of 10 micrograms/deciliter ($\mu$g/dL) assuming exposure to surface soil and subsurface soil brought to the land surface. In children, a blood lead level of between 10 and 15 micrograms per deciliter ($\mu$g/dL) has been associated with a level at which no adverse effects would be expected (Centers for Disease Control and Prevention [CDC], 1985). Since the residential exposure scenario is more conservative than the recreational scenario, the acceptable level of 400 ppm lead is expected to be protective under both the recreational and residential scenarios.

## 5.0 RISK CHARACTERIZATION

This section presents the risk characterization for the Miami-Erie Canal area. Information from the exposure assessment (Section 3) is combined with information from a toxicity assessment (Section 4) to characterize human health risks.

### 5.1 Risk Characterization Methods

Risk characterization integrates the exposure and toxicity assessments by comparing estimates of intake or dose with appropriate toxicity values. This in turn provides an indication of the potential for adverse effects to exposed receptors. The objective of the risk characterization is to determine if exposure to contaminants associated with the site poses risks that exceed EPA target levels for human health effects. The results of the risk assessment may thus support the determination of site release or the need for site remediation.

The RRE reports the incremental risk, total risk, and risk from background for each contaminant evaluated in the Miami-Erie Canal Area. The incremental risk is the risk posed by site-related contamination above the risk posed by background environmental levels. Background risk is the risk resulting from sources other than the Mound-related residual contamination. Site-specific background values are provided in the Mound 2000 RREM (DOE 1997a). The Mound 2000 background values that correspond to the canal COPCs were used as the EPCs to determine background risk. Total risk is the sum of the background and incremental risk. This risk characterization presents a separate evaluation of non-carcinogenic and carcinogenic effects. The assessment distinguishes cancer from non-cancer effects because organisms typically respond differently following exposure to carcinogenic or non-carcinogenic agents. Quantification methods for cancer and non-cancer effects are discussed separately in the following sections.

#### 5.1.1 Quantification of Carcinogenic Risk

Cancer risks are probabilistic estimates of the excess (incremental) lifetime cancer risk for an individual specifically attributable to long term exposure to site-related chemicals. The procedure for calculating risk associated with exposure to carcinogenic compounds has been established by EPA (EPA 1989). A non-threshold, dose-response model was used to calculate a cancer slope (potency) factor for each COPC.

To derive an estimate of risk, the cancer slope factor was multiplied by the estimated chronic daily intake experienced by the exposed individual:

$$\text{Risk} = \text{CDI} \times \text{CSF}$$

Where:

| | | |
|---|---|---|
| Risk | = | High end estimate of the excess lifetime cancer risk to an individual (unitless probability) |
| CDI | = | Chronic daily intake averaged over an established period (mg/kg body weight/day) |
| CSF | = | Cancer slope factor (95% upper-bound estimate of the slope of the dose-response curve) expressed as $(\text{mg/kg body weight/day})^{-1}$. |

To evaluate the risk of exposure to more than one carcinogenic COPC, the risk estimates for each COPC were summed to provide an overall estimate of total carcinogenic risk (EPA 1989).

$$\text{Risk}_T = \sum_{i=1}^{n} \text{Risk}_i$$

Where:

| | | |
|---|---|---|
| $\text{Risk}_T$ | = | The combined excess lifetime cancer risk across chemical carcinogens |
| $\text{Risk}_i$ | = | The risk estimate for the $i^{th}$ chemical of n chemicals under evaluation. |

### 5.1.2 Quantification of Non-carcinogenic Risk

The traditionally accepted practice of evaluating exposure to non-carcinogenic compounds has been to experimentally determine a NOAEL and to divide this by a safety factor to establish an acceptable human dose, for example, acceptable daily intake or RfD. The RfD is then compared to the average daily intake experienced by the exposed population to obtain a measure of concern for adverse non-carcinogenic effects:

$$HQ = \frac{Intake}{RfD}$$

Where:

| | | |
|---|---|---|
| HQ | = | Hazard Quotient: potential for adverse non-carcinogenic effects |
| Intake | = | Average daily intake for subchronic or chronic exposure (mg/kg body weight/day) |
| RfD | = | Acceptable intake for subchronic or chronic exposure (mg/kg body weight/day). |

To evaluate exposure to multiple non-carcinogenic COPCs the HQs for all COPCs were summed to obtain the Hazard Index (HI).

$$HI = \sum HQ_i$$

Where:

| | | |
|---|---|---|
| HI | = | Hazard Index |
| $HQ_i$ | = | Hazard Quotient for the $i^{th}$ chemical of n chemicals under evaluation. |

EPA has established target risk levels for use in determining the need for site remediation. For non-carcinogenic effects, EPA has set the target HQ at one. If the HQ is >1, there is the potential for adverse health effects at the given exposure/dose level, but the HQ value is not an indication of the severity of the effects. For multiple non-carcinogens, the HQs for all of the chemicals under evaluation are summed resulting in the HI. If the HI is > 1, the potential also exists for adverse health effects resulting from exposure to mixtures of chemicals. In cases where the HQ for individual substances is below 1 yet several HQs sum to greater than 1, EPA recommends segregating the compounds into groups with like or common toxicological effects and re-evaluating the potential for the various adverse health effects. In cases where HQs for individual substances are greater than 1, this step is not necessary or useful.

## 5.2 Risk Characterization Results

The following sections present the risk characterization results for the Miami-Erie Canal area by potential receptor. All of the tables for Section 5 (Tables 5.1 through 5.18) are presented at the end of the Section. Risk estimates for individual COPCs for all scenarios and pathways are presented in Tables 5.1

through 5.15. Tables 5.1 through 5.6 present risk estimates based on recreational exposure parameters, Tables 5.7 through 5.12 present risk estimates based on residential exposure parameters and Tables 5.13 through 5.15 present risk estimates based on off site construction worker exposure parameters. Residual risks were calculated based on total risk, background risk and incremental risk. Total risk was calculated using total concentration of the COPCs detected in the area. Background risk was based on background levels of the COPCs, and incremental risk was calculated using the difference between total and background levels. Incremental risk can be used to assess the increase in risk above background levels due to Mound Plant operations. Tables 5.16 through 5.18 present summaries of the results for all scenarios and pathways assessed in the RRE. In the summary tables, risk estimates that are at or above the non-cancer HI of 1 and the cancer target risk range of $10^{-6}$ are bolded. Risk estimates of zero indicate that toxicity criteria were not available for the COPC being evaluated.

**Recreational Adult**

Tables 5.1 through 5.3 present total, background and incremental risk for a recreational adult in the Miami-Erie Canal area. The total, background and incremental non-cancer risk is less than 1 indicating that non-cancer risk is at an acceptable level. Total cancer risk for a recreational adult is $9.4 \times 10^{-6}$, which falls within the target risk range of $10^{-4}$ to $10^{-6}$. The only constituent to exceed $1 \times 10^{-6}$ was radium-226. Residual risk due to radium-226 was driven by external exposure to radium-226 in soil. The majority (66%) of this risk is due to background levels ($6.2 \times 10^{-6}$). The incremental risk due to radium-226 in the canal area to a recreational adult is $3.2 \times 10^{-6}$, which again falls within the target risk range.

**Recreational Child**

Tables 5.4 through 5.6 present total, background and incremental risk for a recreational child in the Miami-Erie Canal area. The total, background and incremental non-cancer risk is less than 1 indicating that non-cancer risk is at an acceptable level. Total cancer risk for a recreational child is $2.4 \times 10^{-6}$, which falls within the target risk range of $10^{-4}$ to $10^{-6}$. The only constituent to exceed $10^{-6}$ was radium-226. Residual risk due to radium-226 was driven by external exposure to radium-226 in soil. The majority of this risk (67%) is due to background levels ($1.6 \times 10^{-6}$). The incremental risk due to radium-226 in the canal area to a recreational child is $2.1 \times 10^{-7}$, which falls below the target risk range.

## Residential Adult

Tables 5.7 through 5.9 present total, background and incremental risk for a residential adult in the Miami-Erie Canal area. The total, background, and incremental non-cancer risk, or HI, is less than 1 indicating that non-cancer risk is at an acceptable level. Total chemical and radiological cancer risk of $3.1 \times 10^{-4}$ for the residential adult exceeds the target cancer risk range of $1 \times 10^{-4}$ to $1 \times 10^{-6}$. Risk from exposure to radionuclides for a residential adult is $1.5 \times 10^{-4}$. Constituents that exceed $1 \times 10^{-6}$ include benzo(a)pyrene, dibenz(a,h)anthracene, arsenic, plutonium-238 and radium-226. Background cancer risk to a residential adult is $1.1 \times 10^{-4}$, which accounts for 34% of the total residual risk. Incremental residual cancer risk for a residential adult in the canal area is $2.1 \times 10^{-4}$, which exceeds the target risk range. 62% of the incremental risk is due to benzo(a)pyrene which is ubiquitous the environment, particularly near rail roads and roadways.

## Residential Child

Tables 5.10 through 5.12 present total, background and incremental risk for a residential child in the Miami-Erie Canal area. The total, background and incremental non-cancer risk is less than 1 indicating that non-cancer risk is at an acceptable level. Total chemical and radiological cancer risk for a residential child is $1.3 \times 10^{-4}$, which slightly exceeds the target risk range of $10^{-4}$ to $10^{-6}$. Constituents that exceed $1 \times 10^{-6}$ include benzo(a)pyrene, dibenz(a,h)anthracene, arsenic, plutonium-238 and radium-226. Background cancer risk to a residential child is $4.2 \times 10^{-5}$, which accounts for 32% of the total residual risk. Incremental residual cancer risk for a residential child in the canal area is $9.0 \times 10^{-5}$, which falls within the target risk range. 69% of the incremental risk is due to benzo(a)pyrene which is ubiquitous in the environment, particularly near rail roads and roadways.

## Off Site Construction Worker

is within the acceptable risk range of $10^{-4}$ to $10^{-6}$.

Tables 5.12 through 5.15 present total, background and incremental risk for an off site construction worker in the Miami-Erie Canal area. The total, background and incremental non-cancer risk is less than 1 indicating that non-cancer risk is at an acceptable level. Total chemical and radiological cancer risk for an off site construction worker is $7.2 \times 10^{-6}$, which The only constituent that exceeds $1 \times 10^{-6}$ is radium-226 via external exposure. Background and incremental, chemical and radiological cancer risk to an off site

construction worker is $5.1 \times 10^{-6}$ and $2.2 \times 10^{-6}$ respectively. Both these values fall within the target risk range of $10^{-4}$ to $10^{-6}$.

## 6.0 UNCERTAINTY IN THE RISK ASSESSMENT

In the following section, an evaluation is presented of the sources of uncertainty in the Miami-Erie Canal area RRE and the relative influence of these sources on the results of the evaluation. Uncertainty is inherent in the selection of input parameters and in every step of the risk assessment process. Risk assessment of contaminated sites must not be viewed as yielding single value, invariant results. Rather, the results of risk assessment are estimates that span a range of possible values, and which must be understood only in light of the assumptions and methods used in the evaluation.

The results of the RRE are presented in terms of the potential for adverse effects based upon a number of conservative assumptions. The tendency to be conservative is an effort to err toward protecting health. Uncertainty can be found at all phases in the risk assessment: in the analytical data, the exposure assessment, the toxicity assessment, and the risk characterization. Where uncertainty does exist, the RRE uses conservative assumptions to ensure that the outcome will be protective.

### 6.1 Uncertainty in Analytical Data

Uncertainty is introduced to the RRE when sample locations are selected and when samples are collected and analyzed. In the RRE, the long-term exposure concentrations were upper estimates of site concentrations (e.g., maximum detect or 95% UCL); therefore, a conservative bias to overestimate potential exposure has been incorporated into the risk estimates. The uncertainty associated with the statistical analysis of environmental data is low, with little introduction of bias. However, it is possible that contaminated areas of the canal were not sampled. This is unlikely given the extent of sampling conducted.

### 6.2 Uncertainty in Exposure Assessment

Exposure assessment may introduce considerable uncertainty in the risk assessment process. The RREM presents exposure and intake calculations based on EPA procedures that were used in the Miami-Erie Canal RRE. Exposure assumption values were also used to develop site-specific risk-based guideline values for the Mound Plant which were approved by Ohio EPA and EPA. Exposure assumptions are based on speculation regarding potential land use, assumptions concerning contaminant fate and transport, and receptor

behavior. The uncertainty associated with the exposure assumptions used in the risk assessment is low to moderate, and most likely overestimates the actual risks.

A major source of uncertainty in the Miami-Erie Canal RRE involves external exposure to gamma-emitting radionuclides. External exposure refers to the irradiation of tissues by radiations emitted by radionuclides located outside the body either dispersed in air, on skin surfaces, or deposited on ground surfaces. Gamma and x-rays are the most penetrating of the emitted radiations and comprise the primary contribution to radiation dose from external exposures. The calculation of risk from external radiation exposure assumes that any gamma-emitting radionuclide in soil is uniformly distributed in soil. The calculation of external radiation exposure risk includes a gamma shielding factor ($S_e$) to account for attenuation of radiation by structures, terrain or engineered barriers. $S_e$ is expressed as a fractional value between 0 and 1, representing the possible risk reduction range from 0% to 100% due to shield. The Miami-Erie Canal RRE used a default value of 0.2 or 20% shielding for both the recreational and residential scenarios. This is a conservative value which does not account for 1-2 feet of clean fill material that was placed over excavated areas. Calculations done using RESRAD Version 5.621 and verified with Microshield Version 4.21 show that the reduction in dose from a gamma source by applying soil covers of various depths would be on the order of a 99% reduction or 99% shielding with 2 feet of soil cover (SAIC 1997). Calculations showing the shielding of external gamma dose, from a soil cover, are included in Appendix A. It is likely that clean fill in the canal area does provide shielding from gamma radiation resulting in lower risk than what is presented here.

omit per EPA comment also Appendix now something else.

### 6.3 Uncertainties Related to Toxicity Information

Although EPA approved toxicity values were used for the RRE a significant amount of uncertainty may surround these values. Identification of the sources of this uncertainty enables the risk assessor to establish the degree of confidence associated with the toxicity measures.

Uncertainty is inherent within the toxicity assessment and is primarily due to differences in study design, species, sex, routes of exposure, or dose-response relationships. A major source of uncertainty involves using toxicity values based on experimental studies that substantially differ from typical human exposure scenarios. The derivation of the toxicity values must take into account such differences as 1) using dose-response information from animal studies to predict effects in humans, 2) extrapolating dose-response

information from high-dose studies to predict adverse health effects from low doses, 3) using data from short-term studies to predict chronic effects, and 4) extrapolating from uniform animal populations to variable human populations.

The cancer slope factors in particular are based on studies that may differ greatly from realistic situations. Experimental cancer bioassays typically expose animals to very high levels of chemicals (i.e., the maximum tolerated dose) for their entire lifetime. After appropriate studies have been identified, the slope factor is calculated as the upper 95th percent confidence limit of the slope of the dose-response curve. This introduces conservatism into the risk assessment. In addition, carcinogens are assumed to be human carcinogens regardless of EPA's weight-of-evidence classification.

The derivation of reference doses involves the use of animal studies. Uncertainty factors ranging from 1 to 1,000 are incorporated into the reference dose to provide an extra level of health protection. The factors used depend on the type of study from which the value has been derived (e.g., animal or human, chronic or acute, study design). The scientific basis for this practice is somewhat subjective. In general, high uncertainty factors are meant to bias the results conservatively so that exposures at the reference dose level will not result in adverse health effects.

Toxicity values derived from oral administered dose studies have been converted to absorbed dose toxicity values for use in evaluating the dermal contact pathway. This is considered a more accurate approach than using unadjusted oral toxicity values for the dermal pathway. Uncertainty is introduced in the use of the gastrointestinal absorption factors. Limited information is available on the gastrointestinal absorption of some analytes and many have no information at all. In addition, no adjustments have been made for the medium of exposure (e.g., when the medium of exposure in the site differs from the medium of exposure assumed by the toxicity value). The uncertainty associated with using the absorbed dose toxicity values for the dermal pathway is moderate and the bias unknown.

There are some chemicals for which no toxicity value exists and for which little information is available. Therefore, a quantitative risk estimate cannot be calculated for these chemicals. For example, many chemicals are not evaluated for the inhalation pathway because of limited inhalation-based toxicological information. The lack of toxicity information for some chemicals contributes to the underestimation of risks.

Cancer and non-cancer risks are summed in the risk characterization process (separately for carcinogens and non-carcinogens) to estimate potential risks associated with the simultaneous exposure to multiple chemicals. In the case of carcinogens, this gives carcinogens with a class B or class C weight-of-evidence the same weight as carcinogens with a class A weight-of-evidence. It also equally weights slope factors derived from animal data with those derived from human data. Uncertainties in the combined risks are also compounded because RfDs and cancer slope factors do not have equal accuracy or levels of confidence and are not based on the same severity of effect.

## 6.4 Uncertainties In Risk Characterization

Uncertainties in any phase of the risk analysis are reflected in the risk estimates. Some uncertainty is associated with the summation of risks and HQs for multiple chemical contaminants. As stated in RAGS (EPA 1989), "The assumption of dose additivity ignores possible synergisms or antagonisms among chemicals, and assumes similarity in mechanisms of action and metabolism." However, summing risks and HQs for multiple substances in this risk assessment provides a conservative estimate.

## 7.0 REFERENCES


Centers of Disease Control and Prevention (CDC), 1985. Preventing Lead Poisoning in Children, U.S. Department of Health and Human Services, Atlanta Georgia.

DOE (United States Department of Energy) 1975. Mound Laboratory Environmental Plutonium Study 1974 (MLM-02249), September 1975

DOE 1974. Mound Laboratory Environmental Plutonium Study. Samples from the park vicinity included in the RRE

DOE 1992. Special Canal Sampling, SAIC 1992

DOE 1993a. OU9 Quality Assurance Project Plan

DOE 1993b. OU5 Quality Assurance Project Plan

DOE 1994. "Health Consultation, DOE Mound Plant" (1994)

DOE 1995. OU-9 Regional Soils Investigation Report, August 1995, Final, Revision 2

DOE 1997a. Mound 2000 Residual Risk Evaluation Methodology, Mound Plant, Miamisburg, Ohio. Final, Revision 0. January 1997

DOE 1997b. Risk-Based Guideline Values, Mound Plant, Miamisburg, Ohio. Prepared by Hazardous Waste Remedial Actions Program managed by Lockheed Martin Energy Systems, Inc. March 1997.

DOE 1999. On-Scene Coordinators Report, OU-4 Miami-Erie Canal Removal Action, Mound Plant Miamisburg, Ohio. Final (Revision 0) June 1999.

EPA. 1998d. *RCRA QAPP Instructions*, USEPA Region 5, Chicago, IL, April 1998 revision. http://www.epa.gov/reg5rcra/wptdiv/cars/cars.htm

EPA 1990. "National Oil and Hazardous Substances Pollution Contingency Plan," Final Rule, FR Vol. 55, No. 46, March 8, 1990, available from U.S. Government Printing Office, Washington, D.C.

EPA 1989. "Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Part A, Interim Final," EPA, Office of Emergency and Remedial Response, Washington, DC.

EPA 1991a. "Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors, Interim Final," OSWER Directive 9285.6-03, EPA, Office of Emergency and Remedial Response, Washington, DC.

EPA 1991b. "Risk Assessment Guidance for Superfund, Vol. I: Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals," OSWER Directive 9285.7-01B, Office of Emergency and Remedial Response, Washington, D.C.

EPA 1992a. "Supplemental Guidance to RAGS: Calculating the Concentration Term," PB92-963373, May 1992. EPA, Office of Emergency and Remedial Response Toxics Integration Branch, Washington, DC.

EPA 1992b. "Dermal Exposure Assessment: Principles and Applications," EPA/600/8-91/011b, Office of Health and Environmental Assessment, Washington, DC.

EPA 1992c. "Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual Supplemental Guidance Dermal Risk Assessment Interim Guidance," EPA, Office of Emergency and Remedial Response Toxics Integration Branch, Washington, DC.

EPA 1994a. Interim Guidance on Establishing Soil Lead Cleanup Levels at RCRA Facilities. Office of Solid Waste and Emergency Response. OSWER Directive #93SS.4-12. Washington D.C.

EPA 1994b. Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children. Office of Emergency and Remedial Response. Washington, D.C. EPA/S40/R-93/081, PB93963610

EPA 1995. "Health Effects Assessment Summary Tables," OHEA ECAO-CIN-909, Office of Research and Development and Office of Emergency and Remedial Response, Washington, D.C.

EPA 1996a. *Radiation Exposure and Risks Assessment Manual (RERAM), Risk Assessment Using Radionuclide Slope Factors*, EPA 402-R-96-016, Air and Radiation, June.

EPA 1996f. Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil. December.

EPA 1997. "Exposure Factors Handbook," Volumes I, II, and III, EPA/600/P-95/002Fa-c, EPA, Office of Research and Development, Washington, DC.

EPA 2000. Integrated Risk Information System (IRIS), National Center for Environmental Assessment, U.S. Environmental Protection Agency, 26 West Martin Luther King Drive, MS-190, Cincinnati, Ohio 45268. (513) 569-7254.

Gilbert, R.O. 1987. Statistical Methods for Environmental Pollution Monitoring. Van Nostrand Reinhold, New York.

PRS 416 Data Package, Unpublished

SAIC 1997. Memo to George Stephens from Genia McDuffee. July 10, 1997on the subject of Shielding of External Gamma Dose from a Soil Cover.