

FMC MIDDLEPORT RISK MANAGEMENT APPROACH FOR THE CORRECTIVE MEASURES STUDY

Suspected Air Deposition and Culvert 105 Study Areas

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ACRONYMS AND ABBREVIATIONS

95UCL	95 percent upper confidence limit on the mean
bgs	below ground surface
BMI	body mass index
CAO	corrective action objectives
CDPHE	Colorado Department of Public Health and the Environment
CMA	corrective measure alternative
CMS	corrective measures study
COC	constituent of concern
CRV	cancer intake reference value
CSF	cancer slope factor
CSM	conceptual site model
CTE	central tendency exposure
EPA	U.S. Environmental Protection Agency
FMC	FMC Corporation
HHRA	human health risk assessment
ICM	interim corrective measure
IRIS	Integrated Risk Information System
NCHS	National Center for Health Statistics
NHANES	National Health and Nutrition Examination Survey
NHAPS	National Human Activity Pattern Survey
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
RCRA	Resource Conservation and Recovery Act
RFI	RCRA facility investigation
RME	reasonable maximum exposure
SCO	soil cleanup objective
SSL	soil screening level
SVOC	semivolatile organic compound
VOC	volatile organic compound

EXECUTIVE SUMMARY

This document describes the use of human health risk assessment (HHRA) in the corrective measures study (CMS) for the suspected air deposition and Culvert 105 study areas associated with the FMC Corporation (FMC) Middleport, New York facility. As stated in the corrective action objectives (CAOs) issued in March 2009 by the New York State Department of Environmental Conservation (NYSDEC) and the United States Environmental Protection Agency (USEPA) in consultation with the New York State Department of Health (NYSDOH) (the Agencies), one of the goals of the corrective measures is to “protect human health and the environment relative to FMC-related contamination.” HHRA will be used to evaluate the degree to which various corrective measures alternatives (CMAs) would achieve this goal with respect to protection of human health.

Based on the screening for constituents of concern (COCs) presented in this document, arsenic is the only COC to be carried forward in the risk assessments for the CMS, and the presence of arsenic in soil will dictate the scope and extent of any corrective measures. Consequently, this document focuses on HHRA methods pertaining to assessing arsenic exposures.

HHRA will be used throughout the CMS process for the following purposes:

- To evaluate site-specific human health risks associated with exposure to soils as they currently exist (i.e., the “no action” and/or “no further action” alternatives) in the CMS study areas
- To evaluate site-specific human health risks associated with exposure to arsenic in soils under background conditions for the Middleport area, using the 2001–2003 Gasport soil sampling data for arsenic to represent Middleport background conditions
- To evaluate site-specific human health risks associated with each CMA using post-remediation arsenic concentrations
- To compare the various CMAs based on the extent to which the corrective measures will reduce site-specific human health risks.

This document was prepared to describe the risk assessment methods that are proposed and to solicit input from the Agencies and the community. The document includes:

- Evaluation of basic (i.e., deterministic) and supplementary (i.e., probabilistic) risk assessment approaches for applicability to the CMS
- Description of the deterministic and probabilistic analysis methods to be used in the CMS
- Description of the conceptual site model and selection of exposure pathways evaluated in the risk assessment

- Screening of constituents of concern
- Evaluation of the adequacy of the arsenic soil data sets for use in the risk assessment
- Identification of the exposure factor assumptions and description of the rationale for use of the selected factors
- Presentation of an example of calculated probabilistic analysis results and discussion of how to interpret the results.

The risk assessment and risk-based analyses conducted as described herein will support several aspects of the CMS:

- Development of the risk-based alternative(s)—One or more of the CMS alternatives will be based on a cleanup objective identified by means of site-specific risk analyses.
- Evaluation of alternatives—All CMS alternatives will be evaluated for protectiveness of human health. Risk-based analyses will play a role in these comparisons.
- Community participation—An HHRA has been requested by members of the community and is important to satisfy community concerns and to facilitate effective participation by various stakeholders in the CMS process.

USEPA (2009a) notes that protection of public health and the environment depends on “rigorous adherence to the best available science.” The Middleport community has been studied extensively through a bioavailability study, a biomonitoring study, and soil sampling, all of which together provide a firm foundation for a high quality risk assessment to support the development of an effective corrective measure or measures. The combination of deterministic and probabilistic risk analysis methods is a powerful tool for use of these site-specific data.

BACKGROUND ON RISK ASSESSMENT METHODS

Risk assessment involves the use of a number of variables, assumptions, or factors in the assessment of exposure. These factors and the resulting exposure estimates vary over time and across populations. The accuracy of the assumed values is associated with varying degrees of uncertainty. For example, exposure factors such as the daily rate of soil ingestion are expected to vary from individual to individual. In addition, measuring soil ingestion is technically challenging and poses the potential for measurement errors and uncertainties. For some exposure factors, there is no consensus in the professional community as to the range of values that best represents a given population.

There are two general risk assessment approaches to characterizing the range of possible exposures in a population. The initial, basic approach, termed deterministic risk assessment, uses point estimates of exposure and toxicity parameters to calculate a point estimate of hypothetical risk. Customarily, both central tendency exposure (CTE) and reasonable

maximum exposure (RME) estimates are included. The CTE is the degree of exposure expected to be the most common, and is derived by using average or typical values for the exposure parameters. The RME is the highest exposure that is reasonably expected to occur at a site, and is derived by using a combination of average and upper-bound values that yield an estimate approximating a 95th percentile exposure. Ideally, point estimates of exposure parameters are selected from a set of values that represents an accurate range of values for the parameter. More commonly, however, CTE and RME estimates are selected based on limited information regarding where in the actual distribution the selected values fall. In selecting these point estimates, the ability to quantify the uncertainty in the values is usually lost.

In a more comprehensive risk assessment approach for characterizing the range of possible exposures, termed probabilistic risk assessment, probability distributions are assigned for one or more exposure parameters to yield an output probability distribution for the exposure estimate. From this output probability distribution, an upper-bound value representing approximately the 95th percentile of the distribution is selected to represent the RME. A probability distribution is a mathematical function that describes the values and the associated probabilities for a given parameter. For example, the probability distribution for adult body weight is described as lognormal, which is a bell-shaped curve with a long tail to the right. The shape of the curve represents the proportions of the population characterized by each body weight, with the tail to the right representing a smaller proportion of individuals with higher body weights.

According to EPA guidance, a site risk assessment will typically begin with deterministic analyses, and then all or some elements of the risk assessment may progress to probabilistic analyses as needed to further elucidate site risks. The advantages of a deterministic approach, when used in the appropriate context, are its simplicity, cost-effectiveness, and ease of understanding; however, sometimes a more refined analysis is needed to more accurately assess risk. EPA guidance requires that risk assessments include an uncertainty analysis that allows risk managers to understand the reliability and representativeness of the risk estimates. Risk assessments that do not adequately evaluate variability and uncertainty are vulnerable to potentially serious pitfalls, such as failing to provide enough information for a reliable comparison of alternative decisions in risk management. Deterministic analyses provide very limited information on uncertainty and variability, while a quantitative analysis of uncertainty and variability such as in a probabilistic analysis can provide a more comprehensive characterization of risk.

For this CMS, two stages of deterministic risk analyses will be performed, followed by probabilistic analyses for one scenario. A deterministic approach will be used initially to assess each of the residential and worker scenarios, at first using default assumptions and then incorporating site-specific exposure assumptions based on studies conducted in Middleport. Based on the results of the risk-based screening assessment of interim corrective measures conducted several years ago, it is anticipated that for residential exposures, probabilistic

analyses will also be needed to more accurately define incremental risks above background as well as risk reduction associated with the proposed remedial alternatives. The probabilistic approach will provide the most effective way to use the site-specific data that have been collected in Middleport. Furthermore, probabilistic analyses are anticipated to be a critical component of remedial decision-making because the variability and uncertainty associated with the risk estimates can be quantified.

MIDDLEPORT RISK ASSESSMENT APPROACH

The HHRA will include the following elements:

- Problem formulation
- Exposure assessment, including the identification of exposure pathways and the calculation of exposure point concentrations
- Toxicity assessment
- Risk characterization
- Description of uncertainties and limitations.

The HHRA will be performed in accordance with the most recent versions of EPA guidance and will consider New York State regulatory documents. The HHRA will include analyses for current conditions in the CMS areas, for soil background conditions, and for post-remediation conditions associated with the various CMAs. Assessments and evaluations of CMAs will consider both current and reasonably anticipated future land uses.

Concentrations of non-arsenic constituents were compared to screening levels from EPA and New York State Department of Environmental Conservation. Background concentrations of metals were also considered during the screening. While non-arsenic constituents (lead, chlorinated pesticides, and other metals) have been detected during the various sampling events at locations within the study areas, these constituents are not considered COCs based on their low frequency of detection, low concentrations, infrequent occurrence above screening levels, and/or occurrence due to natural conditions or non-site-related activities. As a result of the outcome of the COC screening, it is anticipated that remediation alternatives will be based on arsenic concentrations and that the HHRA will focus on arsenic.

Based on an evaluation of the pathways by which residents and workers in the Middleport area could be exposed to arsenic in soil, the HHRA will quantitatively evaluate ingestion of and dermal contact with soil and house dust. Qualitative evaluations will be provided for inhalation of particulates in air and ingestion of homegrown produce. Other potential exposure pathways are considered to be incomplete for each of the study areas.

Residential exposures in the air deposition area and the Culvert 105 study area north of the canal will be evaluated using both deterministic and probabilistic analysis methods. Exposures to Culvert 105 subsurface soils will be evaluated by considering a utility worker scenario.

For residential exposures to surface soils, the HHRA will include an analysis for background arsenic conditions for comparison with Middleport conditions. These paired analyses will be a critical component in assessing the effectiveness of remedial alternatives. Such paired analyses will not be performed for utility worker exposures to subsurface soils because the background data set does not include subsurface soils.

The document provides the equations for calculating site intakes and “cancer intake reference values” (CRVs), the daily intakes of arsenic associated with specified target cancer risk levels (one in a million, one in a hundred thousand, and one in ten thousand, or 10^{-6} , 10^{-5} , and 10^{-4} , respectively). The CRVs provide comparison levels for evaluating the total combined site cancer intakes of arsenic from soil and house dust. The comparison levels for total site noncancer arsenic intakes are reference doses (RfDs).

The document provides CTE and RME values for the exposure and toxicity parameters in the deterministic analyses for residents and utility workers. It also provides point estimates or probability distributions, as applicable, for the exposure parameters in the probabilistic analyses for residents. A justification of the selected values and/or distributions is provided for each of the exposure and toxicity parameters.

The last section of the document provides an example of results of the probabilistic calculations as applied to background conditions with an explanation of how to interpret the results.

1 INTRODUCTION

This document describes the use of human health risk assessment (HHRA) in the corrective measures study (CMS) for the suspected air deposition and Culvert 105 study areas associated with the FMC Corporation (FMC) Middleport, New York facility. As stated in the corrective action objectives (CAOs) issued in March 2009 by the New York State Department of Environmental Conservation (NYSDEC) and the U.S. Environmental Protection Agency (EPA) in consultation with the New York State Department of Health (NYSDOH) (the Agencies), one of the goals of the corrective measures is to “protect human health and the environment relative to FMC-related contamination.” HHRA will be used to evaluate the degree to which various corrective measures alternatives (CMAs) would achieve this goal with respect to protection of human health.

As discussed in the CMS work plan, the presence of arsenic in soil is expected to dictate the scope and extent of any CMA that may be implemented in the CMS areas. Based on the screening for constituents of concern (COCs) presented in Section 2.2 of this document, arsenic will be the only COC carried forward in this HHRA. This document, therefore, describes methods pertaining to assessing arsenic exposures.

HHRA will be utilized throughout the CMS process for the following purposes:

- To evaluate site-specific human health risks associated with exposure to soils as they currently exist (i.e., the “no action” and/or “no further action” alternative) in the CMS study areas
- To evaluate site-specific human health risks associated with exposure to arsenic in soils under background conditions for the Middleport area, using the 2001–2003 Gasport soil sampling data for arsenic as a surrogate for Middleport background conditions
- To evaluate site-specific human health risks associated with each CMA utilizing the post-remediation arsenic concentration distribution
- To compare the various CMAs based on the extent to which the corrective measures will reduce site-specific human health risks.

This document was prepared to describe the human health risk assessment methods that are proposed and to solicit input from the Agencies and the community. The document includes:

- Evaluation of basic (i.e., deterministic) and supplementary (i.e., probabilistic) risk assessment approaches for applicability to the CMS
- Description of the deterministic and probabilistic analysis methods to be used in the CMS

- Description of the conceptual site model and selection of exposure pathways evaluated in the risk assessment
- Screening of constituents of concern
- Evaluation of the adequacy of the arsenic soil data sets for use in the risk assessment
- Identification of the exposure factor assumptions and description of the rationale for use of the selected factors
- Presentation of an example of calculated probabilistic analysis results and discussion of how to interpret the results.

1.1 PURPOSES OF THE HHRA

The risk assessment and risk-based analyses conducted as described herein will support several aspects of the CMS:

- **Development of the risk-based alternative(s)**—One or more of the CMS alternatives will be based on a cleanup objective identified by means of site-specific risk analyses.
- **Evaluation of alternatives**—All CMS alternatives will be evaluated for protectiveness of human health and the environment. Risk-based analyses will be used in these comparisons.
- **Community participation**—An HHRA has been requested by members of the community and is important to satisfy community concerns and to facilitate effective participation by various stakeholders in the CMS process.

The approaches and role of risk assessment in each of these three aspects of the CMS are summarized below.

1.1.1 Development of Risk-Based Alternatives

A site-specific HHRA will be used to develop CMAs that achieve the desired reduction in potential exposure and risk. The CMS will include alternatives for three categories of site soils corresponding to the study areas defined in Section 2.1 of the CMS work plan:

- Surface soils in the suspected air deposition area, including surface soils along Culvert 105 south of the Erie Canal (suspected air deposition study area)
- Surface soils relative to Culvert 105 north of the Erie Canal (Culvert 105 study area north of the canal)
- Subsurface soils relative to Culvert 105 both south and north of the canal (Culvert 105 study area subsurface soils).

As described in the CMS work plan, at least one risk-based alternative will be included among the alternatives considered for each of these areas. For surface soils, all areas will be evaluated based on exposures of residents; however, some areas may also include an evaluation based on commercial and/or industrial worker exposures. For subsurface soils, utility worker exposures will be the basis for the risk-based alternative(s).

1.1.2 Evaluation of Alternatives

At a minimum, the following alternatives are proposed for residential soils in Section 5.6.1 of the CMS work plan:

- No action and/or no further action (post interim corrective measures [ICMs])
- Risk-based (defined target incremental risk vs. background)
- 20 ppm average property arsenic concentration
- 20 ppm maximum property arsenic concentration.

As specified in the CMS work plan, other alternatives, including those with post-remediation arsenic concentrations other than 20 ppm, may be developed and included in the CMA evaluation during the CMS. The health protectiveness of each alternative developed during the CMS will be evaluated by a consistent method. The “no action” approach is based on conditions that existed prior to implementation of any of the ICMs performed (e.g., 1999–2000 Roy-Hart School Football Field Area ICM, 2003 West Properties ICM, 2007 Early Actions). The “no further action” alternative is based on existing conditions, after completion of the interim actions (e.g. ICMs, Interim Remedial Measures, Early Actions) performed to date, and will include incremental risk reduction associated with completion of the ICMs. The other alternatives will be evaluated for additional risk reduction in comparison with the “no further action” alternative.

1.1.3 Community Participation

The community has indicated a desire for the CMS to consider and clearly describe current site-specific health risks and the relative health benefits of proposed remedial alternatives. Three aspects of risk analyses will be needed to satisfy the requests of the community:

- Site-specific health risks will be presented as incremental risks compared with expected risks in the absence of exposure to FMC-related contamination.
- Analogous incremental risks will be calculated for each of the proposed CMAs.
- For arsenic, the health benefits of the CMA will be presented in terms of total arsenic exposure from soil and all other sources, including arsenic naturally present in water, beverages, and food.

1.2 BACKGROUND ON RISK ASSESSMENT METHODS

Risk assessment involves the use of a number of variables, assumptions, or factors in the assessment of exposure. These factors and the resulting exposure estimates vary over time and across populations. The accuracy of the assumed values is also associated with varying degrees of uncertainty. For example, exposure factors such as the daily rate of soil ingestion are expected to vary from individual to individual. In addition, measuring soil ingestion is technically challenging and poses the potential for measurement errors and uncertainties. For some exposure factors, there is no consensus in the professional community as to the range of values that best represents a given population.

There are two general risk assessment approaches to characterizing the range of possible exposures in a population. The initial, basic approach, termed deterministic risk assessment, uses point estimates of exposure and toxicity parameters to calculate a point estimate of hypothetical risk. Customarily, both central tendency exposure (CTE) and reasonable maximum exposure (RME) estimates are calculated by combining exposure parameters that are expected to yield representative exposure estimates. The RME is the highest exposure that is reasonably expected to occur at a site, and is derived by using a combination of average and upper-bound values that yield an estimate approximating a 95th percentile exposure. Ideally, point estimates of exposure parameters are selected from a set of values that represents an accurate range of values for the parameter (USEPA 2001a). More commonly, however, CTE and RME estimates are selected based on limited information regarding where in the actual distribution the selected values fall. In selecting these point estimates, the ability to quantify the uncertainty in the values is usually lost.

In a more comprehensive risk assessment approach for characterizing the range of possible exposures, termed probabilistic risk assessment, probability distributions are assigned for one or more exposure parameters to yield an output probability distribution for the exposure estimate distribution, from which an upper-bound value representing an exposure at approximately the 95th percentile of the distribution is selected to represent the RME. A probability distribution is a mathematical function that describes the values and associated probabilities for a given parameter. For example, the probability distribution for adult body weight is described as lognormal, which is a bell-shaped curve with a long tail to the right. The shape of the curve represents the proportions of the population characterized by each body weight, with the tail to the right representing a smaller proportion of individuals with higher body weights.

Probability distributions are used to describe the variability and/or uncertainty that is inherently present in measures of exposure. Variability refers to true inter-individual (among individuals) and intra-individual (within an individual) diversity that is innate in a parameter and cannot be reduced or eliminated. Uncertainty refers to a lack of knowledge that can be reduced by collecting additional and/or better data (USEPA 2001a). An example of a parameter

with variability but relatively little uncertainty is body weight. Although there is a substantial degree of variability in adult body weight, national studies provide current, accurate records of body weights for a large portion of the U.S. population, so there is little uncertainty about the range of body weights. On the other hand, an example of a parameter with both variability and uncertainty is soil ingestion rate. Studies of soil ingestion have shown a high degree of variability in soil ingestion rates among individuals. Furthermore, because of the technically challenging nature of these studies, there is a high degree of uncertainty associated with the soil ingestion rate estimates. The range of soil ingestion rate estimates in many studies includes zero.

EPA guidance (USEPA 1995, 2000, 2001a) requires that risk assessments include an uncertainty analysis that allows risk managers to understand the reliability and representativeness of the risk estimates. Risk assessments that do not adequately evaluate variability and uncertainty are vulnerable to potentially serious pitfalls, such as not allowing for optimal weighting of the probabilities and consequences of errors, and not providing enough information for a reliable comparison of alternative decisions in both risk assessment and risk management (USEPA 2004a). Deterministic risk assessments provide very limited information on uncertainty and variability, while “quantitative analysis of uncertainty and variability can provide a more comprehensive characterization of risk than is possible in the point estimate [deterministic] approach” (USEPA 2001a). “At some sites, probabilistic analysis can provide a more complete and transparent characterization of the risks and uncertainties in risk estimates than would otherwise be possible with a point estimate approach” (USEPA 2001a).

USEPA (1997a, 2009b) notes the following situations in which probabilistic risk assessment may be useful:

- “[A] screening level deterministic risk assessment indicates that risks are possibly higher than a level of concern, and, therefore, a more refined assessment is needed”
- “[I]t is necessary to disclose the degree of bias associated with point estimates of exposure”
- “[I]t is necessary to rank exposures, exposure pathways, sites, or contaminants”
- “[T]he cost of regulatory or remedial action is high and the exposures are marginal”
- “[T]he consequences of simplistic exposure estimates are unacceptable”
- “To identify promising critical control points and critical levels when evaluating risk management alternatives.”

USEPA (2009b) also notes that probabilistic risk assessment is not necessary in three types of situations, none of which is applicable to Middleport:

- “When a screening-level deterministic risk assessment indicates that risks are negligible, presuming that the assessment is known to be biased to produce overestimates of risk”

- “When the cost of averting the exposure and risk is smaller than the cost of probabilistic analysis”
- “When there is little uncertainty or variability in the analysis.” USEPA (2009b) notes that this is a rare situation.

Probabilistic risk assessment has been used by EPA and others to evaluate a variety of sites, including exposure situations involving arsenic. For example, EPA used probabilistic approaches to evaluate risks associated with ingestion of polychlorinated biphenyls (PCBs) in fish in the Hudson (USEPA and USACE 2000) and Housatonic (USACE and USEPA 2005) rivers, where deterministic cancer risk results fell above EPA’s acceptable risk range of 1×10^{-6} to 1×10^{-4} . EPA (2008a) also used probabilistic approaches to evaluate risks for children contacting playsets and decks treated with the wood preservative chromated copper arsenate.

EPA’s probabilistic risk assessment guidance (USEPA 2001a) recommends an initial deterministic assessment prior to making the decision to proceed with a probabilistic risk assessment. The advantages of a deterministic approach, when used in the appropriate context, are its simplicity, cost-effectiveness, and ease of understanding. For this HHRA we anticipate two stages of deterministic risk analyses, followed by probabilistic analyses for one scenario. A deterministic approach will be used initially to assess each of the residential and utility worker scenarios, at first using default assumptions and then progressing to incorporating site-specific exposure assumptions based on studies conducted in Middleport. Based on the EPA default risk-based soil screening level for soil arsenic, it is anticipated that for residential exposures, probabilistic analyses will also be needed to more accurately define incremental risks above background as well as risk reduction associated with proposed remedial alternatives. Details of the selected assumptions for both deterministic and probabilistic analyses are presented later in this document.

2 RISK ASSESSMENT APPROACH

The HHRA will include the following elements:

- Problem formulation
- Exposure assessment, including the identification of exposure pathways and the calculation of exposure point concentrations
- Toxicity assessment
- Risk characterization
- Description of uncertainties and limitations.

As described in the CMS work plan, the HHRA will be performed in accordance with the most recent versions of relevant EPA guidance, including but not necessarily limited to, the following documents (as appropriate):

- Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part A (USEPA 1989)
- Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part E – Dermal Risk Assessment (USEPA 2004b)
- Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part F – Supplemental Guidance for Inhalation Risk Assessment (USEPA 2009c)
- Risk Assessment Guidance for Superfund: Volume III – Part A, Process for Conducting Probabilistic Risk Assessment (USEPA 2001a)
- Exposure Factors Handbook (USEPA 1997b)
- Guidance for Data Usability in Risk Assessment (USEPA 1992)
- USEPA Risk Characterization Program Memorandum (USEPA 1995)
- Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA 2002)
- Integrated Risk Information System (IRIS), which contains EPA's on-line database of toxicity factors (<http://www.epa.gov/ngispgm3/iris/index.html>).

In addition, the HHRA will consider the following New York State documents:

- NYSDEC Soil Cleanup Objectives (SCOs) identified in 6 NYCRR Subpart 375-6.8(b)
- New York State Brownfield Cleanup Program, Development of Soil Cleanup Objectives Technical Support Document (NYSDEC and NYSDOH 2006).

The HHRA will include analyses for current conditions in the CMS areas for soil background conditions (for surface soil) and for post-remediation conditions associated with the various CMAs. Assessments and evaluations of CMAs will consider both current and reasonably anticipated land uses. The activities involved in the HHRA are summarized in the subsections below.

Residential exposures in the air deposition area and the Culvert 105 study area north of the canal will be evaluated using both deterministic and probabilistic analysis methods. Exposures to Culvert 105 subsurface soils will be evaluated by considering a utility worker scenario. Initially, the utility worker scenario will be evaluated using a deterministic approach to determine if a probabilistic approach is necessary. EPA (2001a) indicates that, in a probabilistic risk assessment, deterministic estimates, such as those planned for the utility worker in this HHRA, may be used to answer scenario-specific questions. If the results of the deterministic analyses for the utility worker are above a level of concern, probabilistic analyses may be conducted. The residential probabilistic and residential deterministic analysis approaches will be discussed together; the utility worker deterministic analysis approach is discussed in a separate section of this document.

For residential exposures to surface soils, the HHRA will also include an analysis for background arsenic conditions for comparison with Middleport conditions. These paired analyses will be a critical component in assessing the effectiveness of remedial alternatives. Such paired analyses will not be performed for utility worker exposures to Culvert 105 subsurface soils because the background data set does not include subsurface soils.

The primary documents that will serve as guidance for the Middleport probabilistic HHRA are the USEPA (1989, 1991, 2001a, 2004b, 2009c) Risk Assessment Guidance for Superfund series. The framework that will be followed for the Middleport HHRA consists of three primary components: problem formulation, analysis, and risk characterization. In problem formulation, data gaps are evaluated and a CSM is finalized to provide the foundation for the second component, analysis. Characterization of arsenic release mechanisms, transport media, exposure routes, and likely receptors is discussed below to help focus the remainder of the risk assessment process on those exposure pathways likely to represent the most significant potential risk.

The exposure and toxicity assessments make up the analysis component of the HHRA. The exposure assessment element generally represents the greatest site-specific effort in the risk assessment process. This element will involve characterizing the soil arsenic concentrations within the three study areas as well as refining the nature of receptor populations to be characterized and the specific exposure characteristics (e.g., contact rate, exposure frequency, and exposure duration) to be used in deriving site-specific exposure estimates. The toxicity assessment includes describing potential adverse health effects associated with various kinds of

exposure to a range of arsenic doses, compilation of carcinogenic and noncarcinogenic arsenic toxicity criteria, and description of the underlying dose-response analyses.

In the risk characterization component of the HHRA, risk estimates generated from integration of the exposure and toxicity assessments will be summarized and an interpretation of the significance of these estimates provided. When probabilistic methods are used for risk calculations, Monte Carlo analysis will be employed. Monte Carlo analysis or simulation is a commonly used probabilistic numerical technique where the uncertainties and variabilities in risk estimates are characterized “by repeatedly sampling the probability distributions of the risk equation inputs and using these inputs to calculate a range of risk values” (USEPA 2001a). While both uncertainty and variability exist in the exposure characteristics that will be used in deriving site-specific exposure estimates, the distributions used to characterize the exposure parameters for the probabilistic analyses of this HHRA primarily will quantify variability. Uncertainty will be formally addressed using sensitivity analysis.

The sections below address the following tasks:

- Conceptual site model and pathway screening
- Identification of constituents of concern
- Evaluation of adequacy of the arsenic concentration data set
- Residential exposure factors
- Utility worker exposure factors.

These sections cover the requirements of Section 4.5 of the CMS work plan for the risk management approach document.

2.1 CONCEPTUAL SITE MODEL AND PATHWAY SCREENING

A site-wide conceptual site model (CSM) describing receptor populations and exposure pathways potentially applicable in some areas of Middleport was provided in the draft RCRA facility investigation (RFI) report (CRA 1999). The exposure pathways identified in the site-wide CSM included sources of potential exposure, mechanisms of chemical transport in various media, exposure points of contact, and exposure routes at the points of contact. Potential human receptors identified include onsite and offsite workers and visitors, residents, school children, and people using the site for recreational activities. The site-wide CSM has been modified to address receptors and pathways relevant for the air deposition area, the Culvert 105 study area north of the canal, and Culvert 105 subsurface soils.

The HHRA of the air deposition area, the Culvert 105 study area north of the canal, and Culvert 105 subsurface soils will focus on ingestion of soil, the exposure pathway expected to contribute most to total exposure. The CSM is presented as Figure 1, and the pathway screening is

described below. Receptors of concern include child and adult Middleport residents and workers at commercial and industrial businesses within the two study areas. The initial deterministic risk analyses will focus only on residents and utility workers. Specific risk estimates will not be included for commercial/industrial workers. Relevant soil concentration data have been collected from all types of properties present in Middleport, including industrial and commercial properties. Because the risk analyses for the air deposition area and the Culvert 105 study area north of the canal will use a residential exposure scenario, exposures to commercial/industrial workers on these properties will be overestimated. Subsequent separate evaluations of risks to workers in these study areas may be conducted later if needed for the CMS.

Primary or complete exposure routes applicable to the air deposition area and the Culvert 105 study area north of the canal are divided into those to be evaluated quantitatively and those to be evaluated qualitatively. Those to be quantified in the initial deterministic risk analyses include ingestion of and dermal contact with soil and house dust. Exposure routes to be evaluated qualitatively include inhalation of suspended particulates and consumption of homegrown produce. Potential pathways identified in the site-wide CSM that are incomplete in the air deposition area and the Culvert 105 study area north of the canal include ingestion of, dermal contact with, and inhalation of vapors from private well water; dermal contact with and inhalation of vapors from groundwater; dermal contact with and ingestion of surface water; ingestion of and dermal contact with sediments; and ingestion of fish. The rationale for these exposure route classifications follows.

As noted above, for both child and adult residents, incidental ingestion of soil and house dust will be quantified. As described later in this report (Section 2.3), house dust arsenic concentrations in Middleport did not correlate with yard soil arsenic concentrations. Nevertheless, house dust arsenic has been assumed to contribute to site-related exposures.

Intake of arsenic via the dermal pathway will also be quantified initially using EPA default values. Subsequent analyses will incorporate site-specific evidence of minimal transfer of arsenic across the skin (Exponent 2007; Lowney et al. 2007). A study in monkeys that included a soil sample collected from the Middleport site found 0.5 percent or less dermal absorption from each of two soil samples. Following application of arsenic-bearing soils to the abdomens of the monkeys, urinary arsenic excretion could not be readily distinguished from background (Lowney et al. 2007), suggesting that absorption was negligible.

Arsenic exposure through inhalation of suspended particulates will only be evaluated qualitatively because risks associated with inhaled dust are typically orders of magnitude lower than risks associated with other exposure pathways, unless unusual circumstances are present. This point is illustrated by considering EPA's residential soil screening levels (SSLs). The SSL for inhalation of fugitive particulates for arsenic is 1,875 times higher than the SSL for soil

ingestion (USEPA 1996). The well-maintained lawns throughout most of Middleport are also expected to minimize the potential for resuspension of soil.

Surface water is not included in the air deposition area or the Culvert 105 study area north of the canal, so it will not be considered as a source of exposure. Exposure through contact with groundwater will not be evaluated because arsenic present in groundwater is likely not a result of site activities and because, to our knowledge, groundwater is not used for drinking water. The materials sampled in the study areas are considered soils rather than sediments, so exposures to sediments are not relevant for the purposes of this HHRA.

As shown by several studies, arsenic exposures through consumption of homegrown produce are likely to be far exceeded by arsenic intake from purchased foods unrelated to the site. Biomonitoring conducted in Middleport found no correlation between consumption of homegrown produce and urinary arsenic levels (Tsuji et al. 2005), which is consistent with findings from other studies (Hwang et al. 1997, Polissar et al. 1987, UCDEH 1997). A recent comprehensive risk assessment conducted by EPA for a Denver, Colorado, site also indicated minimal incremental arsenic exposures via homegrown produce (USEPA 2001b). Based on this body of evidence that includes a site-specific study, dietary intake will not be quantified in the initial phase of the risk assessment.

A subsequent phase of the risk analyses in the CMS will incorporate consumption of arsenic in drinking water and dietary intake as an element to assess total background arsenic exposure so that a realistic evaluation of the fractional reduction of arsenic exposure associated with remedial options can be calculated.

For subsurface soils relative to Culvert 105, the primary receptors of concern are utility workers performing maintenance activities. In areas where the culvert is buried, this could involve trench work. For this exposure scenario, the exposure pathways to be quantified are incidental ingestion of and dermal contact with soil.

2.2 IDENTIFICATION OF CONSTITUENTS OF CONCERN

Arsenic has been identified as the primary COC for the Middleport HHRA, based on its presence in area soils and the potential that historical FMC facility activities may have contributed to concentrations exceeding background (Arcadis 2009a, 2009b). Delineation of other constituents in addition to arsenic that are potentially FMC-related in soil samples within the three study areas has also been conducted and is presented in Volumes II and IV of the RFI report (Arcadis 2009a, 2009b). As part of the delineation, non-arsenic constituent data were compared to background concentrations of metals in soil in the Middleport area, to the SSLs previously presented in the 1999 draft RFI report (CRA 1999¹), and to the NYSDEC SCOs

¹ CRA (1999) is also cited as the source for the screening levels in the 2009 RFI reports (Arcadis 2009a, 2009b).

identified in NYCRR Subpart 375-6.8(b). However, to determine whether further risk-based evaluation of these non-arsenic constituents is needed, additional screening, described below, was conducted for three categories of site soils.

2.2.1 Evaluation of Non-Arsenic Constituents of Potential Concern

As described previously, the CMS will include alternatives for three categories of site soils: surface soils within the air deposition study area, surface soils within the Culvert 105 study area north of the canal, and subsurface soils within the Culvert 105 study areas north and south of the canal. Surface and subsurface soil samples collected for these three study areas have been tested for a wide range of constituents on the master compound list (see Appendix 2A of the RFI report, Volume I [Arcadis and AMEC Geomatrix 2009]), which was developed to represent materials used and/or produced at the facility prior to 1988, including known degradation products and impurities. Included on the master compound list is the off-site investigation parameter list (see Table 3.2 of the RFI report, Volumes II and IV [Arcadis 2009a, 2009b]), which was developed based on criteria that included the quantity of a compound handled at the facility, and its persistence and mobility in the environment.

Data considered in this evaluation were obtained from Appendix D tables presented in Volumes II and IV of the RFI report (Arcadis 2009a, 2009b). Sample data for site soils that were previously removed or excavated were omitted from this screening evaluation. Backfill soils used in place of excavated or removed soils were tested for arsenic and other constituents to confirm that the soil was “clean,” and pre-approved by the Agencies for use as backfill. Backfill soil concentrations were not included in this screening evaluation. For sample results reported as undetected, the reported detection limit at its full concentration value was considered in the screening. Duplicate results reported for the same sample were averaged prior to screening. Split sample results reported by both FMC and the agencies were not combined prior to screening. Summary statistics for constituents included in the screening are presented for the air deposition study area, Culvert 105 study area north of the canal, and Culvert 105 study area subsurface soils in Tables 1, 2, and 3, respectively.²

Based on this screening, it is anticipated that remediation alternatives will be based on arsenic concentrations. While other constituents (lead, chlorinated pesticides, and other metals) have been detected during the various sampling events at locations within the study areas, as described below, these constituents are not considered constituents of potential concern for the CMS based on their low frequency of detection, low concentrations, infrequent occurrence above screening levels, and/or occurrence due to natural conditions or non-site-related activities.

² The chemical lists in Tables 1, 2 and 3 are consistent with those addressed in RFI Volumes II and IV (Arcadis 2009a, 2009b). Each chemical listed was analyzed at least once in one of the three study areas.

2.2.1.1 Soil Screening Values

Table 4 summarizes all of the soil screening values used in this screening evaluation. Consistent with the letter from FMC to the Agencies dated March 28, 2008 (FMC 2008), evaluation of non-arsenic constituents of potential concern utilized the soil screening values that were presented in the 1999 draft RFI report (CRA 1999). These soil screening values consisted of health risk-based SSLs derived for residential and industrial settings using conservative, non-site-specific assumptions and protocols in accordance with EPA guidance (USEPA Soil Screening Guidance: Technical Background Document [USEPA 1996a]).

As noted in EPA's soil screening guidance (USEPA 1996b), SSLs alone are not considered regulatory agency "triggers" for response actions, nor do they define unacceptable concentrations of constituents in soil. Rather, SSLs can be used to screen out contaminants, areas, and conditions that do not warrant further investigation or action.

Table 4 includes the SSLs for both the ingestion and inhalation pathways for both residential and industrial settings. The non-arsenic soil analytical data for each study area were compared to the lowest of the following: 1) the ingestion SSL value for the residential land use type; 2) the inhalation SSL value for the residential land use type; or 3) the saturation concentration, if applicable. In addition, the non-arsenic soil analytical data for each study area were also compared to the lowest of the following: 1) the ingestion SSL value for the industrial land use type; 2) the inhalation SSL value for the industrial land use type; or 3) the saturation concentration, if applicable.

In addition to the SSLs, Table 4 also includes residential and industrial SCOs identified in NYCRR Subpart 375-6.8(b). SCOs were promulgated in 2006 by the New York State Department of Environmental Conservation (NYSDEC) for a wide variety of constituents and with consideration of different property types/usage. The SCOs were developed from ecological and human health-based criteria, and in some cases, from a state-wide background database. The Agencies have indicated that the SCOs, presented in 6 NYCRR Subpart 375-6.8(b) of the NYSDEC regulations, are appropriate for use as comparison criteria in the RFI for the non-arsenic constituents (Arcadis 2009a,b). The non-arsenic soil analytical data for each study area were compared to residential and industrial SCOs where available.

2.2.1.2 Soil Background Levels

The presence of naturally occurring metals in soil and anthropogenic sources of many of the site-related constituents that are not related to past facility operations complicates the evaluation of the source, nature, and extent of these constituents. Past activities that involved these constituents within the study areas, but are not related to facility operations, include:

- Using imported fill of unknown origin for excavation projects and grading

- Storing coal and depositing coal ash
- Using lead-based paints
- Disposing wastes (e.g., household trash, lead-based paint chips, etc.)
- Using pesticides, lawn and plant care products (e.g., fertilizers, amendments), and/or other chemicals at residential, municipal, governmental, school, agricultural, and commercial properties
- Using pressure-treated lumber
- Vehicular traffic and associated emissions.

As discussed in Volumes II and IV of the RFI report (Arcadis 2009a,b), between 1985 and 1993, studies that were conducted to evaluate the background concentration of arsenic in soil in the Middleport area also included evaluation of other metals, including those on the off-site parameter list and others. Table 8.1 of Volume II of the RFI report (Arcadis 2009a) provides the combined results for each metal in 13 soil samples collected at 11 locations, where the locations were identified by the Agencies in a letter to FMC dated January 24, 1996 (NYSDEC and USEPA 1996). The 11 sampling locations are variously located approximately 0.5 to 2 miles east of the facility and approximately 2.5 to 5 miles west of the facility.

These background data were considered, as appropriate, within the context of the constituent screening presented below for each study area.

2.2.2 Evaluation of Constituents of Potential Concern in Surface Soils within the Suspected Air Deposition Study Area

Within the air deposition area, sample results are reported for most of the chlorinated pesticides, metals, phenolic compounds, volatile organic compounds (VOCs), and semivolatiles organic compounds (SVOCs) listed in Table 1. Results are also reported for some furans and carbamates as well as other miscellaneous compounds. Analytical results for chlorinated herbicides and organophosphate pesticides were not available for this study area.

As shown in Table 1, for many of the analytes, including the vast majority of VOCs and SVOCs, the frequency of analysis was low and the frequency of detection was 0 percent. Most frequently detected constituents included: 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, lead, aluminum, barium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, mercury, nickel, potassium, titanium, vanadium, zinc, and naphthalene. Of these, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, lead, aluminum, copper, iron, manganese, mercury, and zinc are on the off-site investigation parameter list.³

³ The off-site investigation parameter list is a subset of the master compound list developed based on criteria including the quantity of a compound handled at the facility and its persistence and mobility in the environment.

Maximum reported concentrations of the following 11 constituents were greater than one or both of the residential screening values (Table 5): 4,4'-DDE, aldrin, beta-BHC, dieldrin, heptachlor epoxide, toxaphene, beryllium, cadmium, chromium, iron, and thallium. However, the maximum reported concentrations were lower than the industrial SSLs and SCOs in all cases where values were available for comparison. Of the constituents with maximum reported concentrations exceeding residential screening values, aldrin, heptachlor epoxide, toxaphene, cadmium, and thallium were never detected. For cadmium, five of the 11 sample results had detection limits ranging from 3 to 4 mg/kg, slightly above the residential SCO of 2.5 mg/kg, but well below the residential SSL of 78.2 mg/kg. The cadmium residential SCO represents the rural soil background concentration determined by the NYSDEC and NYSDOH (2006) rural soil survey. For thallium, six of the eight samples with nondetect results had detection limits that exceeded the residential SSL. However, all of the detection limits were within the range of values reported for thallium in the background sampling locations identified by the Agencies in 1996. NYSDEC has not published a residential SCO for thallium.

Both residential screening values were exceeded for 4,4'-DDE and aldrin. The residential SCO was exceeded for beta-BHC and dieldrin. The SCO for beta-BHC is considerably lower (72 mg/kg) than the corresponding SSL (356 mg/kg). In contrast, the SCO and SSL for dieldrin are very similar (39 and 40 mg/kg, respectively). The single detection limit for dieldrin that exceeded the SCO was 40 mg/kg, equivalent to the SSL. Heptachlor epoxide and toxaphene exceeded only their residential SSLs. No residential SCOs have been published for these constituents. For all six constituents, the exceedances occurred at a single surface soil sample (location ID "1") collected as part of the 1986 NYSDEC Roy-Hart site investigation. None of the other six to 10 sample results reported for these constituents exceeded the residential screening values.

For chromium, three sample results (each reported at 40 mg/kg) slightly exceeded the residential SCO (36 mg/kg), but were all well below the residential SSL (270 mg/kg). All three results were associated with two surface samples (SS-01-85 [a split sample] and SS-02-85) collected during the 1985 Roy-Hart surface soil sampling and analysis program.

For beryllium, all results exceeded the residential SSL of 0.15 mg/kg, but were well below the residential SCO and all of the detected concentrations were within the range of values reported for beryllium in the background sampling locations identified by the Agencies in 1996. However, the detection limits for two of the five undetected results reported for beryllium exceeded this background range. As with chromium, the two high detection limit samples were SS-01-85 and SS-02-85 collected during the 1985 school property sampling. Neither chromium nor beryllium is on the off-site investigation parameter list.

For iron, detections reported for three samples exceeded the residential SSL, but all were within the range of values reported for iron in the background sampling locations identified by the Agencies in 1996.

Based on consideration of the above screening evaluation, none of the 11 constituents that exceeded one or both residential screening values will be carried forward for further evaluation in the risk assessment (Table 5). For these constituents, exceedances were generally associated with a low frequency of detection and sporadically high detection limits. In addition, as discussed above, results exceeding screening values generally occurred infrequently, were close to the screening level values, and were within background range for those constituents where background data were available.

2.2.3 Evaluation of Constituents of Potential Concern in Surface Soils within the Culvert 105 Study Area North of the Canal

As summarized in Table 2, within the Culvert 105 study area north of the canal, sample results are reported for most of the chlorinated pesticides, phenolic compounds, furans and carbamates, chlorinated herbicides, and organophosphate pesticides, but only for a limited number of metals and no VOCs or SVOCs.

As shown in Table 2, for many of the analytes, the number of sample results was low and the frequency of detection was 0 percent. Most frequently detected constituents included 4,4'-DDE, 4,4'-DDT, lead, aluminum, cadmium, copper, iron, manganese, and zinc, all of which are on the off-site investigation parameter list.⁴

Maximum result concentrations were greater than one or both of the residential screening values for the following seven constituents: aldrin, beta-BHC, dieldrin, toxaphene, lead, cadmium, and 4,6-dinitro-2-methylphenol (Table 6). However, the maximum concentration reported for each constituent was lower than the constituent's industrial SSL and SCO in all cases where values were available for comparison, with one exception, beta-BHC. For this constituent, exceedance of the industrial screening values was attributable to a single surface soil sample, C-6 collected during the off-site investigation in 1990. This sample was also for the only one where beta-BHC exceeded both residential screening values. As described in the RFI report, Volume IV (Arcadis 2009b), the result reported for beta-BHC in this sample is considered suspect for several reasons:

- "Sample C-6 (0- to 6-inch) was reported in Table 5.20 of the OSI [Off-Site Investigation] Report (CRA 1993) to contain beta-BHC at a concentration of 51 mg/kg, and no detectable levels of the other three (alpha, delta, gamma) target BHC isomers, with a reporting limit three orders of magnitude lower (0.02 mg/kg)."
- "Elevated levels of beta-BHC are not expected to be found in the absence of other isomers because technical-grade BHC contains a mixture of isomers, with a composition of approximately 5 to 12 percent beta-BHC, 10 to 15 percent gamma- BHC, 60 to 70

⁴ The off-site investigation parameter list is a subset of the master compound list developed based on criteria including the quantity of a compound handled at the facility and its persistence and mobility in the environment.

percent alpha-BHC, and the balance as other isomers (Agency for Toxic Substances and Disease Registry [ATSDR] 2005)."

- "Upstream, downstream, and other nearby samples do not exhibit elevated levels of beta-BHC, including sample C-6 (6- to 12-inch interval), with no detectable levels at a reporting limit of 0.083 mg/kg. A total of 82 other soil samples were analyzed for beta-BHC, and the next highest reported concentration was 0.14 mg/kg, approximately 360 times lower than the value reported for sample C-6 (0- to 6-inch)."

Consequently, beta-BHC will not be carried forward for further risk evaluation based on a low frequency of detection and the suspect result, which represents the only screening value exceedance.

Each of the remaining six constituents exceeding residential screening values, except 4,6-dinitro-2-methylphenol, is on the off-site investigation parameter list. Aldrin, toxaphene, and 4,6-dinitro-2-methylphenol were never detected, but were reported with detection limits which exceeded the corresponding screening values. For aldrin, one of the 18 undetected results reported a detection limit (20 µg/kg) that was slightly greater than the residential SCO (19 µg/kg), but lower than the residential SSL (37.7 mg/kg). For toxaphene, three of the 18 undetected results had detection limits above the residential SSL (920–1,100 µg/kg vs. the residential SSL of 582 µg/kg). NYSDEC has not published a residential SCO for toxaphene. For 4,6-dinitro-2-methylphenol, only two results were reported for samples remaining in this area. Both were nondetects, but had high detection limits that exceeded residential screening values (11 mg/kg and 41 mg/kg vs. the residential SSL of 7.8 mg/kg).

For cadmium, one of the two sample results (2.7 mg/kg) slightly exceeded the residential SCO of 2.5 mg/kg, but was well below the residential SSL of 78.2 mg/kg. As stated previously, the cadmium residential SCO represents the rural soil background concentration determined by a NYSDEC and NYSDOH (2006) rural soil survey. For lead, one of 19 sample results (492 mg/kg) was slightly greater than the residential SSL and SCO, both 400 mg/kg.

For dieldrin, three of the 19 sample results were detected and each of these detected results (48, 84, and 290 mg/kg) exceeded residential screening values (SCO = 39 mg/kg; SSL = 40 mg/kg). Evaluation with the RFI report of the distribution of dieldrin within Culvert 105 indicated a pattern that is not consistent with the pattern expected if originating from the facility (Arcadis 2009b). Specifically, the distribution was not consistent with the expectation of higher concentrations upstream and concentrations decreasing with distance downstream. For that reason, the dieldrin detections are unlikely to be related to the facility and dieldrin will not be carried forward for further evaluation in the risk assessment.

With the exception of 4,6-dinitro-2-methylphenol and dieldrin, the frequency of elevated results for surface soils within the Culvert 105 study area north of the canal was low and generally associated with nondetects having high detection limits. Detected results above screening levels occurred for lead and cadmium, but were infrequent and close to the screening values.

Based on these considerations, aldrin, toxaphene, lead, and cadmium will not be carried forward for further evaluation in the risk assessment (Table 6).

4,6-Dinitro-2-methylphenol is a constituent identified on the master compound list, but not on the off-site investigation parameter list. Given the limited data available for this constituent, excavated sample data for this constituent were also reviewed to better understand the frequency of detection for this constituent. This review revealed high detection limits (10–24 mg/kg) throughout the additional limited excavated data and no detections. Based on the low frequency of detection, elevated detection limit issues, limited data availability, and the absence of this constituent from the off-site parameter investigation list, 4,6-dinitro-2-methylphenol will not be carried forward for further evaluation in the risk assessment.

2.2.4 Evaluation of Constituents of Potential Concern within Culvert 105 Study Area Subsurface Soils

As summarized in Table 3, Culvert 105 subsurface soil sample results are reported for most of the chlorinated pesticides, phenolic compounds, furans and carbamates, chlorinated herbicides, and organophosphate pesticides, but only for a limited number of metals and no VOCs or SVOCs.

As shown in Table 3, for many of the analytes, the frequency of analysis was low and the frequency of detection was 0 percent. Most frequently detected constituents included lead, aluminum, cadmium, copper, iron, manganese, and zinc. All of these constituents are on the off-site investigation parameter list.⁵

Constituents in Culvert 105 subsurface soils will be evaluated in the risk assessment for exposures by utility workers. However, it is possible that, during utility work, subsurface soils could be brought to the surface where residents could contact them. Therefore, both residential and industrial screening values were compared to Culvert 105 subsurface soil concentrations in this screening.

The maximum concentration reported for each constituent was lower than the constituent's industrial SSL and SCO in all cases where values were available for comparison. Maximum results for the following 11 constituents exceeded one or both of their residential screening values: aldrin, beta-BHC, alpha- and gamma-chlordane, dieldrin, heptachlor epoxide, isodrin, toxaphene, lead, iron, and 4,6-dinitro-2-methylphenol (Table 7).

Six of the listed constituents (aldrin, beta-BHC, heptachlor epoxide, isodrin, toxaphene, and 4,6-dinitro-2-methylphenol) were detected in 5 percent or fewer of the samples analyzed for them. As discussed previously (Section 2.2.3), 4,6-dinitro-2-methylphenol is eliminated from further

⁵ The off-site investigation parameter list is a subset of the master compound list developed based on criteria including the quantity of a compound handled at the facility and its persistence and mobility in the environment.

consideration because it was never detected and it is not on the off-site investigation parameter list. The exceedances of residential screening levels reported for the other five constituents were limited to a few elevated detection limits. Aldrin and toxaphene were never detected in any of the three study areas.

The exceedances of residential screening levels reported for alpha- and gamma-chlordane were limited to one elevated detection limit out of 61 samples analyzed for each chemical. Only one result out of 62 samples analyzed for lead exceeded the residential screening levels. The concentrations of iron were within the background concentrations determined by the NYSDEC and NYSDOH (2006) rural soil survey. As discussed previously in Section 2.2.3, the distribution of dieldrin along Culvert 105 was not consistent with FMC as a source of this chemical.

Based on these considerations, none of the non-arsenic constituents in Culvert 105 subsurface soils will be carried forward for further evaluation in the risk assessment (Table 7).

2.3 ARSENIC CONCENTRATION DATA

Arsenic concentration data are available for surface and subsurface soil samples collected in Middleport, surface soil samples collected in a town representative of background conditions, house dust samples collected in Middleport, and house dust samples collected in a non-industrial North American setting similar to Middleport. Following is a discussion of how these site-specific data were evaluated for inclusion in both deterministic and probabilistic risk analyses.

Probabilistic risk analysis methods require a data set of sufficient quantity and quality to produce a distribution that is representative of the critical input parameters. The available study area and background surface soil sample data sets were evaluated to determine whether they are of sufficient quantity and quality to support a probabilistic risk analysis approach for surface and subsurface soil. Additional details regarding creation and evaluation of the study area and background surface soil arsenic data sets are provided in Appendix A.

2.3.1 Surface Soil

2.3.1.1 Suspected Air Deposition Study Area Arsenic Data Set

Arcadis provided Integral with a database containing arsenic and other chemical data for soil samples collected in the air deposition area. The original database of 23,400 data points was filtered⁶ to create the 1,837 surface soil arsenic sample data set that will be used for the risk

⁶ As described in Appendix A, filtering mechanisms involved excluding non-arsenic analytes, arsenic data from toxicity characteristic leaching procedure analysis, samples collected during tributary/culvert sampling events, and any samples removed as part of the 1996 Bleacher Area or 2005 Phase I North Railroad ICMs, and including only

assessment within the air deposition area. A surface sample is defined as one having a start depth of 0 in. below ground surface (bgs) (end depths vary from 0.5 to 6 in. bgs). Of the 1,837 samples, 1,589 samples were collected from property types classified as residential, while the remaining 248 samples were collected from non-residential property types, including agricultural, commercial, industrial, and school.

The resulting surface soil arsenic sample data set for the air deposition area is shown in Figure 2. The unevenness of the data seen at the low end of the distribution is evidence of a large increase in very low values due to low backfill arsenic concentrations following remediation of select properties.

For deterministic analyses, the mean of the data set will be used for the CTE case and the upper 95 percent confidence limit on the mean (95UCL)⁷ will be used for the RME case. The data set shown in Figure 2 was evaluated for the best fitting distribution and determined by Oracle's Crystal Ball[®] software (Gentry et al. 2005) to be gamma distributed.⁸ The surface soil data for the air deposition area will be incorporated into probabilistic analyses via direct sampling from the data set, as opposed to defining a standard distribution using shape parameters (e.g., mean and standard deviation for the normal distribution).

2.3.1.2 Arsenic Data Set for Culvert 105 Study Area North of Canal

Arcadis also provided Integral with a database containing arsenic and other chemical data for soil samples collected in the Culvert 105 study area north of the canal. The original database of 563 data points was filtered in the same manner used for the air deposition area data, as described in Appendix A, to create the 288 surface soil arsenic sample data set that will be used for the risk assessment within the study area north of the canal. A surface sample is defined as one having a start depth of 0 in. bgs (end depths vary from 3 to 6 in. bgs). The resulting surface soil arsenic sample data set for the study area north of the canal is shown in Figure 3. The unevenness of the data seen at the low end of the distribution is evidence of a large increase in very low values due to low backfill arsenic concentrations following remediation of select properties.

For deterministic analyses, the mean of the data set will be used for the CTE case and the 95UCL⁹ will be used for the RME case. The data set shown in Figure 3 was evaluated for the

sample average values, where averages incorporate the sample result and any associated duplicate/split samples, and samples with a start depth of 0 in. bgs.

⁷ The 95UCL for the air deposition area was calculated via 95 percent Chebyshev (mean,sd) as recommended by USEPA's (2007) ProUCL.

⁸ A gamma distribution is a two-parameter family of continuous probability distributions based on the sum of one or more exponentially distributed variables. Under some conditions, it can look similar to the lognormal distribution, particularly at sample sizes smaller than 50 to 70.

⁹ The 95UCL for the area north of the canal was calculated via 97.5 percent Chebyshev (mean,sd) as recommended by USEPA's (2007) ProUCL.

best fitting distribution and determined by Oracle's Crystal Ball® software (Gentry et al. 2005) to be distributed lognormally. The surface soil data for the study area north of the canal will be incorporated into probabilistic analyses via direct sampling from the data set.

2.3.1.3 Background Arsenic Data Sets

Middleport background conditions are assumed to be represented by the soil arsenic concentrations in Gasport, a town located 4.5 miles west of Middleport with similar soil characteristics and historical land uses but not potentially impacted by historical FMC plant operations. As described in Appendix A, background data sets were generated based on 103 surface soil samples (start depth 0 in. bgs, end depth 3 in. bgs) collected in Gasport and documented in Table 1 of *Development of Arsenic Background in Middleport Soils* (CRA 2003). The Middleport surface soil data sets cannot be compared directly to the Gasport surface soil data set because the Gasport samples were not collected from particular property categories (e.g., residential, agricultural) in the same proportions as have been present historically within Middleport. Instead, background data sets expected to be representative of background conditions in Middleport without the influence of the FMC facility were created by applying Middleport property type data for both the air deposition area and Culvert 105 study area north of the canal to the Gasport data set.

Historical land usage is not always clear, so multiple background data sets were generated to accommodate the multiple possible Middleport land usage assumptions. Each background data set created to match the air deposition area contains 1,837 values, and each background data set created to match the Culvert 105 study area north of the canal contains 287 values, so that background data sets are the same sizes as corresponding study area data sets. Each background data set was generated via a similar process that consisted of subdividing the Gasport samples into land use categories, performing distribution goodness-of-fit testing, creating a larger data subset of 1,000 forecast values for each land use category, and sampling from each of the forecast data subsets according to the property type/land usage group weighting factors appropriate to the air deposition area and Culvert 105 study area north of the canal to result in a data set of the appropriate total values representing study area background conditions. This process was repeated for each of four sets of property type/land usage group weighting factors (Appendix A, Attachment 1) and both including and excluding four samples identified as potential outliers in one of the four property type/land usage groups. As a result, eight background data sets were created. Figure 4 shows two example background data sets, generated by incorporating the 2001 Gasport Background Study Work Plan Method (2001 Work Plan Method) calculations¹⁰ for the air deposition area and the Culvert 105 study area north of the canal, and including the four potential outliers. Alternative background data sets generated according to land use assumptions used by the agencies will also be evaluated.

¹⁰ Refer to Appendix A for a description of the calculation methods.

For deterministic analyses, the means of the data sets will be used for the CTE cases and the 95UCLs¹¹ will be used for the RME cases. The background data sets shown in Figure 4 and six additional generated background data sets were evaluated for the best fitting distributions and all were determined by Crystal Ball® to be lognormally distributed. The background data for the study areas will be incorporated into probabilistic analyses via direct sampling from the data sets.

2.3.1.4 Adequacy of Surface Soil Data Sets for Probabilistic Risk Assessment

Because the surface soil data sets for the air deposition area, the Culvert 105 study area north of the canal, and background appear to be of sufficient quantity and quality such that representative distributions can be established, the data sets are adequate for incorporating into probabilistic analyses.

These distributions could be used in two different ways. The data sets could be specified as custom distributions and sampled from directly, or the distributions could be specified based on the gamma and lognormal distribution parameters as applicable. Direct sampling from the data sets was selected as the best approach to adequately reflect the unevenness of the data seen at the low ends of the distributions for the air deposition area and the Culvert 105 study area north of the canal, to accurately reflect the characteristics of the created background data sets, and so that the background data sets are treated similarly to the site data sets.

Use of available site surface soil sample data could miss arsenic concentrations that potentially exist at the very high and very low ends of the concentration distribution. However, given the large number of samples in the two site surface soil data sets, the likelihood of inaccurately representing the distribution tails is small. Furthermore, when used in the Monte Carlo analysis, it is assumed that a receptor is exposed to one sample location for his or her entire exposure duration. In contrast, an individual's actual exposures will be integrated over a range of sample locations. Thus, the upper tail of the distribution will overestimate the highest exposures for an individual and the lower tail will underestimate the lowest exposures. For the background data sets, high and low distribution tails should be adequately represented because they contain data generated from specified distributions.

2.3.2 Culvert 105 Subsurface Soil

The database received contained 942 subsurface soil sample data points collected at start depths of 6 in. bgs and below (end depths vary from 9 to 90 in. bgs) relevant to subsurface soils along the culvert. The subsurface data set was filtered in the same manner used for the other two study areas, and additional samples collected from 3 to 6 in. bgs were added to create a final database of 1,246 samples. The resulting subsurface soil arsenic sample data set is shown in

¹¹ The 95UCLs for the background data sets were calculated via either 95 percent or 97.5 percent Chebyshev (mean,sd) as recommended by USEPA's (2007) ProUCL.

Figure 5. The unevenness of the data seen at the low end of the distribution is evidence of a large increase in very low values due to low backfill arsenic concentrations following remediation of select properties.

For deterministic risk analyses of the utility worker scenario, the mean of the data set will be used for the CTE case and the 95UCL¹² will be used for the RME case. The data set shown in Figure 5 was evaluated for the best fitting distribution and determined by Oracle's Crystal Ball® software (Gentry et al. 2005) to be distributed lognormally.

2.3.3 House Dust

Site-specific house dust arsenic concentration data were collected from 96 homes in Middleport in the summer and fall of 2003 (Tsuji et al. 2005). For deterministic analyses, the geometric mean reported in the study will be used for the CTE case and a 95UCL calculated from the geometric mean and the geometric standard deviation, assuming a sample size of 96, will be used for the RME case to represent house dust concentrations in the air deposition area and the Culvert 105 study area north of the canal. For probabilistic analyses, the geometric mean, geometric standard deviation, minimum, and maximum concentrations reported in the study will be used to define the distribution for house dust concentrations in the two study areas. Use of these data to represent the house dust arsenic concentration distribution assumes that the 96 sampled homes are similar to unsampled homes within the study areas and that the summer and fall house dust concentrations are similar to year-round concentrations. In addition, use of the minimum and maximum concentrations specified in Table 8 assumes that the minimum and maximum of the data set are the true minimum and maximum, and neither under- nor over-estimate the seasonally averaged minimum and maximum.

Tsuji et al. (2005) also collected soil sample arsenic concentration data from a majority of the homes for which residents consented to house dust sampling. The authors found that arsenic in soil appeared to contribute little to arsenic in house dust and that house dust arsenic concentrations were not correlated with average or maximum soil arsenic concentrations. Therefore, study area house dust arsenic concentrations are assumed to be similar to background house dust arsenic concentrations, and the same distribution could be used to represent both the study areas and background conditions.

An alternative source of background house dust data is a study conducted in the winter of 1993 in 50 homes in 10 neighborhoods located across Ottawa, Ontario in Canada (Rasmussen et al. 2001). Because Ottawa is located only approximately 200 miles (straight-line distance) from Middleport and is considered a "non-industrial North American setting," similar to Middleport, but without the influence of FMC facility activities, the Ottawa house dust data were also

¹² The 95UCL for subsurface soils was calculated via 97.5 percent Chebyshev (mean,sd) as recommended by USEPA's (2007) ProUCL.

assumed to represent potential background conditions. The geometric mean and maximum values from the Rasmussen et al. (2001) study (4.9 and 79.5 mg/kg, respectively) are lower than those from the site data (10.8 and 172 mg/kg, respectively).¹³ The Middleport data likely reflect the regional influence of historical arsenical pesticide use in orchards, a factor not expected to have as much influence in Ottawa. Nevertheless, the Rasmussen et al. (2001) study was selected as a more conservative representation of background conditions for comparison with both study areas. For the probabilistic analyses, the mean, 95th percentile, minimum, and maximum values reported in the Rasmussen et al. (2001) study will be used to define the distribution of house dust concentrations. For the deterministic analyses, the arithmetic mean value of 7.3 mg/kg will be used for both the CTE and the RME cases because the 95th percentile value is higher than the RME value calculated for Middleport based on the Tsuji et al. (2005) study and insufficient data are available to calculate a 95UCL based on the Rasmussen et al. (2001) study. It was considered desirable to have an RME background house dust concentration lower than the RME study area house dust concentration.

Use of these data as a surrogate for background conditions assumes that the winter house dust concentrations are similar to year-round concentrations and that the study home construction characteristics are similar to those of homes within the two Middleport study area. Although the distribution of the data was not specified, use of a lognormal distribution was deemed appropriate based on the distribution assumed by Tsuji et al. (2005) and because of the disparity between the study data arithmetic mean and median (7.3 and 4.1 mg/kg, respectively). Finally, use of the minimum and maximum concentrations specified in Table 8 assumes that the minimum and maximum of the data set are the true minimum and maximum, and neither under- nor over-estimate the seasonally averaged minimum and maximum.

2.4 RESIDENTIAL EXPOSURE FACTORS

Arsenic exposures will be calculated using factors that incorporate scenario- and receptor-specific exposure assumptions. For the air deposition area and the Culvert 105 study area north of the canal, the receptors being evaluated are child and adult Middleport residents. The exposure pathways being evaluated are incidental ingestion of and dermal contact with arsenic in soil and house dust. Two equations will be used to calculate exposures. The first equation below, which will be used to calculate intakes due to ingestion exposures, is a modification of the general equation presented in EPA risk assessment guidance (USEPA 1989). The second equation below, which will be used to calculate intakes due to dermal exposures, is a modification of the general equation presented in EPA dermal assessment guidance (USEPA 2004b).

¹³ The arithmetic mean dust concentration for the Rasmussen study is 7.3 mg/kg. No arithmetic mean is provided in Tsuji et al. (2005).

$$I = \frac{[(C_s \times EF_s \times FI_s) + (C_d \times EF_d \times FI_d)] \times IR \times ED \times RBA \times FS \times CF}{BW \times AT}$$

Equation 1. Soil and Dust Ingestion Equation for Residential Scenario

Where:

I	=	daily intake of contaminant (mg/kg-day)
C _s	=	contaminant concentration in soil (mg/kg)
EF _s	=	exposure frequency to soil (days/year)
FI _s	=	fractional intake from soil (unitless)
C _d	=	contaminant concentration in house dust (mg/kg)
EF _d	=	exposure frequency to house dust (days/year)
FI _d	=	fractional intake from house dust (unitless) = 1 - FI _s
IR	=	ingestion rate (mg/day)
ED	=	exposure duration (years)
RBA	=	relative bioavailability adjustment factor (unitless)
FS	=	fraction ingested from source (unitless)
CF	=	conversion factor (1 × 10 ⁻⁶ kg/mg)
BW	=	body weight (kg)
AT	=	averaging time (equal to ED × 365 days/year for noncarcinogens and 70 years × 365 days/year for carcinogens)

$$I = \frac{[(C_s \times EF_s \times FI_s) + (C_d \times EF_d \times FI_d)] \times EV \times AF \times SA \times ABS_d \times ED \times FS \times CF}{BW \times AT}$$

Equation 2. Soil and Dust Dermal Contact Equation for Residential Scenario

Where:

EV	=	event frequency (events/day)
AF	=	adherence factor (mg/cm ² -event)
SA	=	surface area (cm ²)
ABS _d	=	chemical-specific dermal absorption factor (unitless)

(Other parameters are as defined above in Equation 1.)

The variables shown in the intake equations above (Equations 1 and 2) are called exposure factors and vary depending on the receptor population being evaluated. Exposure factor data

will be obtained from a variety of sources. Site-specific soil and house dust arsenic concentration data are available, as discussed above, and will be used to generate statistical values and probability density functions for C_s and C_a . Data for other exposure factors will be obtained from the literature. The *Exposure Factors Handbook Volume 1* (USEPA 1997b) and *Child-Specific Exposure Factors Handbook* (USEPA 2008b) were consulted as preferred exposure factor references, with updates supported by more recent studies applied as appropriate.

For the deterministic analyses, CTE and RME values will be used for each parameter. Values for some parameters will vary between the default and the site-specific deterministic analyses, while the values for other parameters will remain the same. For the probabilistic analyses, exposure factors will be in the form of either probability distributions or point estimates, depending on the parameter and information available. Exposure factors and associated references are identified for the probabilistic risk assessment in Table 8 and for the deterministic analyses in Table 9. If a receptor is not identified for a particular exposure factor, the exposure factor data shown are assumed to be representative of both child and adult residents. A rationale for use of the exposure factors is described in the following text.

2.4.1 Ingestion Rates

Incidental ingestion rates of soil and dust vary based on several factors, such as the frequency of an individual's hand-to-mouth behaviors and individual personal hygiene practices. Studies have found that young children, who have the most frequent hand-to-mouth behaviors, also have the highest soil/dust ingestion rates and this is the reason young children are evaluated separately in risk assessment.

The default deterministic analyses will use EPA's default soil ingestion rates of 100 and 200 mg/day for children (CTE and RME, respectively) and 50 and 100 mg/day for adults (CTE and RME, respectively) (USEPA 1993, 2002, 2008b). Given that these values are highly uncertain, alternate values will also be used as described below. The following text provides a summary of the soil ingestion studies most relevant for assessing exposures in Middleport, and rationale for the development of soil ingestion distributions for use in the probabilistic risk assessment.

Although the goal of characterizing variability in ingestion rates is to ascertain the variability in average rates over long time periods such as years, relevant soil ingestion studies have been performed over much shorter time periods such as days. Estimates of ingestion rates derived from short-term studies overestimate upper percentile values of soil ingestion over longer averaging times. In other words, the highest intake rates observed in a short term study will be much higher than the highest intake rates when the behavior of the study group is averaged over a longer time period. Stanek and Calabrese (2000) and Stanek et al. (2001a, 2001b) addressed the uncertainty related to use of short-term studies to represent long-term daily average intakes, showing that 95th percentile estimates of soil intake decline substantially when the distribution represents a longer time period. USEPA et al. (2002) recognized the importance

of this issue in their risk assessment of the Rocky Flats site in Colorado, for which they relied upon Stanek et al.'s (2001b) long-term soil ingestion estimate data when generating a probability distribution function for the child soil ingestion rate. Long-term daily average intakes are therefore desired to more accurately represent child and adult soil ingestion rates when evaluating chronic exposures.

USEPA (2008b) presents a comprehensive review of the literature on soil ingestion by children and provides recommended central tendency soil ingestion rate estimates for three age ranges, noting that their recommendations are not sufficiently robust for probabilistic risk assessment. Upper percentile recommendations are characterized as pertaining to soil pica and geophagy. The recommendations do not include such information as distribution descriptions, upper percentile values for normal soil ingestion behavior, or standard deviations, which are necessary for defining probability distribution functions. Furthermore, the central tendency recommendations are supported by neither literature citations nor specific derivations from the key studies included in the literature reviewed. For these reasons, it was necessary to derive a probability distribution function for children's soil ingestion rates directly from the key studies.

A series of papers primarily authored by Stanek and Calabrese presenting analyses of data gathered for children ages 1 to 4 years in Anaconda, Montana, and Amherst, Massachusetts, were consulted. Based on climate similarities between Massachusetts and upstate New York and higher soil ingestion rates that are thus more conservative, use of the Amherst data set was desired over the Anaconda data set for the probabilistic analyses. Most recently, Stanek and Calabrese (2000) presented a long-term 95th percentile child soil ingestion rate estimate of 124 mg/day¹⁴ for a 365-day time period from the Amherst study, the previous estimates for which were published in Stanek and Calabrese (1995). However, to date, the authors have not published a long-term central tendency estimate based on Amherst data. Therefore, Stanek et al. (2001b) was consulted for the most recently published short-term (8-day average) central tendency estimate from the Amherst study. Based on this recent analysis, which resulted in a distribution with a 50th percentile value of 45 mg/day, 45 mg/day will be used as the 50th percentile child soil ingestion rate. Although the more recent Stanek et al. (2001b) publication does not clearly specify the data's distribution type, the Amherst data set was considered to be lognormally distributed in Stanek and Calabrese (1995). USEPA et al. (2002) also considered child soil ingestion rate to be lognormally distributed. Thus, the distribution for child soil ingestion rate will be assumed to be lognormal. For the site-specific deterministic analyses, the 50th percentile value of 45 mg/day will be used for the CTE case and the 95th percentile value of 124 mg/day will be used for the RME case.

The Stanek and Calabrese papers did not include minimum and maximum child soil ingestion rate estimates. Therefore, a minimum ingestion rate of 0 mg/day will be used to avoid the possibility of negative ingestion rates. A maximum ingestion rate of 1,000 mg/day will be

¹⁴ This estimate was obtained after excluding the soil-pica subject.

specified based on the USEPA (2008b) recommended lower-bound soil-pica ingestion rate of 1,000 mg/day. Because soil-pica is considered a special case scenario, children exhibiting soil-pica behaviors will not be included in the probabilistic analyses. The truncation values of 0 and 1,000 mg/day are in agreement with those presented in USEPA et al. (2002).

Less information is available regarding adult soil ingestion rates. Stanek et al. (1997) published an estimated mean adult soil ingestion rate of 10 mg/day and standard deviation of 94 mg/day based on a duplicate diet, mass-balance study conducted in 10 male adult volunteers who ingested varying quantities of soil in capsules. Fecal output of nine inorganic elements was measured and three elements were chosen as reliable tracers for measuring soil ingestion. However, because of the high degree of uncertainty in the results of this small, pilot-sized study, this study has questionable reliability regarding its use in probabilistic analyses. Instead, a lognormal adult soil ingestion rate distribution will be created with 50th and 95th percentile values that are half those of the child soil ingestion rate distribution, or 22.5 and 62 mg/day, respectively. The minimum and maximum ingestion rates will be set to 0 and 1,000 mg/day to mirror the minimum and maximum ingestion rates set for children, respectively. For the site-specific deterministic analyses, these distributions provide alternate assumptions to the EPA default values. Specifically, the 50th percentile value of 22.5 mg/day will be used for the CTE case and the 95th percentile value of 62 mg/day will be used for the RME case.

The statistical methods used by Stanek and Calabrese (2000) and Stanek et al. (2001a, 2001b) account for reduced variability in long-term ingestion rates, but do not account for potential seasonal changes in ingestion rates. It is possible that ingestion rates of house dust decrease during winter months, when less dust settles on indoor surfaces. Edwards et al. (1998) found that the mass of house dust deposited on indoor surfaces of four New Jersey homes, studied over two 30-day periods, was less in February 1995 than in August 1994. The deposition rates ranged from 0.18 to 0.25 $\mu\text{g}/\text{cm}^2\text{-day}$ during the winter and from 0.24 to 0.49 $\mu\text{g}/\text{cm}^2\text{-day}$ during the summer, which were statistically significantly different ($p < 0.009$). More particles were deposited in the winter than in the summer, but winter deposits were smaller, suggesting indoor combustion sources. If house dust ingestion rates decrease during winter months, assuming a constant house dust ingestion rate throughout the year, as in this HHRA, overestimates risks.

2.4.2 Fractional Intake

The ingestion rate parameter discussed above encompasses ingestion of both soil and house dust, so intake fractioning for each medium should be applied when data for each medium are available. USEPA (1994) assumes that 55 percent of soil ingestion comes from house dust. USEPA (1994) cites a study (van Wijnen et al. 1990) in general support of their discussion of the 55 percent fractional intake, but they provide no explanation of their derivation of the value and the data in the van Wijnen et al. (1990) study do not apportion between soil and dust intake. For the deterministic analyses, the EPA default values of 0.45 for soil and 0.55 for house dust

will be used for both the CTE and the RME cases. For the probabilistic analyses, a triangular distribution with 55 percent as the likeliest value will be used because the 55 percent value is expected to vary to some unknown extent. The minimum and maximum values of 30 and 80 percent, respectively, will be used based on professional judgment. The remaining source fraction is assumed to consist of soil.

To determine whether the fractional intake distribution for house dust could be further refined, a time-activity analysis was performed based on data compiled in USEPA (1997b) from the National Human Activity Pattern Survey (NHAPS) (Tsang and Klepeis 1996), one of the largest and most recent of similar U.S.-based surveys available. From statistics representing 24-hour cumulative numbers of minutes spent sleeping or napping, indoors in a residence and outdoors outside the residence, the average fraction of time spent indoors while awake was calculated to approximate the period during which dust ingestion could occur. For ages 1 to 6 years, 18 to 64 years, and all ages, the mean fractional intakes for house dust were approximated to be 0.60, 0.48, and 0.52, respectively. These values are all close to the likeliest value of 0.55 for the fractional intake distribution, so their use was judged to be reasonable.

2.4.3 Event Frequency

Event frequency (EV) is used in evaluating dermal exposure (Equation 2). It represents the number of soil or dust contact events per day, and the standard assumption is 1 for both CTE and RME (USEPA 2004b). This parameter is used primarily to make units cancel correctly in the equation. Dermal absorption will be evaluated in the initial stage of the deterministic analyses that use standard, default exposure assumptions. In the second stage of the deterministic analyses and in the probabilistic analyses, it is assumed based on site-specific data that dermal absorption is negligible so the dermal pathway will not be evaluated (see Section 2.1 above).

2.4.4 Adherence Factor

Another assumption used to assess dermal exposures in the initial deterministic analyses is the adherence factor (AF), which represents the amount of soil or dust adhering to the skin per unit of surface area. The value of AF depends on the soil type and the moisture content and it varies with different parts of the body and activities (USEPA 2004b). The default CTE and RME values for children of 0.04 and 0.2 mg/cm²-event, respectively (USEPA 2004b), will be used. For adults, the default CTE and RME values of 0.01 and 0.07 mg/cm²-event, respectively (USEPA 2004b), will be used.

2.4.5 Surface Area

The surface area of skin exposed to soil or dust depends on the type of clothing worn. The default assumptions of 5,700 and 2,800 cm² (USEPA 2004b) will be used for children and adults, respectively, for both CTE and RME in the initial deterministic analyses.

2.4.6 Dermal Absorption

Dermal absorption across the skin is a chemical-specific value. USEPA's (2004b) default assumption of 0.03 for arsenic will be used for both CTE and RME in the initial deterministic analyses. This is equivalent to assuming that 3 percent of the arsenic in soil or dust on the skin crosses the skin to enter the bloodstream.

2.4.7 Exposure Frequency

Exposure frequency (EF) describes how many days per year someone may have contact with an exposure medium (e.g., soil or house dust) in a typical 1-year period. Values for exposure frequency can vary by receptor, scenario, and different exposure pathways within a scenario.

2.4.7.1 House Dust

For adult and child residents who have contact with soil and particulates in their yards and homes, USEPA (1991, 1993) generally recommends an exposure frequency of 350 days/yr for both the CTE and the RME cases for the general population. This value, which will be used for the deterministic analyses, is based on an assumption that residents spend at least 2 weeks at a location other than their home each year (e.g., a 2-week vacation or other period of absence from the home). For the probabilistic analyses, this value will be used as the likeliest value in a triangular distribution for house dust exposure frequency. A highly conservative value of 365 days/yr, which assumes that some residents never leave their homes each year, will be used as the maximum house dust exposure frequency. The minimum value of 104 days/yr will be used based on the assumption that a child may have two family homes with only one in Middleport or have childcare in another town, or that an adult may spend substantial periods of time at other locations.

2.4.7.2 Surface Soil

The USEPA (1991, 1993) default value of 350 days/yr will also be used for soil exposure frequency in the default stage of the deterministic analyses. The site-specific stage of deterministic analyses and the probabilistic analyses will consider climate factors that affect soil exposure frequency. Depending on the geographical region, the frequency of exposure to soil outdoors may be limited by weather conditions that reduce or eliminate soil contact (USEPA 1993), including snow cover or prolonged frozen conditions. Rain and inclement weather may

also limit time spent outdoors, but that impact was not quantified in this analysis. Available data for both snow cover and ambient temperature were reviewed, and snow cover data was found to be the most robust data set to support surface soil exposure frequency estimates.

Data were available from the National Weather Service (2008) on the number of days per year, from the years 1950 to 2005, that various depths of snow remained on the ground in Buffalo, New York, where the National Weather Service forecast office closest to Middleport is located. One inch of snow cover was selected as a reasonable estimate of snow cover that would limit soil exposures. These data are summarized in Figure 6, which shows the number of days per year with less than one inch of snow cover. For site-specific deterministic analyses, the mean value (291 days/yr) is appropriate for both CTE and RME as a measure of surface soil exposure frequency per year. The distribution to be used in the probabilistic risk analyses, shown in Table 8, was derived using Crystal Ball® from data on the number of days per year when at least 1 in. of snow was measured on the ground¹⁵. Use of the converse of these data, or data on the number of days per year when less than 1 in. of snow was measured on the ground, as a surrogate for soil exposure frequency assumes that Middleport residents are not exposed to soil on days where there is at least 1 in. of snow on the ground. It is also assumed that weather conditions in Middleport are similar to those in Buffalo, and that snow patterns will not change from previous years. No change in the snow pattern was evident in the 55 years of available data.

Use of the maximum days per year as specified in Table 8 assumes that the maximum of the data set is the true maximum. The minimum value for house dust exposure frequency is less than the minimum value for soil exposure frequency, but a conditional formula will be added to the model to preclude the possibility of an individual having a higher soil exposure frequency than house dust exposure frequency. If time is spent away from the home so that house dust exposure does not occur, soil exposure will also not occur during that time. The conditional formula states that if the soil exposure frequency selected for a particular model simulation¹⁶ is higher than that of the house dust exposure frequency, the soil exposure frequency will be set equal to the house dust exposure frequency.

The assumption of no soil ingestion on days when there is snow cover effectively reduces the total soil/dust ingestion rate for those days to just the dust ingestion rate, which is consistent with the findings of van Wijnen et al. (1990), who reported that total soil/dust ingestion by children ages 1 to 5 years was lower during periods of inclement weather when presumably the children spent less time outdoors. In addition, the *Child-Specific Exposure Factors Handbook*

¹⁵ Because Crystal Ball will select one EF value from the distribution for each run regardless of the exposure duration value selected. The variability in number of days with at least 1 in. of snow on the ground for exposure durations of two years or more will be less than in the data set used to estimate soil exposure frequency. This effect will be greater for longer exposure durations, and it will stretch out the tails of the predicted risk distribution possibly causing an overestimate of RME exposures. The impact of this issue may be studied in the uncertainty analysis.

¹⁶ The model will consist of performing 10,000 simulations for each risk calculation.

(USEPA 2008b) presents recommended CTE values for daily soil, dust, and soil plus dust ingestion rates. Although not explicitly stated, their presentation implies reduced, dust-only ingestion on days when soil exposure does not occur.

Additional surrogate data, such as the average number of days per year where the maximum air temperature was at or below freezing conditions and the average number of days per year with 0.1 or more inches of snowfall, were considered for soil exposure frequency. However, the alternative data sets were considered less suitable because they are not correlated as closely with actual soil conditions. For example, freezing air temperatures do not necessarily indicate freezing ground temperatures and measurements of snowfall do not necessarily indicate snow on the ground, while measurements of snow on the ground do indicate that soil exposure will be limited because the soil is covered. In addition, the alternative data sets only provide average values, which are insufficient for specifying distributions. The data set based on snow cover was determined to be the most robust data set because of the volume of data collected, because all of the data were available, and because of the close correlation between snow cover and limited soil exposure.

Point estimates based on other National Weather Service (2008) data are within the range of the distribution derived based on the snow cover data. Between the years 1922 and 2002, the average number of days per year where the maximum air temperature was at or below freezing conditions was 52 (National Weather Service 2008). Assuming air and ground temperatures are related, the average number of days per year where the maximum air temperature was above freezing, and therefore soil exposure could potentially occur, is 313. The ground is likely to be frozen for a longer period than that represented by the number of days with maximum temperature below freezing. The number of days with average temperature below freezing may provide a more accurate estimate of the period of time during which the ground will be frozen, but those data were not available from the National Weather Service database. During the same years, the average number of days per year with at least 0.1 in. of snowfall was 66 (National Weather Service 2008). Assuming snowfall and snow cover are related, the average number of days per year with less than 0.1 in. of snowfall, and therefore soil exposure could potentially occur, was 299.

NHAPS (Tsang and Klepeis 1996) data compiled in USEPA (1997b) were analyzed to determine whether adults and children are likely to experience the same soil exposure frequencies based on the amount of time each age group spends outdoors. From statistics representing 24-hour cumulative numbers of minutes spent at home in areas outside of the house, the ratio of adult (ages 18 to 64 years) to child (ages 1 to 6 years) average time spent outdoors was calculated to be 0.97. Because this ratio is very close to 1.0, and in the absence of soil exposure data specific to children and adults, the same soil exposure frequency distribution will be used for both age groups.

2.4.8 Exposure Duration

The age range for child receptors is defined as 1 through 6 years, based on peak soil ingestion rates. For the deterministic analyses, default exposure durations of 2 years for the CTE and 6 years for the RME case will be used (USEPA 1993). For the probabilistic analyses, a triangular distribution will be used for child exposure duration with a minimum of 1 year, most likely value of 3.5 years, and maximum of 6 years. For adult exposures, the default values of 9 and 30 years will be used for CTE and RME, respectively (USEPA 1993).

For the adult plus child scenario in probabilistic analyses, a lognormal distribution with a minimum of 1 year, arithmetic mean of 12.6 years, standard deviation of 16.2 years, and maximum of 87 years is planned to represent the distribution of residence time in the U.S., based on data from USEPA (1997b) and analysis by USEPA et al. (2002). Use of the maximum number of years as specified in Table 8 assumes that the reported maximum of the data set (USEPA 1997b) is the true maximum.

For the adult plus child scenario, the portion of the total adult plus child exposure duration spent as a child will be based on an independently drawn child exposure duration. This scenario conservatively assumes a minimum of 1 year of exposure during young childhood, though it is likely that some people move into the Middleport area at age 7 or older.¹⁷ Based on the distributions of exposure duration values, adult plus child exposure durations of less than or equal to the child exposure duration will be possible for some model simulations. In such cases, the exposure scenario for that model run will be assumed to represent a situation in which a person lives in Middleport during childhood only, and only child-specific exposure assumptions will be used to estimate intakes. For exposure duration values in the adult plus child distribution that are greater than the child exposure duration, the exposure scenario will be assumed to represent a situation in which a person lives in Middleport during both childhood and adulthood, with the child exposure portion equal to the child exposure duration of between 1 and 6 years and the adult exposure portion equal to the remaining exposure duration for that model run.

2.4.9 Relative Bioavailability

The default deterministic analyses will use the default relative bioavailability adjustment (RBA) of 1.0, as requested by the Agencies. The site-specific deterministic analyses will use the site-specific mean value of 0.22, based on data obtained from a study of RBA of arsenic in 14 soil samples from 12 different sites, one of which was Middleport, administered to male *Cynomolgus* monkeys (Exponent 2007, Roberts et al. 2007). A portion of each of three Middleport soil samples of varying concentrations was administered to five monkeys, and a

¹⁷ A sensitivity analysis using a child exposure duration range of 0 to 6 years will be conducted to determine the impact of using a minimum value of 1 year.

mean and standard deviation for RBA were reported for each of the Middleport samples. Use of the data from this study for the HHRA assumes that human RBA is similar to that of monkeys.

The distribution developed for the probabilistic analyses for RBA will also be based on the site-specific data. The RBA data were assumed to be distributed normally and to have equal variance. For the purposes of this HHRA, the mean RBA (0.22) was calculated as the arithmetic mean of the three site-specific means reported for the Middleport samples and the standard deviation (0.083) was calculated using the coefficient of variation for the three Middleport samples. The maximum value was determined based on the Middleport soil sample yielding the maximum RBA result. The maximum value (0.48) was calculated as the maximum reported mean plus 2 times the standard deviation for that same soil sample. The minimum value calculated using a parallel approach based on the soil sample yielding the minimum RBA result is 0.09.

2.4.10 Fraction Ingested from Source

The FS variable represents the fraction of ingested soils that come from the study area. For the residential scenarios evaluated in this document, it is assumed that all ingested soils and house dust are from the study area (air deposition area or Culvert 105 study area north of the canal), so FS will be set to 1 for both the probabilistic and the deterministic analyses. A value of less than 1 might be used for a future commercial/industrial worker scenario in which the individual is assumed to work in, but live outside of, the study area.

The probabilistic risk calculations will be structured to use individual sampling results, which is equivalent to assuming an individual receives his or her entire lifetime exposure (whether it be 1 year or 86 years) from one sampling point. While the presentation of a cumulative probability function partially recognizes the variability in soil concentrations throughout Middleport, it does not fully address the exposure averaging that occurs as individuals move within their own properties and within the community. One solution is to incorporate property- and community-wide averages into the probabilistic risk calculations. Another solution is to use these concepts as the rationale for defining the RME scenario in less conservative terms (e.g., 90th percentile exposure rather than 95th or 99th percentiles). This issue will be considered in the risk characterization discussion of the risk assessment report.

2.4.11 Body Weight

For the deterministic analyses, the default child body weight value of 15 kg (USEPA 2002) will be used for both the CTE and the RME cases. For probabilistic analyses, body weight for child receptors, a lognormal distribution with a mean of 17.27 kg and standard deviation of 4.97 kg will be used, as derived by Portier et al. (2007) and based on National Health and Nutrition Examination Survey (NHANES) IV data. NHANES is an extensive and periodically updated

database of information collected by the National Center for Health Statistics (NCHS) to describe the health and nutrition status of a nationally representative sample of the civilian U.S. population at least 2 months of age. As noted in the *Child-Specific Exposure Factors Handbook* (USEPA 2008b), NHANES is the “principal source of body weight data collected nationwide from a large number of subjects.” NHANES IV, which began in March 1999 and is continuously added to on an annual basis, is the most recent of five surveys. This survey oversampled from low-income, adolescent (12 to 19 years old), elderly (at least 60 years old), African American, and Mexican American civilians; however, results were weighted to provide estimates representative of the U.S. population (USDHHS 2008a, 2008b, 2008c, 2008d). Although Portier et al. (2007) reports estimates of the mean and variance that were calculated from NHANES data using a method that tends to bias the mean upward from the true population mean, this bias approaches zero with increasing sample size and the sample sizes for NHANES (1,174 for children and 4,110 for adults) are sufficiently large to virtually eliminate such bias (Gilbert 1987).

For the deterministic analyses, the EPA default body weight value of 70 kg (USEPA 2002) is planned for assessing noncancer risks in adults. The body weight distribution planned for probabilistic analyses is lognormal, with a mean of 79.96 kg and a standard deviation of 20.73 kg. This distribution, derived by Portier et al. (2007) and based on NHANES IV data, will be used to represent body weight for adults aged 18 through 65 years.

For assessing cancer risks in adults, the assumed body weight of 70 kg used in the derivation of cancer slope factors (CSFs) constrains the body weight that may be used in risk analyses. This value is planned for use in deterministic analyses for both the CTE and RME cases, and to be consistent with the CSF, a body weight distribution centered around 70 kg is also planned for the probabilistic analyses. A lognormal distribution with a mean of 70.7 kg and standard deviation of 14.4 kg used to represent adult body weights in a cancer scenario was derived by Richardson (1997). Use of lower body weight data is conservative because the same amount of contaminant is distributed over less mass.

Because minimum and maximum body weights are not provided by the sources discussed above, they were calculated based on separate sources using professional judgment. The child minimum was calculated as half the weight of girls between ages 1 and 2 years in the 5th percentile, and the child maximum was calculated as twice the weight of boys between 3 and 6 years in the 95th percentile, based on data presented in the *Child-Specific Exposure Factors Handbook* (USEPA 2008b), which was derived from NHANES (1999 to 2006; USDHHS 2008a–d). The adult minimum was calculated as half the weight of adult females in the 5th percentile, and the adult maximum was calculated as twice the weight of adult males in the 95th percentile, based on data in *Exposure Factors Handbook Volume 1* (USEPA 1997b).

Although weak but uniformly positive correlations have been found between birth weight and adult body mass index (BMI) as a marker of obesity in numerous studies (e.g., Sorensen et al

[1997] and Whitfield et al [2001]¹⁸), a correlation between child and adult body weights will not be included in the adult plus child scenario model for two reasons. First, the correlation seems to appear predominantly in the high end, with high birth weight or high child BMI being positively correlated with high adult BMI, while the rest of the spectrum is not clearly identified as also showing this trend. Second, studies could not be found linking child body weight alone to adult body weight alone, most likely because factors such as height are integral in determining whether a high weight is indicative of obesity. Because the correlation between birth weight, or child BMI, and adult BMI may only occur for heavier populations and because the adult plus child scenario model does not include information on individual height so that an accurate indicator of obesity can be calculated, inclusion of a correlation between child and adult body weights was deemed inappropriate.

The decision not to include correlation between child and adult body weights is supported by EPA guidance (USEPA 2001a) and the findings of two studies on the role of correlation among variables in probabilistic risk assessment (Bukowski et al. 1995; Smith et al. 1992). The studies found that the impact of correlation between two variables on the output is most important if the correlation between the variables is high and if the variables are large contributors to the variance of the output. The presence of other, uncorrelated variables modulates any effect of neglecting the correlation between the variables (Smith et al. 1992). Overall, accurate choice of shape for distributions is more important than inclusion of correlations (Bukowski et al. 1995).

2.4.12 Averaging Time

The averaging time is the period over which an exposure is averaged. When evaluating noncarcinogenic effects, chemical intakes are averaged over the exposure duration, so the noncancer averaging time is a function of the exposure duration distribution. When evaluating carcinogenic effects, however, chemical intakes are averaged over a full lifetime (70 years or 25,550 days) to be consistent with the way CSFs are derived. Because the exposure duration distribution selected for probabilistic analyses has a maximum of 87 years (see Section 2.4.8 above), for a particular probabilistic model simulation for an adult plus child cancer risk scenario, it is possible that the exposure duration could exceed the averaging time of 70 years. If the exposure duration selected for a particular simulation does exceed the averaging time point estimate of 70 years, the averaging time will be adjusted to equal the exposure duration.

2.5 UTILITY WORKER EXPOSURE FACTORS

For subsurface soils along Culvert 105, the receptors being evaluated are utility workers performing maintenance activities. Only incidental ingestion of and dermal contact with arsenic in soil will be evaluated, because utility workers will not contact house dust. The

¹⁸ The conclusions of these studies are consistent with an independent review of similar abstracts on the subject.

following equations are modifications of the soil and dust ingestion intake and dermal contact equations presented for residential exposures (Equations 1 and 2), with exposures to house dust eliminated.

$$I = \frac{C_s \times EF_s \times FI_s \times IR \times ED \times RBA \times FS \times CF}{BW \times AT}$$

Equation 3. Soil Ingestion Equation for Utility Worker Scenario

Where:

I	=	daily intake of contaminant (mg/kg-day)
C _s	=	contaminant concentration in soil (mg/kg)
EF _s	=	exposure frequency to soil (days/year)
FI _s	=	fractional intake from soil (unitless)
IR	=	ingestion rate (mg/day)
ED	=	exposure duration (years)
RBA	=	relative bioavailability adjustment factor (unitless)
FS	=	fraction ingested from source (unitless)
CF	=	conversion factor (1 × 10 ⁻⁶ kg/mg)
BW	=	body weight (kg)
AT	=	averaging time (equal to ED × 365 days/year for noncarcinogens and 70 years × 365 days/year for carcinogens)

$$I = \frac{C_s \times EF_s \times FI_s \times EV \times AF \times SA \times ABS_d \times ED \times FS \times CF}{BW \times AT}$$

Equation 4. Soil Dermal Contact Equation for Utility Worker Scenario

Where:

EV	=	event frequency (events/day)
AF	=	adherence factor (mg/cm ² -event)
SA	=	surface area (cm ²)
ABS _d	=	chemical-specific dermal absorption factor (unitless)

(Other parameters are as defined above in Equation 3.)

Exposure factor data for utility workers will be obtained from a variety of sources. Site-specific soil concentration data are available, as discussed previously. Data for other exposure factors

will be obtained from the literature. The *Exposure Factors Handbook Volume 1* (USEPA 1997b) will be consulted as a preferred exposure factor references, with updates supported by more recent studies applied as appropriate.

Exposure factors are presented as point estimates for deterministic analyses. Exposure factors and associated references are identified in Table 10. A rationale for use of the exposure factors is described in the following text.

2.5.1 Ingestion Rate

Current soil screening guidance (USEPA 2002) recommends default soil ingestion rates of 100 and 330 mg/day for outdoor workers and construction workers, respectively. These values are highly uncertain, but are expected to be very conservative.

USEPA (2002) defines the outdoor worker as:

...a long-term receptor exposed during the work day who is a full time employee of the company operating onsite and who spends most of the work day conducting maintenance activities outdoors. The activities for this receptor (e.g., moderate digging, landscaping) typically involve onsite exposures to surface and shallow subsurface soils (at depths of zero to two feet).

USEPA (2002) defines the construction worker as:

...a short-term adult receptor who is exposed to soil contaminants during the work day for the duration of a single construction project (typically a year or less). If multiple non-concurrent construction projects are anticipated, it was assumed that different workers will be employed for each project. The activities for this receptor typically involve substantial onsite exposures to surface and subsurface soils. The construction worker is expected to have a very high soil ingestion rate....

The EPA values of 100 and 330 mg/day will be used as the CTE and RME values, respectively, for the onsite utility worker.

2.5.2 Fractional Intake

While residents are assumed to ingest both soil and house dust, utility workers are assumed to ingest only soil. Thus, fractional intake for soil is set to 1.

2.5.3 Event Frequency

EV for utility workers is the same as discussed above for residents, i.e., 1 event/day. Dermal absorption will be evaluated in the default deterministic analyses but not in the site-specific deterministic analyses.

2.5.4 Adherence Factor

The default CTE and RME values planned for utility workers are 0.02 and 0.2 mg/cm²-event, respectively (USEPA 2004b) in the default deterministic analyses.

2.5.5 Surface Area

The default value of 3,300 cm² (USEPA 2004b) will be used for both CTE and RME for utility workers in the default deterministic analyses.

2.5.6 Dermal Absorption

The default value of 0.03 (USEPA 2004b) will be used for both CTE and RME for utility workers in the default deterministic analyses, as discussed above for residents.

2.5.7 Exposure Frequency

For the CTE case, utility workers are assumed, based on professional judgment, to perform maintenance on Culvert 105 for a period of 2 weeks, which is 10 work days. For the RME case, utility workers are assumed to perform maintenance for 1 month, which is an average of 22 work days.

2.5.8 Exposure Duration

The utility worker scenario is assumed to be a one-time event, so the exposure duration will be set to 1 year.

2.5.9 Relative Bioavailability

The CTE and RME values for RBA are the same as discussed above for residents, i.e., both the default value of 1.0 and the site-specific value of 0.22 will be used for both CTE and RME.

2.5.10 Fraction Ingested from Source

As discussed above for residents, FS is set to 1 to indicate that all the soil ingested by utility workers on the days they perform maintenance on Culvert 105 is assumed to originate from the vicinity of Culvert 105.

2.5.11 Body Weight

The body weights planned for utility workers are the same as those discussed above for the deterministic analyses for residents (i.e., 70 kg for both the CTE and the RME cases for assessing both noncancer and cancer effects).

2.5.12 Averaging Time

As discussed above for residents, for evaluating carcinogenic effects, chemical intakes are averaged over a full lifetime (25,550 days for both CTE and RME) to be consistent with the way CSFs are derived. When evaluating noncarcinogenic effects, however, chemical intakes are averaged over the exposure duration, so the noncancer averaging time will be 365 days for both the CTE and the RME cases.

2.6 TOXICITY ASSESSMENT

Toxicity values to be used for comparison with resulting intake distributions will be point estimates (i.e., deterministic values). Cancer and chronic noncancer toxicity values were obtained from EPA's Integrated Risk Information System (IRIS) (USEPA 2008c). The oral slope factor for carcinogenic effects, or CSF, is 1.5 per mg/kg-day based on an assessment of increased incidence of skin cancer. The chronic oral reference dose (RfD) for noncarcinogenic effects is 0.0003 mg/kg-day based on the critical effects of hyperpigmentation, keratosis (thick, scaly, crusty patches of skin), and possible vascular complications.

Subchronic toxicity values, which would be appropriate for evaluation of childhood noncarcinogenic exposures, are not available in IRIS. However, Tsuji et al. (2004) developed a reference level of 0.005 mg/kg-day for subchronic exposures (e.g., 14 days to 6 years) based on the most sensitive endpoint established for arsenic, changes to the skin.

The risk assessment report will present a detailed discussion of arsenic toxicity and the derivation of these toxicity values.

3 RISK CHARACTERIZATION

Intakes calculated in the exposure assessment will be evaluated using information developed in the toxicity assessment to characterize risks. For residents, the three scenarios that will be evaluated are cancer risks for an adult plus child (i.e., lifetime); noncancer risks for an adult plus child; and noncancer risks for a child-only. For utility workers, the two scenarios that will be evaluated are cancer risks for an adult and noncancer risks for an adult. These scenarios will be evaluated using deterministic analyses, both default and site-specific. Residential scenarios will also be evaluated using probabilistic analyses.

Deterministic analysis results for intake of arsenic in soil and house dust by child and adult receptors will be calculated by incorporating the exposure factors presented above, either default or site-specific, into the modified general incidental ingestion and dermal contact equations (Equations 1 and 2). The intakes calculated from the soil and house dust ingestion and dermal contact exposure pathway equations will then be added together to result in a total arsenic intake value. Intakes will be calculated for both CTE and RME cases for all residential scenarios.

Because data for the IR, AF, SA, and BW exposure factors were available for only child or adult receptors separately, these data need to be combined for the adult plus child scenarios. Equations 5 and 6 (below) will be used to combine the data for these variables based on the child and adult plus child EDs for a particular simulation. Equation 5 will be applied in place of the IR and BW variables in Equation 1 only for the adult plus child scenarios:

$$CF_i = \left[\left(\frac{ED_{adult+child} - ED_{child}}{ED_{adult+child}} \right) \times \left(\frac{IR_{adult}}{BW_{adult}} \right) \right] + \left[\left(\frac{ED_{child}}{ED_{adult+child}} \right) \times \left(\frac{IR_{child}}{BW_{child}} \right) \right]$$

Equation 5. Ingestion Equation Adult plus Child Combination Factor

Where:

CF _i	=	combination factor for ingestion (mg/day-kg)
ED	=	exposure duration (years)
IR	=	ingestion rate (mg/day)
BW	=	body weight (kg)

All other variables included in Equation 1 will be left as shown.

Equation 6 will be applied in place of the AF, SA, and BW variables in Equation 2 only for the adult plus child scenarios:

$$CF_d = \left[\left(\frac{ED_{adult+child} - ED_{child}}{ED_{adult+child}} \right) \times \left(\frac{AF_{adult} \times SA_{adult}}{BW_{adult}} \right) \right] + \left[\left(\frac{ED_{child}}{ED_{adult+child}} \right) \times \left(\frac{AF_{child} \times SA_{child}}{BW_{child}} \right) \right]$$

Equation 6. Dermal Contact Equation Adult plus Child Combination Factor

Where:

CF _d	=	combination factor for dermal contact (mg/day-kg)
ED	=	exposure duration (years)
AF	=	adherence factor (mg/cm ² -event)
SA	=	surface area (cm ²)
BW	=	body weight (kg)

All other variables included in Equation 2 will be left as shown.

Deterministic analysis results for intake of arsenic in soil by utility workers will be calculated by incorporating the exposure factors presented above into Equations 3 and 4 for ingestion and dermal contact, respectively. The intakes calculated from the soil ingestion and dermal contact exposure pathway equations will then be added together to result in a total arsenic intake value. Intakes will be calculated for both CTE and RME cases for all utility worker scenarios.

Probabilistic analysis results for incidental ingestion of arsenic in soil and house dust by child and adult receptors will be calculated by incorporating the modified general intake equation (Equation 1) and exposure factors presented above into Crystal Ball® for Monte Carlo analysis. For each risk model, 10,000 simulations will be performed. Example probabilistic analysis results for one scenario under background conditions are provided below.

As discussed previously for the deterministic analyses, Equation 5 will also be used for the probabilistic analyses to combine child-only and adult-only IR and BW data for the adult plus child scenarios. If in a particular probabilistic simulation the child ED is greater than the adult plus child ED, a negative combination factor (Equation 5) would result. To preclude the possibility of a negative combination factor, the following rule will be applied to the combination factor calculation:

$$\text{If } ED_{child} \geq ED_{adult+child}, \text{ then } ED_{adult+child} = ED_{child}$$

In other words, if the child ED is greater than or equal to the adult plus child ED for a particular model run, the exposure scenario for that run will be assumed to represent a situation in which a person lives in Middleport during childhood only, and only child-specific exposure assumptions will be used to estimate intakes.

For the example probabilistic analysis calculation, a probability distribution representing intakes was generated instead of one representing risks. Quantitative estimates of intakes can be simpler and more transparent when appropriate risk targets (discussed below) have not yet been decided, or for comparison with background intake values. For carcinogenic health risks, to allow for comparison of intakes to estimated cancer risk numbers, an intake reference value will be calculated. Discussion of this reference value is provided below.

CTE and RME intake values can be obtained from intake probability distributions by considering appropriate mid-range and high-end percentiles of the distributions. The CTE is defined as the 50th percentile of the distribution, while the RME is defined as the 90th or the 95th percentile (USEPA 1989). The choice of percentile for the RME depends on such risk management issues as the degree of conservatism used in the calculations, background and community-wide exposures, and remediation constraints.

3.1 NONCANCER RISKS

A noncarcinogenic health risk is characterized as the increased likelihood that an individual will suffer noncancer-related adverse health effects as a result of chemical exposure. If receptors are exposed to contaminant levels less than or equal to an acceptable level, such as an RfD, no adverse health effects are expected. Exposures above an RfD do not mean that adverse human health effects are certain to occur, but rather that further evaluation is appropriate.

To evaluate noncancer risks, typically the ratio of the daily contaminant intake to the contaminant-specific RfD is calculated. This ratio is referred to as the hazard quotient. If the calculated value of the hazard quotient is less than or equal to 1.0, no adverse health effects are expected. If the calculated value of the hazard quotient is greater than 1.0, further risk evaluation is needed. For the purposes of this risk assessment, because intake estimates will be calculated instead of risk numbers, the intake estimates will be compared directly to the RfDs of 0.0003 and 0.005 mg/kg-day for the adult plus child and the child scenarios, respectively. These RfDs are assumed to represent the daily intakes of arsenic below which no adverse health effects are expected. Intakes for both the study areas and background conditions will be provided.

An example intake probability distribution and RfD are included in Figure 7, which shows intakes for the noncancer adult plus child scenario under background¹⁹ conditions. Table 11 provides percentiles of interest for the probability distribution. The entire intake probability distribution in Figure 7 falls below the RfD, indicating that all of the predicted exposures under

¹⁹ Only one of eight potential background distributions is presented herein for illustrative purposes. The example background distribution shown was generated by incorporating the 2001 Work Plan Method calculations for the air deposition area including the four potential outliers. Alternate background distributions will be considered in the full probabilistic risk assessment.

background conditions are considered to be acceptable for noncancer health effects. This is confirmed by the fact that the 95th percentile is more than an order of magnitude below the RfD (Table 11). Another way to evaluate the data presented in Table 11 is to consider hazard quotients calculated from the intake percentiles and associated RfD. For example, the RME hazard quotient for intake values at the 95th percentile is 0.04, which is well below a hazard quotient of 1.0.

3.2 CANCER RISKS

A cancer risk estimate derived using standard risk assessment methods is characterized as the excess probability that an individual will develop cancer during his or her lifetime due to exposure to site-related chemicals resulting from the specific exposure scenario evaluated. The term “excess” reflects the fact that the calculated risk associated with site-related exposures is in addition to background cancer risk experienced by all individuals in the course of daily life.

Excess lifetime cancer risks for ingestion exposure pathways are typically calculated by multiplying the daily contaminant intake by the contaminant-specific oral CSF. Risk levels of 1 in 1,000,000 (10^{-6}), 1 in 100,000 (10^{-5}), and 1 in 10,000 (10^{-4}) will be evaluated. Because intake estimates will be calculated instead of risk numbers for this risk assessment, intake reference values, derived from the excess lifetime cancer risk equation, will be calculated as follows:

$$CRV = \frac{Risk}{CSF}$$

Equation 7. Excess Lifetime Cancer Risk

Where:

CRV	=	cancer intake reference value (mg/kg-day)
Risk	=	excess lifetime cancer risk (unitless)
CSF	=	cancer slope factor ([mg/kg-day] ⁻¹)

The CRV can be used to evaluate arsenic soil intakes for cancer scenarios in a similar fashion to the way the RfD is used to evaluate arsenic soil intakes for noncancer scenarios. Multiple CRVs are possible, depending on the target risk level desired. The CRVs for excess lifetime cancer risk levels of 10^{-6} , 10^{-5} , and 10^{-4} for an adult plus child scenario are 6.7×10^{-7} , 6.7×10^{-6} , and 6.7×10^{-5} mg/kg-day, respectively. These values are consistent with an acceptable intake over a 70-year period, which is conservative when compared with the 30-year lifetime exposure duration used by EPA as a default for residents in deterministic risk assessments.

For the probabilistic analyses, because there are risks associated with both current study area and background conditions, the critical issue is in comparison between study area and background conditions. This risk difference is termed the “incremental” risk to reflect the risks currently present in the study areas above background conditions. Calculated intake probability distributions for both the study areas and background conditions for the cancer adult plus child scenario will be provided.

3.3 INTERPRETATION OF RISK RESULTS

Because metals are widely distributed in the environment and food supply from many natural and anthropogenic sources, it is useful for the community to understand the magnitude of potential risk from historical site operations versus from other sources of exposure. By providing calculated intake probability distributions for both the study areas and background conditions, a comparison between potential site-related and background risks will be made possible.

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FIGURES

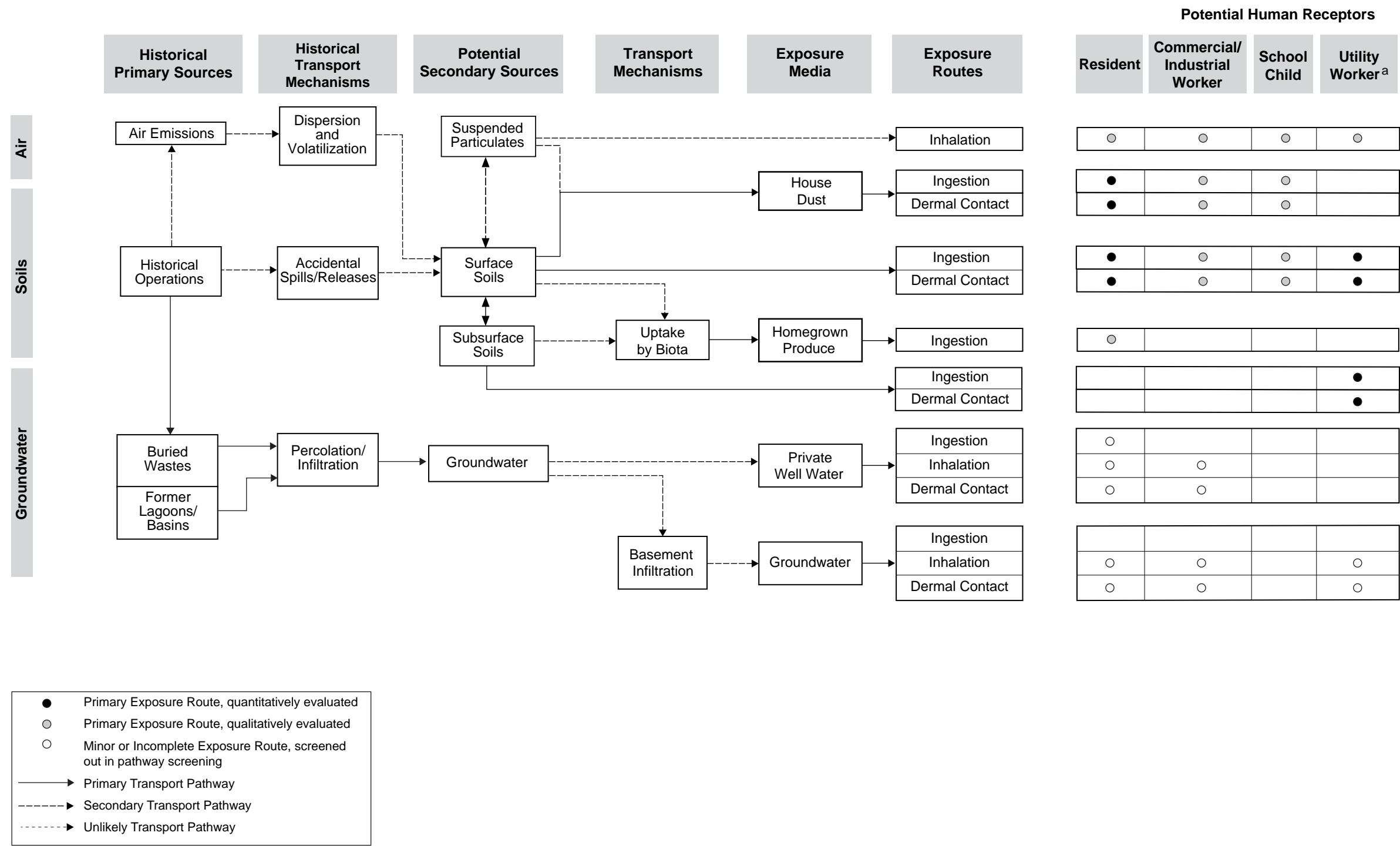


Figure 1. Conceptual Site Model of Human Exposure for Air Deposition Area and Culvert 105

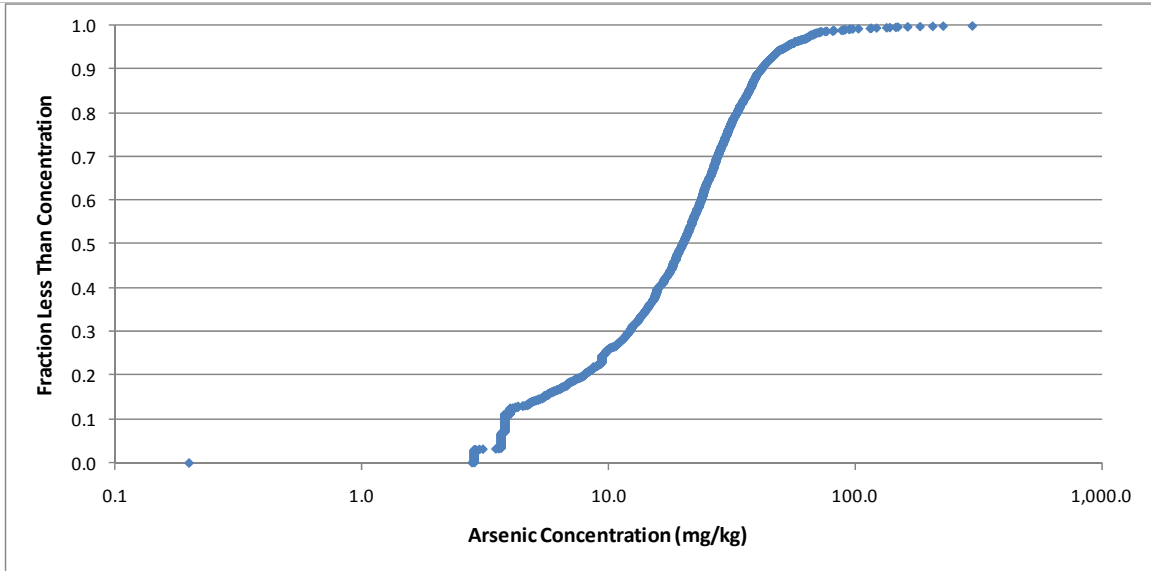


Figure 2. Cumulative Frequency Distribution of Air Deposition Study Area Surface Soil Arsenic Concentration Data, Post Remediation¹

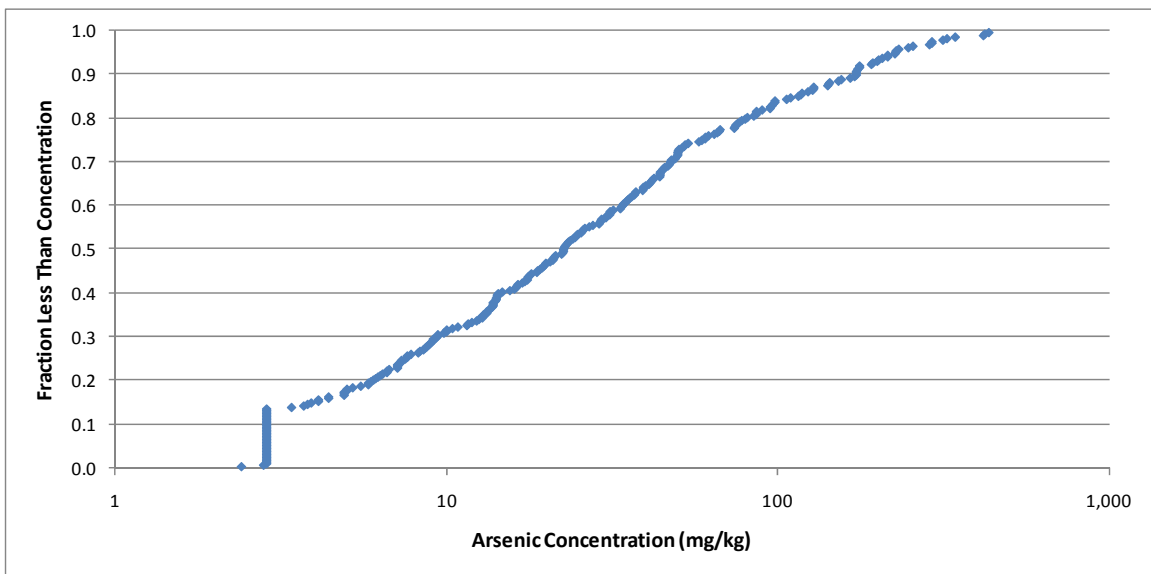


Figure 3. Cumulative Frequency Distribution of Surface Soil Arsenic Concentration Data for the Culvert 105 Study Area North of Canal, Post-Remediation²

¹ Surface soil arsenic concentrations shown are from sample data updated as recently as following the 2007 early actions interim corrective measure activities conducted in 2008. Of 1,837 sample locations included in the air deposition area surface soil sample data set, 239 sample locations have undergone remedial activities.

² Surface soil arsenic concentrations shown are from sample data updated as recently as following the 2007 early actions interim corrective measure activities conducted in 2008. Of 287 sample locations included in the surface soil sample data set for the Culvert 105 study area north of the canal, 37 sample locations have undergone remedial activities.

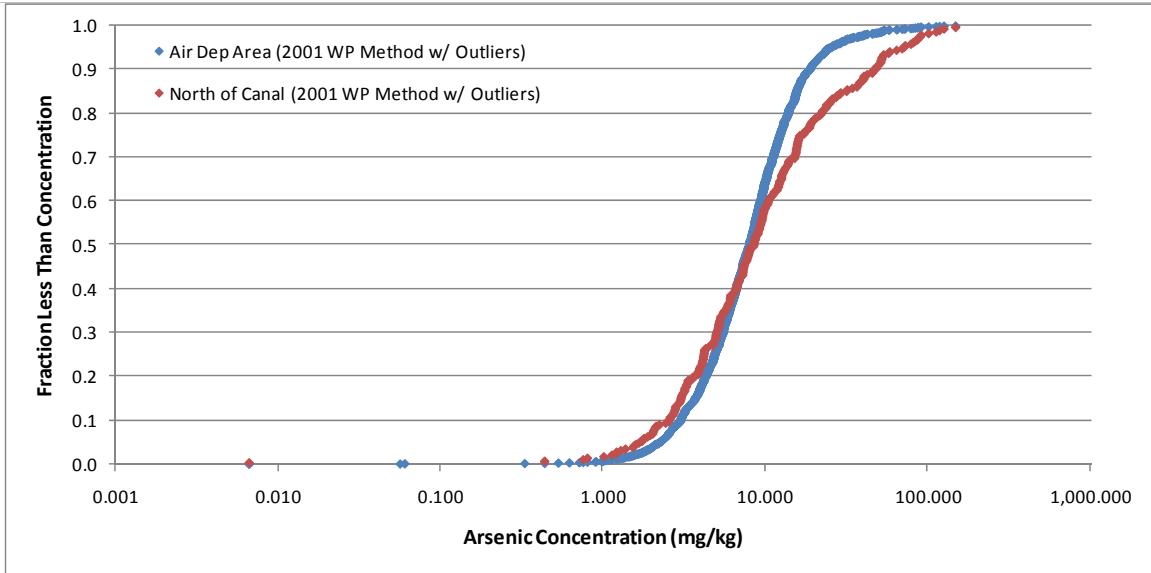


Figure 4. Cumulative Frequency Distribution of Background³ Surface Soil Arsenic Concentration Data

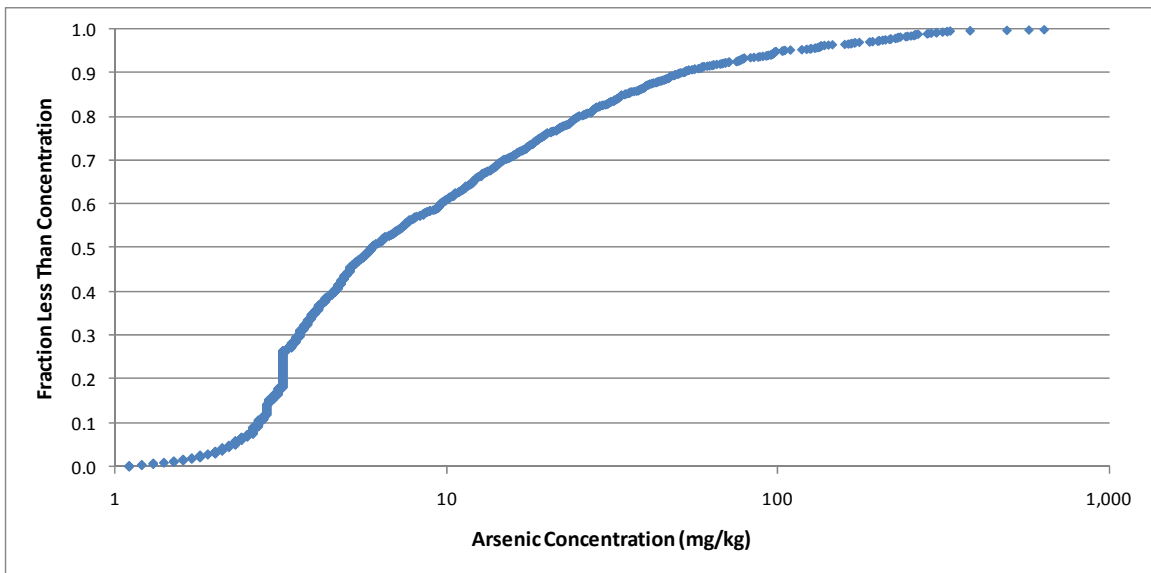


Figure 5. Cumulative Frequency Distribution of Arsenic Concentration Data for Subsurface Soils along Culvert 105, Post-Remediation⁴

³ The background data sets shown incorporate the 2001 Work Plan Method calculations and the four potential outliers (“2001 WP Method w/ Outliers”) for the air deposition area and the Culvert 105 study area north of the canal.

⁴ Subsurface soil arsenic concentrations shown are from sample data updated as recently as following the 2007 early actions interim corrective measure activities conducted in 2008. Of 1,245 samples included in the subsurface soil sample data set, 130 samples representing 55 sample locations have undergone remedial activities.

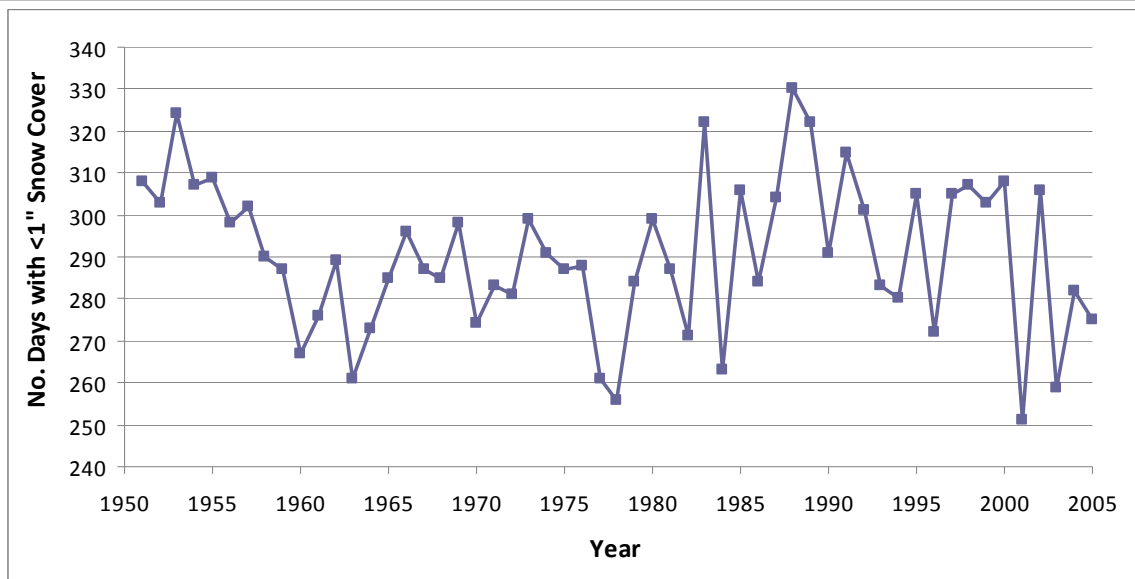


Figure 6. Number of Days per Year with Less Than 1 Inch Snow Cover in Buffalo, New York

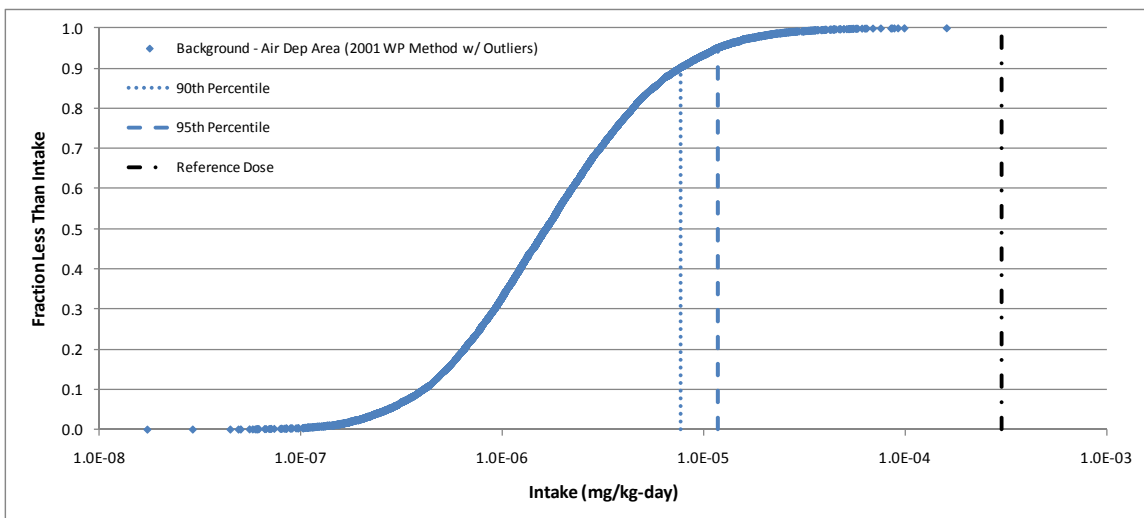


Figure 7. Intake Probability Distribution for Adult plus Child Noncancer Risk Scenario – Background⁵ Conditions

⁵ The background data set shown incorporates the 2001 Work Plan Method calculations and the four potential outliers (“2001 WP Method w/ Outliers”) for the air deposition area.

TABLES

Table 1. Screening Results and Summary Statistics for the Air Deposition Area

Constituent	Units	Exceeds Residential SCO?	Exceeds Residential SSL?	Exceed Industrial SCO?	Exceed Industrial SSL?	Total Number of Results	Number Detected	Frequency of Detection	Minimum Result	Maximum Result	
Chlorinated Pesticides											
4,4'-DDD	µg/kg	No	No	No	No	11	8	73%	0.05	*	90
4,4'-DDE	µg/kg	Yes	Yes	No	No	11	9	82%	0.16	*	3,000
4,4'-DDT	µg/kg	No	No	No	No	11	9	82%	0.05	*	590
Aldrin	µg/kg	Yes	Yes	No	No	11	0	0%	0.14	*	40
alpha-BHC	µg/kg	No	No	No	No	11	2	18%	0.05	*	80
beta-BHC	µg/kg	Yes	No	No	No	11	1	9%	0.20	*	80
delta-BHC	µg/kg	No	No	No	No	11	0	0%	0.05	*	80
gamma-BHC (Lindane)	µg/kg	No	No	No	No	11	2	18%	0.05	*	80
alpha-Chlordane	µg/kg	No	No	No	No	4	0	0%	2.0	*	2.0
gamma-Chlordane	µg/kg	NV	No	NV	No	4	0	0%	2.0	*	2.0
Chlordane (total)	µg/kg	NV	NV	NV	NV	3	0	0%	2.0	*	190
Dieldrin	µg/kg	Yes	No	No	No	11	5	45%	0.08	*	40
Dinocap	µg/kg	NA	NA	NA	NA	0	NA	NA	NA		NA
Endosulfan I	µg/kg	No	No	No	No	11	0	0%	0.05	*	90
Endosulfan II	µg/kg	No	No	No	No	11	0	0%	0.05	*	90
Endosulfan sulfate	µg/kg	No	No	No	No	9	1	11%	0.05	*	90
Endrin	µg/kg	No	No	No	No	9	0	0%	0.05	*	40
Endrin aldehyde	µg/kg	NV	No	NV	No	9	0	0%	0.38	*	40
Endrin ketone	µg/kg	NV	No	NV	No	4	0	0%	4.0	*	4.0
Heptachlor	µg/kg	No	No	No	No	9	0	0%	0.46	*	90
Heptachlor Epoxide	µg/kg	NV	Yes	NV	No	9	0	0%	0.05	*	90
Isodrin	µg/kg	NV	No	NV	No	4	0	0%	4.0	*	4.0
Methoxychlor	µg/kg	NV	No	NV	No	7	0	0%	20	*	1,900
Toxaphene	µg/kg	NV	Yes	NV	No	7	0	0%	20	*	1,900
Metals											
Lead	mg/kg	No	No	No	NV	74	74	100%	0.4		277
Aluminum	mg/kg	NV	No	NV	No	9	9	100%	8,810		25,100
Antimony	mg/kg	No	No	NV	No	8	1	13%	1.0	*	20
Barium	mg/kg	No	No	No	No	9	9	100%	55		163
Beryllium	mg/kg	No	Yes	No	No	11	6	55%	0.90	*	4.0
Cadmium	mg/kg	Yes	No	No	No	11	0	0%	2.0	*	4.0
Calcium	mg/kg	No	No	NV	No	3	3	100%	3,320		5,920
Chromium	mg/kg	Yes	No	No	No	12	12	100%	13		40
Cobalt	mg/kg	No	No	No	No	9	9	100%	4.5		8.0
Copper	mg/kg	No	No	No	No	10	10	100%	13		62
Iron	mg/kg	NV	Yes	NV	No	9	9	100%	12,800		26,800
Magnesium	mg/kg	No	No	No	No	3	3	100%	2,440		4,980
Manganese	mg/kg	No	No	No	No	9	9	100%	420		943
Mercury	mg/kg	No	No	No	No	12	9	75%	0.07		0.21
Molybdenum		NV	NV	NV	NV	6	0	0%	8.0	*	8.0
Nickel	mg/kg	No	No	No	No	11	11	100%	12		38
Potassium	mg/kg	No	No	No	No	3	3	100%	1,410		3,240

Table 1. Screening Results and Summary Statistics for the Air Deposition Area

Constituent	Units	Exceeds Residential SCO?	Exceeds Residential SSL?	Exceed Industrial SCO?	Exceed Industrial SSL?	Total Number of Results	Number Detected	Frequency of Detection	Minimum Result	Maximum Result	
Selenium	mg/kg	No	No	No	No	8	2	25%	0.50	* 1.0	*
Silver	mg/kg	No	No	No	No	11	0	0%	4.0	* 11.0	*
Sodium	mg/kg	NV	NV	NV	NV	3	0	0%	900	* 1,000	*
Thallium	mg/kg	NV	Yes	NV	No	8	0	0%	2.0	* 10.0	*
Titanium	mg/kg	No	No	No	No	6	6	100%	290	466	
Vanadium	mg/kg	No	No	No	No	9	9	100%	20	41	
Zinc	mg/kg	No	No	No	No	11	11	100%	56	247	
Phenolic Compounds											
2-Methylphenol (o-Cresol)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA	
4,6-Dinitro-2-methylphenol	mg/kg	NV	No	NV	No	2	0	0%	0.00005	* 0.00005	*
Phenol	mg/kg	No	No	No	No	5	2	40%	0.10	0.20	
Furans and Methyl Carbamates											
7-Hydroxybenzofuran	mg/kg	NV	NV	NV	NV	3	0	0%	1.0	* 1.0	*
Baygon (propoxur)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA	
Carbofuran	mg/kg	NV	No	NV	No	7	0	0%	1.0	* 10	*
Carbaryl (Sevin)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA	
Chloroprotham	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA	
Chlorinated Herbicides											
2,4-D	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA	
2,4,5-T	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA	
Dinoseb	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA	
Organophosphate Pesticides											
Chlorpyrifos (Dursban)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA	
Ethion	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA	
Diazinon	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA	
Malathion	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA	
Methyl Parathion	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA	
Phorate (Thimet)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA	
Ronnel	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA	
Ethyl Parathion	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA	
Volatile Organic Compounds											
1,1,1-Trichloroethane	mg/kg	No	No	No	No	2	0	0%	0.00003	* 0.00003	*
1,1,2,2-Tetrachloroethane	mg/kg	NV	NV	NV	NV	2	0	0%	0.00003	* 0.00003	*
1,1,2-Trichloroethane	mg/kg	NV	No	NV	No	2	0	0%	0.00003	* 0.00003	*
1,1-Dichloroethane	mg/kg	No	NV	No	NV	2	0	0%	0.00003	* 0.00003	*
1,1-Dichloroethene	mg/kg	No	No	No	No	2	0	0%	0.00003	* 0.00003	*
1,2,4-trimethylbenzene	mg/kg	No	NV	No	NV	2	1	50%	0.00003	* 0.00026	*
1,2-Dichlorobenzene	mg/kg	No	No	No	No	2	0	0%	0.00005	* 0.00005	*
1,2-Dichloroethane	mg/kg	No	No	No	No	2	0	0%	0.00003	* 0.00003	*
1,2-Dichloropropane	mg/kg	NV	NV	NV	NV	2	0	0%	0.00003	* 0.00003	*
1,3,5-trimethylbenzene	mg/kg	No	NV	No	NV	2	1	50%	0.00003	* 0.00017	*

Table 1. Screening Results and Summary Statistics for the Air Deposition Area

Constituent	Units	Exceeds Residential SCO?	Exceeds Residential SSL?	Exceed Industrial SCO?	Exceed Industrial SSL?	Total Number of Results	Number Detected	Frequency of Detection	Minimum Result	Maximum Result	
1,4-Dichlorobenzene	mg/kg	No	No	No	No	2	0	0%	0.00005	* 0.00005	
2-Chloroethyl vinyl ether	mg/kg	NV	NV	NV	NV	2	0	0%	0.00003	* 0.00003	
2-Phenylbutane	mg/kg	NV	NV	NV	NV	2	0	0%	0.00003	* 0.00003	
2/4-Chlorotoluene	mg/kg	NV	NV	NV	NV	2	0	0%	0.00003	* 0.00003	
3-Chlorotoluene	mg/kg	NV	NV	NV	NV	2	0	0%	0.00003	* 0.00003	
Benzene	mg/kg	No	No	No	No	2	0	0%	0.00003	* 0.00003	
Butyl-benzene	mg/kg	No	NV	No	NV	2	1	50%	0.00003	* 0.00031	
Benzene, cyclopropyl-	mg/kg	NV	NV	NV	NV	2	0	0%	0.00003	* 0.00003	
Benzofuran	mg/kg	NV	NV	NV	NV	2	0	0%	0.00003	* 0.00003	
Bromobenzene	mg/kg	NV	NV	NV	NV	2	0	0%	0.00003	* 0.00003	
Bromodichloromethane	mg/kg	NV	NV	NV	NV	2	0	0%	0.00003	* 0.00003	
Bromoform	mg/kg	NV	NV	NV	NV	2	0	0%	0.00003	* 0.00003	
Bromomethane	mg/kg	NV	NV	NV	NV	2	0	0%	0.00003	* 0.00003	
Carbon tetrachloride	mg/kg	No	NV	No	NV	2	0	0%	0.00003	* 0.00003	
Chlorobenzene	mg/kg	No	No	No	No	2	0	0%	0.00003	* 0.00003	
Chloroethane	mg/kg	NV	NV	NV	NV	2	0	0%	0.00003	* 0.00003	
Chloroform	mg/kg	No	No	No	No	2	0	0%	0.00003	* 0.00003	
Chloromethane	mg/kg	NV	NV	NV	NV	2	0	0%	0.00003	* 0.00003	
cis-1,3-Dichloropropene	mg/kg	NV	NV	NV	NV	2	0	0%	0.00003	* 0.00003	
Cymene	mg/kg	NV	NV	NV	NV	2	0	0%	0.00003	* 0.00003	
Dibromochloromethane	mg/kg	NV	NV	NV	NV	2	0	0%	0.00003	* 0.00003	
Dichlorodifluoromethane	mg/kg	NV	NV	NV	NV	2	0	0%	0.00003	* 0.00003	
Ethylbenzene	mg/kg	No	No	No	No	2	0	0%	0.00003	* 0.00003	
Isopropylbenzene	mg/kg	NV	NV	NV	NV	2	0	0%	0.00003	* 0.00003	
Methylene chloride	mg/kg	No	No	No	No	2	0	0%	0.00003	* 0.00003	
n-Propylbenzene	mg/kg	No	NV	No	NV	2	0	0%	0.00003	* 0.00003	
p-Bromofluorobenzene	mg/kg	NV	NV	NV	NV	2	0	0%	0.00003	* 0.00003	
Styrene	mg/kg	NV	NV	NV	NV	2	0	0%	0.00003	* 0.00003	
tert-Butylbenzene	mg/kg	No	NV	No	NV	2	0	0%	0.00003	* 0.00003	
Tetrachloroethene	mg/kg	No	No	No	NV	2	0	0%	0.00003	* 0.00003	
Toluene	mg/kg	No	No	No	No	2	0	0%	0.00003	* 0.00003	
trans-1,2-Dichloroethene	mg/kg	No	No	No	No	2	0	0%	0.00003	* 0.00003	
trans-1,3-Dichloropropene	mg/kg	NV	NV	NV	NV	2	0	0%	0.00003	* 0.00003	
Trichloroethene	mg/kg	No	No	No	No	2	0	0%	0.00003	* 0.00003	
Trichlorofluoromethane	mg/kg	NV	NV	NV	NV	2	0	0%	0.00003	* 0.00003	
Vinyl chloride	mg/kg	No	NV	No	NV	2	0	0%	0.00003	* 0.00003	
m-Xylene	mg/kg	No	No	No	No	2	1	50%	0.00003	* 0.0008	
o-Xylene	mg/kg	No	No	No	No	2	0	0%	0.00003	* 0.00003	
p-Xylene	mg/kg	No	No	No	No	2	0	0%	0.00003	* 0.00003	
Semi-Volatile Organic Compounds											
1,2,3-Trichlorobenzene	mg/kg	NV	NV	NV	NV	2	0	0%	0.00003	* 0.00003	
1,2,4-Trichlorobenzene	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00005	
1,2-Diphenylhydrazine	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00005	

Table 1. Screening Results and Summary Statistics for the Air Deposition Area

Constituent	Units	Exceeds Residential SCO?	Exceeds Residential SSL?	Exceed Industrial SCO?	Exceed Industrial SSL?	Total Number of Results	Number Detected	Frequency of Detection	Minimum Result	Maximum Result
1,3-Dichlorobenzene	mg/kg	No	NV	No	NV	2	0	0%	0.00005	* 0.00005
2,4,5-Trichlorophenol	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00005
2,4,6-Trichlorophenol	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00014
2,4-Dichlorophenol	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00005
2,4-Dimethylphenol	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00005
2,4-Dinitrophenol	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00058
2,4-Dinitrotoluene	mg/kg	NV	NV	NV	NV	2	0	0%	0.00006	* 0.00006
2,6-Dinitrotoluene	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00005
2-Chloronaphthalene	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00005
2-Chlorophenol	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00005
2-Nitrophenol	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00005
4-Bromophenyl phenyl ethe	mg/kg	NV	NV	NV	NV	2	0	0%	0.00002	* 0.00002
4-Chloro-3-methylphenol	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00005
4-Chlorophenyl phenyl ethe	mg/kg	NV	NV	NV	NV	2	0	0%	0.00016	* 0.00016
4-Nitrophenol	mg/kg	NV	NV	NV	NV	2	0	0%	0.00004	* 0.00004
Acenaphthene	mg/kg	No	NV	No	NV	2	0	0%	0.00005	* 0.00005
Acenaphthylene	mg/kg	No	NV	No	NV	2	0	0%	0.00005	* 0.00005
Anthracene	mg/kg	No	NV	No	NV	2	0	0%	0.00004	* 0.00004
Benzidine	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00006
Benzo(a)anthracene	mg/kg	No	NV	No	NV	2	0	0%	0.00005	* 0.00005
Benzo(a)pyrene	mg/kg	No	NV	No	NV	2	0	0%	0.00005	* 0.00005
Benzo(b)fluoranthene	mg/kg	No	NV	No	NV	2	0	0%	0.00005	* 0.00005
Benzo(g,h,i)perylene	mg/kg	No	NV	No	NV	2	0	0%	0.00005	* 0.00005
Benzo(k)fluoranthene	mg/kg	No	NV	No	NV	2	0	0%	0.00005	* 0.00005
bis(2-Chloroethoxy)methane	mg/kg	NV	NV	NV	NV	2	0	0%	0.00018	* 0.00018
bis(2-Chloroethyl)ether	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00005
bis(2-chloroisopropyl) ether	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00005
bis(2-Ethylhexyl)phthalate	mg/kg	NV	No	NV	No	2	0	0%	0.00005	* 0.00005
Butyl benzylphthalate	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00005
Chrysene	mg/kg	No	NV	No	NV	2	0	0%	0.00005	* 0.00005
Di-n-butylphthalate	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00005
Di-n-octyl phthalate	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00005
Dibenz(a,h)anthracene	mg/kg	No	NV	No	NV	2	0	0%	0.00005	* 0.00005
Diethyl phthalate	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00005
Dimethyl phthalate	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00005
Flouranthene	mg/kg	No	NV	No	NV	2	0	0%	0.00004	* 0.00004
Flourene	mg/kg	No	NV	No	NV	2	0	0%	0.00005	* 0.00005
Hexachlorobenzene	mg/kg	No	NV	No	NV	2	0	0%	0.00004	* 0.00004
Hexachlorobutadiene	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00005
Hexachlorocyclopentadiene	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00005
Hexachloroethane	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00006
Indeno(1,2,3-cd)pyrene	mg/kg	No	NV	No	NV	2	0	0%	0.00005	* 0.00005
Isophorone	mg/kg	NV	No	NV	No	2	0	0%	0.00005	* 0.00005

Table 1. Screening Results and Summary Statistics for the Air Deposition Area

Constituent	Units	Exceeds Residential SCO?	Exceeds Residential SSL?	Exceed Industrial SCO?	Exceed Industrial SSL?	Total Number of Results	Number Detected	Frequency of Detection	Minimum Result	Maximum Result	
N-Nitrosodi- <i>n</i> -propylamine	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00005	
N-Nitrosodiphenylamine	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00005	
Naphthalene	mg/kg	No	No	No	No	2	2	100%	0.00012	0.00012	
Nitrobenzene	mg/kg	NV	NV	NV	NV	2	0	0%	0.00005	* 0.00005	
Pentachlorophenol	mg/kg	No	NV	No	NV	2	0	0%	0.00014	* 0.00014	
Phenanthrene	mg/kg	No	NV	No	NV	2	1	50%	0.00043	0.0006	
Phenol	mg/kg	No	No	No	No	2	0	0%	0.00005	* 0.00005	
Pyrene	mg/kg	No	NV	No	NV	2	0	0%	0.00005	* 0.00005	
Miscellaneous Compounds											
Ethylenethiourea (ETU)	mg/kg	NV	No	NV	No	2	1	50%	0.022	* 0.049	
Polychlorinated biphenyls	mg/kg										
Aroclor-1016 (PCB-1016)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA	
Aroclor-1221 (PCB-1221)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA	
Aroclor-1232 (PCB-1232)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA	
Aroclor-1242 (PCB-1242)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA	
Aroclor-1248 (PCB-1248)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA	
Aroclor-1254 (PCB-1254)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA	
Total PCBs	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA	

Notes:
 NA = not applicable to this constituent
 NV = no value available
 SCO = soil cleanup objective
 SSL = soil screening level
 * = Result was reported as undetected (i.e., "U" qualified)

Table 2. Screening Results and Summary Statistics for the Culvert 105 Study Area North of the Canal

Constituent	Units	Exceeds	Exceeds	Exceeds	Exceeds	Total		Frequency of Detection	Minimum Result	Maximum Result
		Residential SCO?	Residential SSL?	Industrial SCO?	Industrial SSL?	Number of Results	Number Detected			
Chlorinated Pesticides										
4,4'-DDD	µg/kg	No	No	No	No	19	10	53%	0.93	1,300
4,4'-DDE	µg/kg	No	No	No	No	19	18	95%	0.78	200
4,4'-DDT	µg/kg	No	No	No	No	19	16	84%	0.90	190
Aldrin	µg/kg	Yes	No	No	No	18	0	0%	2.1	20 *
alpha-BHC	µg/kg	No	No	No	No	18	0	0%	2.1	20 *
beta-BHC	µg/kg	Yes	Yes	Yes	Yes	19	2	11%	2.1	51,000 *
delta-BHC	µg/kg	No	No	No	No	19	1	5%	2.1	20 *
gamma-BHC (Lindane)	µg/kg	No	No	No	No	19	2	11%	2.1	80 *
alpha-Chlordane	µg/kg	No	No	No	No	18	1	6%	2.1	200 *
gamma-Chlordane	µg/kg	NV	No	NV	No	18	1	6%	2.1	200 *
Chlordane (total)	µg/kg	NV	NV	NV	NV	1	1	100%	750	750
Dieldrin	µg/kg	Yes	Yes	No	No	19	3	16%	4.0	290 *
Dinocap	µg/kg	NV	NV	NV	NV	2	0	0%	2,200	4,100 *
Endosulfan I	µg/kg	No	No	No	No	19	0	0%	2.1	20 *
Endosulfan II	µg/kg	No	No	No	No	18	4	22%	0.85	41 *
Endosulfan sulfate	µg/kg	No	No	No	No	18	0	0%	4.0	41 *
Endrin	µg/kg	No	No	No	No	18	1	6%	0.99	41 *
Endrin aldehyde	µg/kg	NV	No	NV	No	18	6	33%	1.0	41 *
Endrin ketone	µg/kg	NV	No	NV	No	16	0	0%	4.0	21 *
Heptachlor	µg/kg	No	No	No	No	18	1	6%	2.1	20 *
Heptachlor Epoxide	µg/kg	NV	No	NV	No	18	0	0%	2.1	20 *
Isodrin	µg/kg	NV	No	NV	No	18	1	6%	0.81	21 *
Methoxychlor	µg/kg	NV	No	NV	No	18	0	0%	21	200 *
Toxaphene	µg/kg	NV	Yes	NV	No	18	0	0%	210	1,100 *
Metals										
Lead	mg/kg	Yes	Yes	No	NV	19	19	100%	19.3	492
Aluminum	mg/kg	NV	No	NV	No	2	2	100%	5,290	9,250
Antimony	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Barium	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Beryllium3	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Cadmium	mg/kg	Yes	No	No	No	2	2	100%	1.0	2.7
Calcium	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Chromium	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Cobalt	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Copper	mg/kg	No	No	No	No	2	2	100%	19.1	69.2
Iron	mg/kg	NV	No	NV	No	2	2	100%	9,890	16,900
Magnesium	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Manganese	mg/kg	No	No	No	No	3	3	100%	388	1,160
Mercury	mg/kg	No	No	No	No	2	1	50%	0.36	0.41 *
Molybdenum	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Nickel	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Potassium	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Selenium	mg/kg	No	No	No	No	2	0	0%	7.0	12.5 *

Table 2. Screening Results and Summary Statistics for the Culvert 105 Study Area North of the Canal

Constituent	Units	Exceeds	Exceeds	Exceeds	Exceeds	Total		Frequency of Detection	Minimum Result	Maximum Result
		Residential SCO?	Residential SSL?	Industrial SCO?	Industrial SSL?	Number of Results	Number Detected			
Silver	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Sodium	mg/kg	NV	NV	NV	NV	2	0	0%	695	* 1,270
Thallium	mg/kg	NV	No	NV	No	2	0	0%	0.7	* 1.3
Titanium	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Vanadium	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Zinc	mg/kg	No	No	No	No	3	3	100%	126	660
Phenolic Compounds										
2-Methylphenol (o-Cresol)	mg/kg	No	No	No	No	2	0	0%	2.3	* 8.4
4,6-Dinitro-2-methylphenol	mg/kg	NV	Yes	NV	No	2	0	0%	11	* 41
Phenol	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Furans and Methyl Carbamates										
7-Hydroxybenzofuran	µg/kg	NV	NV	NV	NV	3	0	0%	2,500	* 46,000
Baygon (propoxur)	µg/kg	NV	No	NV	No	3	0	0%	1,300	* 18,000
Carbofuran	µg/kg	NV	No	NV	No	3	0	0%	1,300	* 18,000
Carbaryl (Sevin)	µg/kg	NV	No	NV	No	3	0	0%	640	* 9,200
Chloropropham	µg/kg	NV	No	NV	No	3	0	0%	660	* 9,200
Chlorinated Herbicides										
2,4-D	µg/kg	NV	No	NV	No	2	0	0%	21	* 25
2,4,5-T	µg/kg	NV	No	NV	No	2	0	0%	4.2	* 5.1
Dinoseb	µg/kg	NV	No	NV	No	2	0	0%	10	* 13
Organophosphate Pesticides										
Chlorpyrifos (Dursban)	µg/kg	NV	No	NV	No	2	0	0%	170	* 250
Ethion	µg/kg	NV	No	NV	No	2	0	0%	170	* 250
Diazinon	µg/kg	NV	No	NV	No	2	0	0%	170	* 250
Malathion	µg/kg	NV	No	NV	No	2	0	0%	250	* 880
Methyl Parathion	µg/kg	NV	No	NV	No	2	0	0%	170	* 250
Phorate (Thimet)	µg/kg	NV	No	NV	No	2	0	0%	170	* 250
Ronnel	µg/kg	NV	No	NV	No	2	0	0%	170	* 250
Ethyl Parathion	µg/kg	NV	No	NV	No	2	0	0%	170	* 250
Volatile Organic Compounds										
1,1,1-Trichloroethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,1,2,2-Tetrachloroethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,1,2-Trichloroethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,1-Dichloroethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,1-Dichloroethene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,2,4-trimethylbenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,2-Dichlorobenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,2-Dichloroethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,2-Dichloropropane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,3,5-trimethylbenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,4-Dichlorobenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA

Table 2. Screening Results and Summary Statistics for the Culvert 105 Study Area North of the Canal

Constituent	Units	Exceeds	Exceeds	Exceeds	Exceeds	Total		Frequency of Detection	Minimum Result	Maximum Result
		Residential SCO?	Residential SSL?	Industrial SCO?	Industrial SSL?	Number of Results	Number Detected			
2-Chloroethyl vinyl ether	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
2-Phenylbutane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
2/4-Chlorotoluene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
3-Chlorotoluene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Benzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Butyl-benzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Benzene, cyclopropyl-	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Benzofuran	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Bromobenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Bromodichloromethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Bromoform	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Bromomethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Carbon tetrachloride	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Chlorobenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Chloroethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Chloroform	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Chloromethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
cis-1,3-Dichloropropene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Cymene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Dibromochloromethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Dichlorodifluoromethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Ethylbenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Isopropylbenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Methylene chloride	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
n-Propylbenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
p-Bromofluorobenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Styrene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
tert-Butylbenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Tetrachloroethene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Toluene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
trans-1,2-Dichloroethene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
trans-1,3-Dichloropropene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Trichloroethene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Trichlorofluoromethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Vinyl chloride	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
m-Xylene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
o-Xylene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
p-Xylene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Semi-Volatile Organic Compounds										
1,2,3-Trichlorobenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,2,4-Trichlorobenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,2-Diphenylhydrazine	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,3-Dichlorobenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
2,4,5-Trichlorophenol	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA

Table 2. Screening Results and Summary Statistics for the Culvert 105 Study Area North of the Canal

Constituent	Units	Exceeds	Exceeds	Exceeds	Exceeds	Total		Frequency of Detection	Minimum Result	Maximum Result
		Residential	Residential	Industrial	Industrial	Number of Results	Number Detected			
		SCO?	SSL?	SCO?	SSL?					
2,4,6-Trichlorophenol	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
2,4-Dichlorophenol	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
2,4-Dimethylphenol	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
2,4-Dinitrophenol	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
2,4-Dinitrotoluene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
2,6-Dinitrotoluene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
2-Chloronaphthalene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
2-Chlorophenol	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
2-Nitrophenol	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
4-Bromophenyl phenyl ethe	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
4-Chloro-3-methylphenol	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
4-Chlorophenyl phenyl ethe	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
4-Nitrophenol	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Acenaphthene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Acenaphthylene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Anthracene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Benzidine	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Benzo(a)anthracene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Benzo(a)pyrene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Benzo(b)fluoranthene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Benzo(g,h,i)perylene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Benzo(k)fluoranthene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
bis(2-Chloroethoxy)methane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
bis(2-Chloroethyl)ether	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
bis(2-chloroisopropyl) ether	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Butyl benzylphthalate	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Chrysene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Di-n-butylphthalate	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Di-n-octyl phthalate	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Dibenz(a,h)anthracene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Diethyl phthalate	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Dimethyl phthalate	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Flouranthene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Flourene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Hexachlorobenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Hexachlorobutadiene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Hexachlorocyclopentadiene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Hexachloroethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Isophorone	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
N-Nitrosodi-n-propylamine	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
N-Nitrosodiphenylamine	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Naphthalene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA

Table 2. Screening Results and Summary Statistics for the Culvert 105 Study Area North of the Canal

Constituent	Units	Exceeds	Exceeds	Exceeds	Exceeds	Total		Frequency of Detection	Minimum Result	Maximum Result
		Residential SCO?	Residential SSL?	Industrial SCO?	Industrial SSL?	Number of Results	Number Detected			
Nitrobenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Pentachlorophenol	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Phenanthrene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Phenol	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Pyrene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Miscellaneous Compounds										
Ethylenethiourea (ETU)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Polychlorinated biphenyls	mg/kg									
Aroclor-1016 (PCB-1016)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Aroclor-1221 (PCB-1221)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Aroclor-1232 (PCB-1232)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Aroclor-1242 (PCB-1242)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Aroclor-1248 (PCB-1248)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Aroclor-1254 (PCB-1254)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Total PCBs	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA

Notes:

NA = not applicable to this constituent

NV = no value available

SCO = soil cleanup objective

SSL = soil screening level

* = Result was reported as undetected (i.e., "U" qualified)

Table 3. Screening Results and Summary Statistics for Culvert 105 Study Area Subsurface Soils

Constituent	Units	Exceeds	Exceeds	Exceeds	Exceeds	Total	Number	Frequency	Minimum	Maximum
		Residential	Residential	Industrial	Industrial	Number				
		SCO?	SSL?	SCO?	SSL?	of	Detected	of Detection	Result	Result
						Results				
Chlorinated Pesticides										
4,4'-DDD	µg/kg	No	No	No	No	61	16	26%	0.34	1,900
4,4'-DDE	µg/kg	No	No	No	No	61	31	51%	0.34	730
4,4'-DDT	µg/kg	No	No	No	No	61	27	44%	0.51	810
Aldrin	µg/kg	Yes	Yes	No	No	61	0	0%	1.7	83 *
alpha-BHC	µg/kg	No	No	No	No	61	1	2%	1.7	83 *
beta-BHC	µg/kg	Yes	No	No	No	56	2	4%	1.9	83 *
delta-BHC	µg/kg	No	No	No	No	61	1	2%	1.7	83 *
gamma-BHC (Lindane)	µg/kg	No	No	No	No	61	0	0%	1.7	180 *
alpha-Chlordane	µg/kg	No	Yes	No	No	61	8	13%	1.7	830 *
gamma-Chlordane	µg/kg	NV	Yes	NV	No	61	6	10%	1.7	830 *
Chlordane (total)	µg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Dieldrin	µg/kg	Yes	Yes	No	No	61	7	11%	0.77	240
Dinocap	µg/kg	NV	NV	NV	NV	2	0	0%	3,600	17,000 *
Endosulfan I	µg/kg	No	No	No	No	61	0	0%	1.7	83 *
Endosulfan II	µg/kg	No	No	No	No	61	5	8%	0.29	170 *
Endosulfan sulfate	µg/kg	No	No	No	No	61	0	0%	3.3	170 *
Endrin	µg/kg	No	No	No	No	61	2	3%	0.59	170 *
Endrin aldehyde	µg/kg	NV	No	NV	No	61	3	5%	0.67	170 *
Endrin ketone	µg/kg	NV	No	NV	No	59	0	0%	3.3	85 *
Heptachlor	µg/kg	No	No	No	No	61	0	0%	1.7	83 *
Heptachlor Epoxide	µg/kg	NV	Yes	NV	No	61	3	5%	1.7	83 *
Isodrin	µg/kg	NV	Yes	NV	No	55	0	0%	3.7	85 *
Methoxychlor	µg/kg	NV	No	NV	No	61	0	0%	17	830 *
Toxaphene	µg/kg	NV	Yes	NV	No	61	0	0%	170	4,400 *
Metals										
Lead	mg/kg	Yes	Yes	No	NV	62	61	98%	2.6	541
Aluminum	mg/kg	NV	No	NV	No	2	2	100%	10,500	13,600
Antimony	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Barium	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Beryllium3	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Cadmium	mg/kg	No	No	No	No	2	2	100%	1.2	1.9
Calcium	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Chromium	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Cobalt	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Copper	mg/kg	No	No	No	No	2	2	100%	9.6	232
Iron	mg/kg	NV	Yes	NV	No	2	2	100%	25,400	29,700
Magnesium	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Manganese	mg/kg	No	No	No	No	2	2	100%	804	1,080
Mercury	mg/kg	No	No	No	No	2	1	50%	0.11	0.41 *
Molybdenum		NA	NA	NA	NA	0	NA	NA	NA	NA
Nickel	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Potassium	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA

Table 3. Screening Results and Summary Statistics for Culvert 105 Study Area Subsurface Soils

Constituent	Units	Exceeds				Total Number of Results	Number Detected	Frequency of Detection	Minimum Result	Maximum Result
		Residential SCO?	Residential SSL?	Industrial SCO?	Industrial SSL?					
Selenium	mg/kg	No	No	No	No	2	0	0%	0.56	* 2.1 *
Silver	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Sodium	mg/kg	NV	NV	NV	NV	2	0	0%	564	* 1,040 *
Thallium	mg/kg	NV	No	NV	No	2	0	0%	1.1	* 4.2 *
Titanium	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Vanadium	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Zinc	mg/kg	No	No	No	No	2	2	100%	141	575
Phenolic Compounds										
2-Methylphenol (o-Cresol)	mg/kg	No	No	No	No	2	0	0%	0.37	* 3.4 *
4,6-Dinitro-2-methylphenol	mg/kg	NV	Yes	NV	No	2	0	0%	17	* 17 *
Phenol	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Furans and Methyl Carbamates										
7-Hydroxybenzofuran	µg/kg	NV	NV	NV	NV	2	0	0%	2,300	* 4,200 *
Baygon (propoxur)	µg/kg	NV	No	NV	No	2	0	0%	1,100	* 2,100 *
Carbofuran	µg/kg	NV	No	NV	No	2	0	0%	1,100	* 17,000 *
Carbaryl (Sevin)	µg/kg	NV	No	NV	No	2	0	0%	560	* 8,300 *
Chloroprotham	µg/kg	NV	No	NV	No	2	0	0%	560	* 8,300 *
Chlorinated Herbicides										
2,4-D	µg/kg	NV	No	NV	No	2	0	0%	21	* 21 *
2,4,5-T	µg/kg	NV	No	NV	No	2	0	0%	4.2	* 4.2 *
Dinoseb	µg/kg	NV	No	NV	No	2	0	0%	10	* 10 *
Organophosphate Pesticides										
Chlorpyrifos (Dursban)	µg/kg	NV	No	NV	No	2	0	0%	170	* 170 *
Ethion	µg/kg	NV	No	NV	No	2	0	0%	170	* 170 *
Diazinon	µg/kg	NV	No	NV	No	2	0	0%	170	* 170 *
Malathion	µg/kg	NV	No	NV	No	2	0	0%	880	* 880 *
Methyl Parathion	µg/kg	NV	No	NV	No	2	0	0%	170	* 170 *
Phorate (Thimet)	µg/kg	NV	No	NV	No	2	0	0%	170	* 170 *
Ronnel	µg/kg	NV	No	NV	No	2	0	0%	170	* 170 *
Ethyl Parathion	µg/kg	NV	No	NV	No	2	0	0%	170	* 170 *
Volatile Organic Compounds										
1,1,1-Trichloroethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,1,2,2-Tetrachloroethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,1,2-Trichloroethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,1-Dichloroethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,1-Dichloroethene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,2,4-trimethylbenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,2-Dichlorobenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,2-Dichloroethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,2-Dichloropropane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,3,5-trimethylbenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,4-Dichlorobenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA

Table 3. Screening Results and Summary Statistics for Culvert 105 Study Area Subsurface Soils

Constituent	Units	Exceeds				Total Number of Results	Number Detected	Frequency of Detection	Minimum Result	Maximum Result
		Residential SCO?	Residential SSL?	Industrial SCO?	Industrial SSL?					
2-Chloroethyl vinyl ether	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
2-Phenylbutane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
2/4-Chlorotoluene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
3-Chlorotoluene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Benzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Butyl-benzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Benzene, cyclopropyl-	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Benzofuran	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Bromobenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Bromodichloromethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Bromoform	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Bromomethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Carbon tetrachloride	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Chlorobenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Chloroethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Chloroform	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Chloromethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
cis -1,3-Dichloropropene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Cymene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Dibromochloromethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Dichlorodifluoromethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Ethylbenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Isopropylbenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Methylene chloride	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
n-Propylbenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
p-Bromofluorobenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Styrene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
tert -Butylbenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Tetrachloroethene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Toluene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
trans -1,2-Dichloroethene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
trans -1,3-Dichloropropene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Trichloroethene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Trichlorofluoromethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Vinyl chloride	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
m-Xylene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
o-Xylene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
p-Xylene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Semi-Volatile Organic Compounds										
1,2,3-Trichlorobenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,2,4-Trichlorobenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,2-Diphenylhydrazine	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
1,3-Dichlorobenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA

Table 3. Screening Results and Summary Statistics for Culvert 105 Study Area Subsurface Soils

Constituent	Units	Exceeds				Total Number of Results	Number Detected	Frequency of Detection	Minimum Result	Maximum Result
		Residential SCO?	Residential SSL?	Industrial SCO?	Industrial SSL?					
2,4,5-Trichlorophenol	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
2,4,6-Trichlorophenol	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
2,4-Dichlorophenol	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
2,4-Dimethylphenol	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
2,4-Dinitrophenol	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
2,4-Dinitrotoluene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
2,6-Dinitrotoluene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
2-Chloronaphthalene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
2-Chlorophenol	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
2-Nitrophenol	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
4-Bromophenyl phenyl ethe	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
4-Chloro-3-methylphenol	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
4-Chlorophenyl phenyl ethe	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
4-Nitrophenol	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Acenaphthene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Acenaphthylene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Anthracene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Benzidine	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Benzo(a)anthracene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Benzo(a)pyrene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Benzo(b)fluoranthene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Benzo(g,h,i)perylene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Benzo(k)fluoranthene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
bis(2-Chloroethoxy)methane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
bis(2-Chloroethyl)ether	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
bis(2-chloroisopropyl) ether	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Butyl benzylphthalate	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Chrysene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Di-n-butylphthalate	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Di-n-octyl phthalate	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Dibenz(a,h)anthracene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Diethyl phthalate	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Dimethyl phthalate	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Flouranthene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Flourene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Hexachlorobenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Hexachlorobutadiene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Hexachlorocyclopentadiene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Hexachloroethane	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Isophorone	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
N-Nitrosodi-n-propylamine	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA

Table 3. Screening Results and Summary Statistics for Culvert 105 Study Area Subsurface Soils

Constituent	Units	Exceeds				Total Number of Results	Number Detected	Frequency of Detection	Minimum Result	Maximum Result
		Residential SCO?	Residential SSL?	Industrial SCO?	Industrial SSL?					
N-Nitrosodiphenylamine	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Naphthalene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Nitrobenzene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Pentachlorophenol	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Phenanthrene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Phenol	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Pyrene	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Miscellaneous Compounds										
Ethylenethiourea (ETU)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Polychlorinated biphenyls	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Aroclor-1016 (PCB-1016)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Aroclor-1221 (PCB-1221)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Aroclor-1232 (PCB-1232)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Aroclor-1242 (PCB-1242)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Aroclor-1248 (PCB-1248)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Aroclor-1254 (PCB-1254)	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA
Total PCBs	mg/kg	NA	NA	NA	NA	0	NA	NA	NA	NA

Notes:

NA = not applicable to this constituent

NV = no value available

SCO = soil cleanup objective

SSL = soil screening level

* = Result was reported as undetected (i.e., "U" qualified)

Table 4. Summary of Available Residential and Industrial Screening Values

Constituent	Units	Residential	Residential	Values Used to Derive Residential SSL ^c			Industrial	Industrial	Values Used to Derive Industrial SSL ^c		
		Soil Cleanup Objective (SCO) ^a	Soil Screening Level (SSL) ^b	Ingestion Pathway Screening Level	Inhalation Pathway Screening Level	Soil Saturation Concentration (Csat)	Soil Cleanup Objective (SCO) ^a	Soil Screening Level (SSL) ^b	Ingestion Pathway Screening Level	Inhalation Pathway Screening Level	Soil Saturation Concentration (Csat)
Chlorinated Pesticides											
4,4'-DDD	µg/kg	2,600	2,670	2,670	NV	2,610,000	180,000	238,000	238,000	NV	2,610,000
4,4'-DDE	µg/kg	1,800	1,880	1,880	NV	15,600,000	120,000	168,000	168,000	NV	15,600,000
4,4'-DDT	µg/kg	1,700	1,880	1,880	1,700,000	1,910,000	94,000	168,000	168,000	28,500,000	1,910,000
Aldrin	µg/kg	19	37.7	37.7	7,730	12,800,000	1,400	3,370	3,370	130,000	12,800,000
alpha-BHC	µg/kg	97	102	102	1,690	71,500	6,800	9,080	9,080	28,400	71,500
beta-BHC	µg/kg	72	356	356	14,000	8,790	14,000	8,790	31,800	235,000	8,790
delta-BHC	µg/kg	100,000	102	102	NV	n.a.	1,000,000	9,080	9,080	NV	n.a.
gamma-BHC (Lindane)	µg/kg	280	493	493	NV	212,000	23,000	44,000	44,000	NV	212,000
alpha-Chlordane	µg/kg	910	493	493	44,100	195,000	47,000	44,000	44,000	741,000	195,000
gamma-Chlordane	µg/kg	NV	493	493	44,100	195,000	NV	44,000	44,000	741,000	195,000
Chlordane (total)	µg/kg	NV	NV	493	44,100	195,000	NV	NV	44,000	741,000	195,000
Dieldrin	µg/kg	39	40	40	2,560	121,000	2,800	3,580	3,580	43,000	121,000
Dinocap	µg/kg	NV	NV	NV	NV	n.a.	NV	NV	NV	NV	n.a.
Endosulfan I	µg/kg	4,800	31,700	469,000	NV	31,700	920,000	31,700	12,300,000	NV	31,700
Endosulfan II	µg/kg	4,800	31,700	469,000	NV	31,700	920,000	31,700	12,300,000	NV	31,700
Endosulfan sulfate	µg/kg	4,800	31,700	469,000	NV	31,700	920,000	31,700	12,300,000	NV	31,700
Endrin	µg/kg	2,200	23,500	23,500	NV	89,200	410,000	89,200	613,000	NV	89,200
Endrin aldehyde	µg/kg	NV	23,500	23,500	NV	89,200	NV	89,200	613,000	NV	89,200
Endrin ketone	µg/kg	NV	23,500	23,500	NV	89,200	NV	89,200	613,000	NV	89,200
Heptachlor	µg/kg	420	142	142	258	7,360,000	29,000	4,330	12,700	4,330	7,360,000
Heptachlor Epoxide	µg/kg	NV	70.4	70.4	10,700	483,000	NV	6,290	6,290	181,000	483,000
Isodrin	µg/kg	NV	38.0	38.0	7,700	n.a.	NV	3,400	3,400	130,000	n.a.
Methoxychlor	µg/kg	NV	128,000	391,000	NV	128,000	NV	128,000	10,200,000	NV	128,000
Toxaphene	µg/kg	NV	582	582	202,000	5,520,000	NV	52,000	52,000	3,390,000	5,520,000
Metals											
Lead	mg/kg	400	400	400	NV	n.a.	3,900	NV	NV	NV	n.a.
Aluminum	mg/kg	NV	78,000	78,000	NV	n.a.	NV	1,000,000	1,000,000	NV	n.a.
Antimony	mg/kg	NV	NV	NV	NV	n.a.	NV	NV	NV	NV	n.a.
Barium	mg/kg	350	5,500	5,500	690,000	n.a.	10,000	140,000	140,000	960,000	n.a.
Beryllium	mg/kg	14	0.15	0.15	1,300	n.a.	2,700	13	13	22,000	n.a.
Cadmium	mg/kg	2.5	78.2	78.2	1,780	n.a.	60	2,040	2,040	30,000	n.a.
Calcium	mg/kg	NV	NV	NV	NV	n.a.	NV	NV	NV	NV	n.a.
Chromium	mg/kg	36	270	390	270	n.a.	6,800	4,500	10,000	4,500	n.a.
Cobalt	mg/kg	NV	4,700	4,700	NV	n.a.	NV	120,000	120,000	NV	n.a.
Copper	mg/kg	270	2,890	2,890	48,200,000	n.a.	10,000	75,600	75,600	67,500,000	n.a.
Iron	mg/kg	NV	23,000	23,000	NV	n.a.	NV	610,000	610,000	NV	n.a.
Magnesium	mg/kg	NV	NV	NV	NV	n.a.	NV	NV	NV	NV	n.a.
Manganese	mg/kg	2,000	1,800	1,800	69,000	n.a.	10,000	47,000	47,000	96,000	n.a.
Mercury	mg/kg	0.81	10.5	23.5	10.5	n.a.	5.7	14.7	613	14.7	n.a.
Molybdenum	mg/kg	NV	NV	NV	NV	n.a.	NV	NV	NV	NV	n.a.
Nickel	mg/kg	140	1,600	1,600	NV	n.a.	10,000	41,000	41,000	NV	n.a.
Potassium	mg/kg	NV	NV	NV	NV	n.a.	NV	NV	NV	NV	n.a.

Table 4. Summary of Available Residential and Industrial Screening Values

Constituent	Units	Residential	Residential	Values Used to Derive Residential SSL ^c			Industrial	Industrial	Values Used to Derive Industrial SSL ^c		
		Soil Cleanup Objective (SCO) ^a	Soil Screening Level (SSL) ^b	Ingestion Pathway Screening Level	Inhalation Pathway Screening Level	Soil Saturation Concentration (C _{sat})	Soil Cleanup Objective (SCO) ^a	Soil Screening Level (SSL) ^b	Ingestion Pathway Screening Level	Inhalation Pathway Screening Level	Soil Saturation Concentration (C _{sat})
Selenium	mg/kg	36	391	391	NV	n.a.	6,800	10,200	10,200	NV	n.a.
Silver	mg/kg	36	NV	NV	NV	n.a.	6,800	NV	NV	NV	n.a.
Sodium	mg/kg	NV	NV	NV	NV	n.a.	NV	NV	NV	NV	n.a.
Thallium	mg/kg	NV	5.48	5.48	NV	n.a.	NV	143	143	NV	n.a.
Titanium	mg/kg	NV	NV	NV	NV	n.a.	NV	NV	NV	NV	n.a.
Vanadium	mg/kg	NV	550	550	NV	n.a.	NV	NV	NV	NV	n.a.
Zinc	mg/kg	2,200	23,500	23,500	48,200,000	n.a.	10,000	613,000	613,000	67,500,000	n.a.
Phenolic Compounds											
2-Methylphenol (o-Cresol)	mg/kg	100	3,910	3,910	NV	71,400	1,000	71,400	102,000	NV	71,400
4,6-Dinitro-2-methylphenol	mg/kg	NV	7.8	7.8	NV	n.a.	NV	200	200	NV	n.a.
Phenol	mg/kg	100	33,600	46,900	33,600	77,400	1,000	47,000	1,230,000	47,000	77,400
Furans and Methyl Carbamates											
7-Hydroxybenzofuran	mg/kg	NV	NV	NV	NV	n.a.	NV	NV	NV	NV	n.a.
Baygon (propoxur)	mg/kg	NV	313	313	NV	n.a.	NV	8,180	8,180	NV	n.a.
Carbofuran	mg/kg	NV	391	391	NV	n.a.	NV	10,200	10,200	NV	n.a.
Carbaryl (Sevin)	mg/kg	NV	7,820	7,820	NV	n.a.	NV	204,000	204,000	NV	n.a.
Chloroprotham	mg/kg	NV	15,600	15,600	NV	n.a.	NV	409,000	409,000	NV	n.a.
Chlorinated Herbicides											
2,4-D	mg/kg	NV	782	782	NV	n.a.	NV	20,400	20,400	NV	n.a.
2,4,5-T	mg/kg	NV	782	782	NV	n.a.	NV	20,400	20,400	NV	n.a.
Dinoseb	mg/kg	NV	78.2	78.2	NV	n.a.	NV	2,040	2,040	NV	n.a.
Organophosphate Pesticides											
Chlorpyrifos (Dursban)	mg/kg	NV	235	235	NV	n.a.	NV	6,130	6,130	NV	n.a.
Ethion	mg/kg	NV	39.1	39.1	NV	n.a.	NV	1,020	1,020	NV	n.a.
Diazinon	mg/kg	NV	70.4	70.4	NV	n.a.	NV	1,840	1,840	NV	n.a.
Malathion	mg/kg	NV	1,560	1,560	NV	n.a.	NV	40,900	40,900	NV	n.a.
Methyl Parathion	mg/kg	NV	19.6	19.6	NV	n.a.	NV	511	511	NV	n.a.
Phorate (Thimet)	mg/kg	NV	15.6	15.6	NV	n.a.	NV	409	409	NV	n.a.
Ronnel	mg/kg	NV	3,910	3,910	NV	n.a.	NV	102,000	102,000	NV	n.a.
Ethyl Parathion	mg/kg	NV	469	469	NV	n.a.	NV	12,300	12,300	NV	n.a.
Volatile Organic Compounds (VOCs)											
1,1,1-Trichloroethane	mg/kg	100	4.55E+03	NV	4.59E+03	4.55E+03	1,000	4.55E+03	NV	6.42E+03	4.55E+03
1,1,2,2-Tetrachloroethane	mg/kg	NV	NV				NV	NV			
1,1,2-Trichloroethane	mg/kg	NV	1.96E+00	1.12E+01	1.96E+00	6.89E+03	NV	3.29E+01	1.00E+03	3.29E+01	6.89E+03
1,1-Dichloroethane	mg/kg	19	NV				480	NV			
1,1-Dichloroethene	mg/kg	100	1.24E-01	1.07E+00	1.24E-01	4.52E+03	1,000	2.08E+00	9.54E+01	2.08E+00	4.52E+03
1,2,4-trimethylbenzene	mg/kg	47	NV	NV	NV	n.a.	380	NV	NV	NV	n.a.
1,2-Dichlorobenzene	mg/kg	100	5.60E+02	5.60E+02	7.00E+03	5.60E+02	1,000	5.60E+02	NV	NV	5.60E+02
1,2-Dichloroethane	mg/kg	2.3	6.32E-01	7.04E+00	6.32E-01	5.21E+03	60.0	1.06E+01	6.29E+02	1.06E+01	5.21E+03
1,2-Dichloropropane	mg/kg	NV	NV				NV	NV			
1,3,5-trimethylbenzene	mg/kg	47	NV	NV	NV	n.a.	380	NV	NV	NV	n.a.
1,4-Dichlorobenzene	mg/kg	9.8	2.67E+01	2.67E+01	2.39E+04	1.33E+03	250.0	1.33E+03	2.38E+03	3.34E+04	1.33E+03
2-Chloroethyl vinyl ether	mg/kg	NV	NV				NV	NV			

Table 4. Summary of Available Residential and Industrial Screening Values

Constituent	Units	Residential	Residential	Values Used to Derive Residential SSL ^c			Industrial	Industrial	Values Used to Derive Industrial SSL ^c		
		Cleanup Objective (SCO) ^a	Soil Screening Level (SSL) ^b	Ingestion Pathway Screening Level	Inhalation Pathway Screening Level	Soil Saturation Concentration (Csat)	Cleanup Objective (SCO) ^a	Soil Screening Level (SSL) ^b	Ingestion Pathway Screening Level	Inhalation Pathway Screening Level	Soil Saturation Concentration (Csat)
2-Phenylbutane	mg/kg	NV	NV				NV	NV			
2/4-Chlorotoluene	mg/kg	NV	NV				NV	NV			
3-Chlorotoluene	mg/kg	NV	NV				NV	NV			
Benzene	mg/kg	2.9	1.57E+00	2.21E+01	1.57E+00	3.24E+03	89.0	2.64E+01	1.97E+03	2.64E+01	3.24E+03
Butyl-benzene	mg/kg	100	NV	NV	NV	n.a.	1,000	NV	NV	NV	n.a.
Benzene, cyclopropyl-	mg/kg	NV	NV				NV	NV			
Benzofuran	mg/kg	NV	NV				NV	NV			
Bromobenzene	mg/kg	NV	NV				NV	NV			
Bromodichloromethane	mg/kg	NV	NV				NV	NV			
Bromoform	mg/kg	NV	NV				NV	NV			
Bromomethane	mg/kg	NV	NV				NV	NV			
Carbon tetrachloride	mg/kg	1.4	NV				44.0	NV			
Chlorobenzene	mg/kg	100	2.81E+02	1.56E+03	2.81E+02	3.06E+03	1,000	3.93E+02	4.09E+04	3.93E+02	3.06E+03
Chloroethane	mg/kg	NV	NV				NV	NV			
Chloroform	mg/kg	10	5.32E-01	1.05E+02	5.32E-01	1.02E+04	700	8.95E+00	9.38E+03	8.95E+00	1.02E+04
Chloromethane	mg/kg	NV	NV				NV	NV			
cis-1,3-Dichloropropene	mg/kg	NV	NV				NV	NV			
Cymene	mg/kg	NV	NV				NV	NV			
Dibromochloromethane	mg/kg	NV	NV				NV	NV			
Dichlorodifluoromethane	mg/kg	NV	NV				NV	NV			
Ethylbenzene	mg/kg	30	1.81E+03	7.82E+03	1.22E+04	1.81E+03	780	1.81E+03	2.04E+05	1.71E+04	1.81E+03
Isopropylbenzene	mg/kg	NV	NV				NV	NV			
Methylene chloride	mg/kg	51	2.04E+01	8.54E+01	2.04E+01	5.93E+03	1,000	3.43E+02	7.63E+03	3.43E+02	5.93E+03
n-Propylbenzene	mg/kg	100	NV				1,000	NV			
p-Bromofluorobenzene	mg/kg	NV	NV				NV	NV			
Styrene	mg/kg	NV	NV				NV	NV			
tert-Butylbenzene	mg/kg	100	NV				1,000	NV			
Tetrachloroethene	mg/kg	5.5	1.10E+00	1.10E+00	1.20E+00	--	300.0	NV	NV	NV	--
Toluene	mg/kg	100	2.83E+03	1.56E+04	1.14E+05	2.83E+03	1,000	2.83E+03	4.09E+05	1.59E+05	2.83E+03
trans-1,2-Dichloroethene	mg/kg	100	1.60E+03	3.10E+03	1.60E+03	3.10E+03	1,000	3.10E+03	NV	NV	3.10E+03
trans-1,3-Dichloropropene	mg/kg	NV	NV				NV	NV			
Trichloroethene	mg/kg	10	9.77E+00	5.82E+01	9.77E+00	5.49E+03	400	1.64E+02	5.20E+03	1.64E+02	5.49E+03
Trichlorofluoromethane	mg/kg	NV	NV				NV	NV			
Vinyl chloride	mg/kg	0.21	NV				27.00	NV			
m-Xylene	mg/kg	100	4.20E+02	4.20E+02	1.60E+05	4.20E+02	1,000	4.20E+02	NV	NV	4.20E+02
o-Xylene	mg/kg	100	4.10E+02	4.10E+02	1.60E+05	4.10E+02	1,000	4.10E+02	NV	NV	4.10E+02
p-Xylene	mg/kg	100	4.60E+02	4.60E+02	1.60E+05	4.60E+02	1,000	4.60E+02	NV	NV	4.60E+02
Semi-Volatile Organic Compounds											
1,2,3-Trichlorobenzene	mg/kg	NV	NV				NV	NV			
1,2,4-Trichlorobenzene	mg/kg	NV	NV				NV	NV			
1,2-Diphenylhydrazine	mg/kg	NV	NV				NV	NV			
1,3-Dichlorobenzene	mg/kg	17	NV				560	NV			
2,4,5-Trichlorophenol	mg/kg	NV	NV				NV	NV			

Table 4. Summary of Available Residential and Industrial Screening Values

Constituent	Units	Residential	Residential	Values Used to Derive Residential SSL ^c			Industrial	Industrial	Values Used to Derive Industrial SSL ^c		
		Cleanup Objective (SCO) ^a	Soil Screening Level (SSL) ^b	Ingestion Pathway Screening Level	Inhalation Pathway Screening Level	Soil Saturation Concentration (C _{sat})	Cleanup Objective (SCO) ^a	Soil Screening Level (SSL) ^b	Ingestion Pathway Screening Level	Inhalation Pathway Screening Level	Soil Saturation Concentration (C _{sat})
2,4,6-Trichlorophenol	mg/kg	NV	NV				NV	NV			
2,4-Dichlorophenol	mg/kg	NV	NV				NV	NV			
2,4-Dimethylphenol	mg/kg	NV	NV				NV	NV			
2,4-Dinitrophenol	mg/kg	NV	NV				NV	NV			
2,4-Dinitrotoluene	mg/kg	NV	NV				NV	NV			
2,6-Dinitrotoluene	mg/kg	NV	NV				NV	NV			
2-Chloronaphthalene	mg/kg	NV	NV				NV	NV			
2-Chlorophenol	mg/kg	NV	NV				NV	NV			
2-Nitrophenol	mg/kg	NV	NV				NV	NV			
4-Bromophenyl phenyl ether	mg/kg	NV	NV				NV	NV			
4-Chloro-3-methylphenol	mg/kg	NV	NV				NV	NV			
4-Chlorophenyl phenyl ether	mg/kg	NV	NV				NV	NV			
4-Nitrophenol	mg/kg	NV	NV				NV	NV			
Acenaphthene	mg/kg	100	NV	NV	NV	n.a.	1,000	NV	NV	NV	n.a.
Acenaphthylene	mg/kg	100	NV				1,000	NV			
Anthracene	mg/kg	100	NV	NV	NV	n.a.	1,000	NV	NV	NV	n.a.
Benzidine	mg/kg	NV	NV				NV	NV			
Benzo(a)anthracene	mg/kg	1	NV				11	NV			
Benzo(a)pyrene	mg/kg	1	NV				1.1	NV			
Benzo(b)fluoranthene	mg/kg	1	NV				11	NV			
Benzo(g,h,i)perylene	mg/kg	100	NV				1000	NV			
Benzo(k)fluoranthene	mg/kg	1	NV				110	NV			
bis(2-Chloroethoxy)methane	mg/kg	NV	NV				NV	NV			
bis(2-Chloroethyl)ether	mg/kg	NV	NV				NV	NV			
bis(2-chloroisopropyl) ether	mg/kg	NV	NV				NV	NV			
bis(2-Ethylhexyl)phthalate	mg/kg	NV	4.57E+01	4.57E+01	NV	1.49E+05	NV	4.09E+03	4.09E+03	NV	1.49E+05
Butyl benzylphthalate	mg/kg	NV	NV				NV	NV			
Chrysene	mg/kg	1	NV				110	NV			
Di-n-butylphthalate	mg/kg	NV	NV				NV	NV			
Di-n-octyl phthalate	mg/kg	NV	NV				NV	NV			
Dibenz(a,h)anthracene	mg/kg	0.33	NV				1.1	NV			
Diethyl phthalate	mg/kg	NV	NV				NV	NV			
Dimethyl phthalate	mg/kg	NV	NV				NV	NV			
Flouranthene	mg/kg	100	NV	NV	NV	n.a.	1,000	NV	NV	NV	n.a.
Flourene	mg/kg	100	NV	NV	NV	n.a.	1,000	NV	NV	NV	n.a.
Hexachlorobenzene	mg/kg	0.33	NV				12	NV			
Hexachlorobutadiene	mg/kg	NV	NV				NV	NV			
Hexachlorocyclopentadiene	mg/kg	NV	NV				NV	NV			
Hexachloroethane	mg/kg	NV	NV				NV	NV			
Indeno(1,2,3-cd)pyrene	mg/kg	0.5	NV				11	NV			
Isophorone	mg/kg	NV	6.74E+02	6.74E+02	NV	1.75E+04	NV	1.75E+04	6.02E+04	NV	1.75E+04
N-Nitrosodi-n-propylamine	mg/kg	NV	NV				NV	NV			
N-Nitrosodiphenylamine	mg/kg	NV	NV				NV	NV			

Table 4. Summary of Available Residential and Industrial Screening Values

Constituent	Units	Residential	Residential	Values Used to Derive Residential SSL ^c			Industrial	Industrial	Values Used to Derive Industrial SSL ^c		
		Soil Cleanup Objective (SCO) ^a	Soil Screening Level (SSL) ^b	Ingestion Pathway Screening Level	Inhalation Pathway Screening Level	Soil Saturation Concentration (C _{sat})	Soil Cleanup Objective (SCO) ^a	Soil Screening Level (SSL) ^b	Ingestion Pathway Screening Level	Inhalation Pathway Screening Level	Soil Saturation Concentration (C _{sat})
Naphthalene	mg/kg	100	1,800	3,130	NV	1,800	1,000	1,800	81,800	NV	1,800
Nitrobenzene	mg/kg	NV	NV				NV	NV			
Pentachlorophenol	mg/kg	2.4	NV				55	NV			
Phenanthrene	mg/kg	100	NV	NV	NV	n.a.	1,000	NV	NV	NV	n.a.
Phenol	mg/kg	100	3.36E+04	4.69E+04	3.36E+04	7.74E+04	1,000	4.70E+04	1.23E+06	4.70E+04	7.74E+04
Pyrene	mg/kg	100	NV	NV	NV	n.a.	1,000	NV	NV	NV	n.a.
Miscellaneous Compounds											
Ethylenethiourea (ETU)	mg/kg	NV	5.8	5.8	NV	n.a.	NV	164	164	NV	n.a.
Polychlorinated biphenyls	mg/kg	1	1.0	1.0	NV	n.a.	25	NV	NV	NV	n.a.
Aroclor-1016 (PCB-1016)	mg/kg	NV	NV				NV	NV			
Aroclor-1221 (PCB-1221)	mg/kg	NV	NV				NV	NV			
Aroclor-1232 (PCB-1232)	mg/kg	NV	NV				NV	NV			
Aroclor-1242 (PCB-1242)	mg/kg	NV	NV				NV	NV			
Aroclor-1248 (PCB-1248)	mg/kg	NV	NV				NV	NV			
Aroclor-1254 (PCB-1254)	mg/kg	NV	NV				NV	NV			
Total PCBs	mg/kg	1	1.0	1.0	NV	n.a.	25	NV	NV	NV	n.a.

Notes:

NV = no value available

n.a. = not applicable to this constituent

^a Residential and Industrial Remedial Program Soil Cleanup Objectives (SCOs) listed in Table 375-6.8(b) of 6 NYCRR Subpart 375-6.

^b Residential and Industrial Soil Screening Levels (SSLs) listed in Table 7.2 of the 1999 Draft RFI Report.

^c The SSL is the lowest of three values: the ingestion pathway screening level, the inhalation pathway screening level, and the saturation concentration, if applicable.

Table 5. Chemicals Exceeding Residential Screening Levels in Air Deposition Area

Chemical	Number Samples	FOD	Exceeds Residential SCO?	Exceeds Residential SSL?	Exceeds Industrial SLs?	Exceeds Background?	On Off-site Investigation Param. List?	Selected as COC?	Comment
4,4'-DDE	11	73	Y	Y	n	--	Y	n	Only 1 detect exceeds, no DLs exceed
Aldrin	11	0	Y	Y	n	--	Y	n	1 DL exceeds SLs, never detected anywhere
beta-BHC	11	9	Y	n	n	--	Y	n	1 DL slightly exceeds
Dieldrin	11	45	Y	n	n	--	Y	n	1 DL slightly exceeds
Heptachlor epoxide	9	0	nv	Y	n	--	Y	n	1 DL slightly exceeds
Toxaphene	7	0	nv	Y	n	--	Y	n	1 DL exceeds 1 SL, never detected anywhere
Beryllium	9	55	n	Y	n	Y	n	n	2 DL exceed background, all detects below background, not on off-site parameter list
Cadmium	11	0	Y	n	n	Y	Y	n	5 DLs exceed SCO but not SSL
Chromium	12	100	Y	n	n	Y	n	n	Not on off-site parameter list, 3 detects slightly exceed SCO but not SSL
Iron	9	100	nv	Y	n	n	Y	n	Within background
Thallium	8	0	nv	Y	n	n	Y	n	Within background

Notes:

- = not applicable
- COC = chemical of concern
- DL = detection limit
- FOD = frequency of detection
- n = no
- nv = no value available
- SCO = soil cleanup objective from New York State Department of Health
- SL = screening level (either SCO or SSL)
- SSL = soil screening level from U.S. Environmental Protection Agency
- Y = yes

Table 6. Chemicals Exceeding Residential Screening Levels in Culvert 105 Study Area North of Canal

Chemical	Number Samples	FOD	Exceeds Residential SCO?	Exceeds Residential SSL?	Exceeds Industrial SLs?	Exceeds Background?	On Off-site Investigation Param. List?	Selected as COC?	Comment
Aldrin	18	0	Y	n	n	--	Y	n	1 DL slightly exceeds SCO but not SSL, never detected anywhere
beta-BHC	19	11	Y	Y	Y	--	Y	n	Single exceedance is suspect
Dieldrin	19	16	Y	Y	n	--	Y	n	Distribution not consistent with FMC as source
Toxaphene	18	0	nv	Y	n	--	Y	n	3 DLs exceed, never detected anywhere
Lead	19	100	Y	Y	n	Y	Y	n	1 slight exceedance
Cadmium	2	100	Y	n	n	Y	Y	n	1 detect slightly exceeds SCO but not SSL
4,6-Dinitro-2-methyphenol	2	0	nv	Y	n	--	n	n	Not on off-site parameter list, never detected anywhere

Notes:

- = not applicable
- COC = chemical of concern
- FOD = frequency of detection
- n = no
- nv = no value available
- SCO = soil cleanup objective from New York State Department of Health
- SLs = screening levels (either SCO or SSL)
- SSL = soil screening level from U.S. Environmental Protection Agency
- Y = yes

Table 7. Chemicals Exceeding Residential Screening Levels in Culvert 105 Study Area Subsurface Soils

Chemical	Number Results	FOD	Exceeds Residential SCO?	Exceeds Residential SSL?	Exceeds Industrial SLs?	Exceeds Background?	On Off-site Investigation Param. List?	Selected as COC?	Comment
Aldrin	61	0	Y	Y	n	--	Y	n	5 DLs exceed residential SLs but not industrial SLs, never detected anywhere
beta-BHC	56	4	Y	n	n	--	Y	n	FOD<5%, 1DL exceeds residential SCO but no other SLs
alpha-Chlordane	61	13	n	Y	n	--	Y	n	1 DL exceeds residential SSL but no other SLs
gamma-Chlordane	61	10	nv	Y	n	--	Y	n	1 DL exceeds residential SSL but not industrial SSL
Dieldrin	61	11	Y	Y	n	--	Y	n	4 detects exceed both residential SLs, distribution not consistent with FMC as source
Heptachlor epoxide	61	5	nv	Y	n	--	Y	n	1 DL exceeds residential SSL but not industrial SSL
Isodrin	55	0	nv	Y	n	--	Y	n	5 DLs exceed residential SSL but not industrial SSL
Toxaphene	61	0	nv	Y	n	--	Y	n	7 DLs exceed residential SSL but not industrial SSL, never detected anywhere
Lead	62	98	Y	Y	n	Y	Y	n	1 detect exceeds residential SLs
Iron	2	100	nv	Y	n	n	Y	n	Within background
4,6-Dinitro-2-methylphenol	2	0	nv	Y	n	--	n	n	Not on off-site parameter list, never detected anywhere

Notes:

- = not applicable
- COC = chemical of concern
- DL = detection limit
- FOD = frequency of detection
- n = no
- nv = no value available
- SCO = soil cleanup objective from New York State Department of Health
- SLs = screening levels (either SCO or SSL)
- SSL = soil screening level from U.S. Environmental Protection Agency
- Y = yes

Table 8. Proposed Probabilistic Exposure Factor Descriptions and Sources for Residential Scenario

Exposure Factor	Units	Distribution Type	Probability Distribution Parameter(s)	Source(s)/Notes
C _s (Air Deposition Area)	mg/kg	Custom	N/A	Sample directly from site-specific database ^a
C _s (Area North of Canal)	mg/kg	Custom	N/A	Sample directly from site-specific database ^a
C _s (Subsurface Soils)	mg/kg	Custom	N/A	Sample directly from site-specific database ^a
C _s (Background for Air Deposition Area)	mg/kg	Custom	N/A	Sample directly from database generated from Gasport data ^a
C _s (Background for Area North of Canal)	mg/kg	Custom	N/A	Sample directly from database generated from Gasport data ^a
C _d (Middleport)	mg/kg	Lognormal	Geometric mean 10.8, geometric std. dev.3.0, min 1.0, max 172	Tsuji et al. 2005
C _d (Background)	mg/kg	Lognormal	Mean 7.3, 95th percentile 18.5, min 1.7, max 79.5	Rasmussen et al. 2001
EF _s	days/yr	Weibull	Location 225.68, scale 71.56, shape 4.01, min 104, max 330	National Weather Service 2008
EF _d	days/yr	Triangular	Min 104, likeliest 350, max 365	USEPA 1991, professional judgment
FI _s	unitless	Triangular	Min 0.20, likeliest 0.45, max 0.70	USEPA 1994, professional judgment
FI _d	unitless	Triangular	Varies with FI _s (1 – FI _s)	Same as above
IR (Child)	mg/day	Lognormal	50th percentile 45, 95th percentile 124, min 0, max 1,000	Stanek et al. 2001b, Stanek and Calabrese 2000, USEPA 2008a
IR (Adult)	mg/day	Lognormal	50th percentile 22.5, 95th percentile 62, min 0, max 1,000	Professional judgment
ED (Child)	yrs	Triangular	Min 1, likeliest 3.5, max 6	Professional judgment

Table 8. Proposed Probabilistic Exposure Factor Descriptions and Sources for Residential Scenario

Exposure Factor	Units	Distribution Type	Probability Distribution Parameter(s)	Source(s)/Notes
ED (Adult+Child)	yrs	Lognormal	Mean 12.6, std. dev. 16.2, min 1, max 87	USEPA, CDPHE, and DOE 2002
RBA	unitless	Normal	Mean 0.22, std. dev. 0.083, min 0.09, max 0.48	Derived from data presented in Roberts et al. 2007
FS	unitless	Point Estimate	1	Considers residential scenario only
BW (Child)	kg	Lognormal	Mean 17.27, std. dev. 4.97, min 4.4, max 52.4	Portier et al. 2007, professional judgment
BW (Adult, Cancer)	kg	Lognormal	Mean 70.7, std. dev. 14.4, min 23.9, max 205.4	Richardson 1997, professional judgment
BW (Adult, Noncancer)	kg	Lognormal	Mean 79.96, std. dev. 20.73, min 23.9, max 205.4	Portier et al. 2007, professional judgment
AT (Cancer)	days	Point Estimate	25,550 ^b	USEPA 2001a
AT (Noncancer)	days	Varies	Varies with ED (ED x 365 days/yr)	USEPA 2001a

Notes:

Exposure factor definitions:

- AT = averaging time (equal to ED x 365 days/year for noncarcinogens and 70 years x 365 days/year for carcinogens)
- BW = body weight
- C_d = contaminant concentration in house dust
- C_s = contaminant concentration in soil
- ED = exposure duration
- EF_d = exposure frequency to house dust
- EF_s = exposure frequency to soil
- FI_d = fractional intake from house dust
- FI_s = fractional intake from soil
- FS = fraction ingested from source
- IR = ingestion rate
- RBA = relative bioavailability adjustment factor

^a See Appendix A for details.

^b For a particular model simulation for an adult plus child cancer risk scenario, if the exposure duration exceeds the averaging time point estimate of 25,550 days, the averaging time will be set to equal the exposure duration.

Table 9. Proposed Deterministic Exposure Factor Values and Sources for Residential Scenario

Exposure Factor	Units	CTE Value	CTE Source	RME Value	RME Source
C _s (Air Deposition Area)	mg/kg	22.8	Arithmetic mean of site-specific database ^a	24.8	95UCL ^b of site-specific database ^a
C _s (Area North of Canal)	mg/kg	22.5	Arithmetic mean of site-specific database ^a	82.0	97.5UCL ^b of site-specific database ^a
C _s (Background ^c for Air Deposition Area)	mg/kg	10.4	Arithmetic mean of database generated from Gasport data ^a	11.5	95UCL ^b of database generated from Gasport data ^a
C _s (Background ^c for Area North of Canal)	mg/kg	16.7	Arithmetic mean of database generated from Gasport data ^a	25.0	97.5UCL ^b of constructed site-specific database generated from Gasport data ^a
C _d (Middleport)	mg/kg	10.8	Geometric mean from Tsuji et al. 2005	11.5	95UCL calculated from geometric mean and std. dev. reported in Tsuji et al. 2005
C _d (Background)	mg/kg	7.3	Arithmetic mean from Rasmussen et al. 2001	7.3	Arithmetic mean from Rasmussen et al. 2001
EF _s (alternative 1)	days/yr	350	USEPA 1991	350	USEPA 1991
EF _s (alternative 2)	days/yr	291	Mean of NWS 2008 data	291	Mean of NWS 2008 data
EF _d	days/yr	350	Likeliest value based on USEPA 1991	350	Likeliest value based on USEPA 1991
FI _s	unitless	0.45	Likeliest value based on USEPA 1994	0.45	Likeliest value based on USEPA 1994
FI _d	unitless	0.55	1 – FI _s	0.55	1 – FI _s
IR (Child) (default)	mg/day	100	USEPA 1993, 2008b	200	USEPA 1993, 2002

Table 9. Proposed Deterministic Exposure Factor Values and Sources for Residential Scenario

Exposure Factor	Units	CTE Value	CTE Source	RME Value	RME Source
IR (Child) (site-specific)	mg/day	45	50th percentile based on Stanek et al. 2001b, Stanek and Calabrese 2000, USEPA 2008a	124	95th percentile based on Stanek et al. 2001b, Stanek and Calabrese 2000, USEPA 2008a
IR (Adult) (default)	mg/day	50	USEPA 1993	100	USEPA 1993, 2002
IR (Adult) (site-specific)	mg/day	22.5	50th percentile based on professional judgment	62	95th percentile based on professional judgment
EV (default)	events/day	1	USEPA 2004b	1	USEPA 2004b
AF (Child) (site-specific)	mg/cm ² -event	0.04	USEPA 2004b	0.2	USEPA 2004b
AF (Adult) (default)	mg/cm ² -event	0.01	USEPA 2004b	0.07	USEPA 2004b
SA (Child) (default)	cm ²	5,700	USEPA 2004b	5,700	USEPA 2004b
SA (Adult) (default)	cm ²	2,800	USEPA 2004b	2,800	USEPA 2004b
ABS _d (default)	unitless	0.03	USEPA 2004b	0.03	USEPA 2004b
ED (Child)	yrs	2	USEPA 1993	6	USEPA 1996
ED (Adult+Child)	yrs	9	USEPA 1993	30	USEPA 1993
RBA (default)	unitless	1	Default requested by Agencies	1	Default requested by Agencies

Table 9. Proposed Deterministic Exposure Factor Values and Sources for Residential Scenario

Exposure Factor	Units	CTE Value	CTE Source	RME Value	RME Source
RBA (site-specific)	unitless	0.22	Mean calculated from data presented in Roberts et al. 2007	0.22	95UCL calculated from data presented in Roberts et al. 2007
FS	unitless	1	Considers residential scenario only	1	Considers residential scenario only
BW (Child)	kg	15	USEPA 2002	15	USEPA 2002
BW (Adult, Cancer)	kg	70	USEPA 2002	70	USEPA 2002
BW (Adult, Noncancer)	kg	70	USEPA 2002	70	USEPA 2002
AT (Cancer)	days	25,550	USEPA 2001a	25,550	USEPA 2001a
AT (Child, Noncancer)	days	730	ED x 365 days/yr (USEPA 2001a)	2,190	ED x 365 days/yr (USEPA 2001a)
AT (Adult + Child, Noncancer)	days	3,285	ED x 365 days/yr (USEPA 2001a)	10,950	ED x 365 days/yr (USEPA 2001a)

Notes:

CTE = central tendency exposure

RME = reasonable maximum exposure

Exposure factor definitions:

- ABS_d = chemical-specific dermal absorption factor
- AF = adherence factor
- AT = averaging time (equal to ED x 365 days/year for noncarcinogens and 70 years x 365 days/year for carcinogens)
- BW = body weight
- C_d = contaminant concentration in house dust
- C_s = contaminant concentration in soil
- ED = exposure duration
- EF_d = exposure frequency to house dust
- EF_s = exposure frequency to soil
- EV = event frequency
- FI_d = fractional intake from house dust

FI_s = fractional intake from soil
FS = fraction ingested from source
IR = ingestion rate
RBA = relative bioavailability adjustment factor
SA = surface area

^a See Appendix A for details.

^b As recommended by USEPA's (2007) ProUCL.

^c The example background distribution shown was generated by incorporating FMC's updated 2001 work plan calculations including the four potential outliers.

Table 10. Proposed Deterministic Exposure Factor Values and Sources for Utility Worker Scenario

Exposure Factor	Units	CTE Value	RME Value	Source(s)/Notes
C _s	mg/kg	23.8	33.3	Mean (CTE) and 97.5UCL ^a (RME) of site-specific database ^b
EF _s	days/yr	10	22	Professional judgment
FI _s	unitless	1	1	Professional judgment
IR	mg/day	100	330	USEPA 2002
EV (default)	events/day	1	1	USEPA 2004b
AF (default)	mg/cm ² -event	0.02	0.2	USEPA 2004b
SA (default)	cm ²	3,300	3,300	USEPA 2004b
ABS _d (default)	unitless	0.03	0.03	USEPA 2004b
ED	yrs	1	1	Professional judgment
RBA (default)	unitless	1	1	Default requested by Agencies
RBA (site-specific)	unitless	0.22	0.22	Mean (CTE) and 95UCL (RME) calculated from data presented in Roberts et al. 2007
FS	unitless	1	1	Defined for scenario
BW (Cancer)	kg	70	70	USEPA 2002
BW (Noncancer)	kg	70	70	USEPA 2002
AT (Cancer)	days	25,550	25,550	USEPA 2001a
AT (Noncancer)	days	365	365	ED x 365 days/yr (USEPA 2001a)

Notes:

CTE = central tendency exposure

RME = reasonable maximum exposure

Exposure factor definitions:

ABS_d = chemical-specific dermal absorption factor

AF = adherence factor

AT = averaging time (equal to ED x 365 days/year for noncarcinogens and 70 years x 365 days/year for carcinogens)

BW = body weight

C_s = contaminant concentration in soil

ED = exposure duration

EF_s = exposure frequency to soil

EV = event frequency

FI_s = fractional intake from soil

FS = fraction ingested from source

IR = ingestion rate

RBA = relative bioavailability adjustment factor

SA = surface area

^a As recommended by USEPA's (2007) ProUCL.

^b See Appendix A for details.

Table 11. Intake Probability Distribution Statistics for Adult Plus Child Noncancer Risk Scenario

Study Area	95th Percentile	90th Percentile	50th Percentile	Reference Dose
Background ^a for Air Deposition Area	1.17E-05	7.65E-06	1.66E-06	3.0E-4

Notes:

Intakes in mg/kg-day.

^a Only one of eight potential background distributions is presented herein for illustrative purposes. The example background distribution shown was generated by incorporating FMC's updated 2001 work plan calculations for the air deposition area including the four potential outliers.