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Joe Martens
Commissioner

September 16, 2014

Mr. John P. McAuliffe, P.E.
Program Director, Syracuse
Honeywell International, Inc.
301 Plainfield Road
Suite 330
Syracuse, NY 13212

Re: Willis Avenue Chlorobenzene Site - Remedial Investigation Report - March 2014, Revised September 2014 (Site No. 7-34-026)

Dear Mr. McAuliffe:

The New York State Department of Environmental Conservation (Department) has reviewed the report entitled "Willis Avenue Chlorobenzene Site, Remedial Investigation, Geddes, New York, March 2014, revised September 2014" (RI Report). The RI Report is hereby approved.

Per the August 21, 1998 letter from Mr. A.J. Labuz of AlliedSignal (subsequently Honeywell International, Inc.) to Mr. Donald J. Hesler of the Department, the Feasibility Study should be sent to the Department within four (4) months from the date that the Department approves the RI Report. Therefore, the RI Report should be submitted to the Department for review by January 16, 2015. If you have any questions regarding this letter, please feel free to contact me *via* telephone at 518-402-9676.

Sincerely,

Richard A. Mustico, P.E.
Project Manager
Remedial Bureau D
Division of Environmental Remediation

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Harry Warner – NYSDEC
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September 10, 2014

Mr. Richard Mustico, Project Manager
New York State Department of Environmental Conservation
Remedial Bureau D
625 Broadway - 12th Floor
Albany, New York 12233-7016

Re: Willis Avenue Chlorobenzene Site Consent Order #R7-0201-87-08
Revised Remedial Investigation Report

Dear Mr. Mustico:

This letter provides replacement pages for insertion into the March 2014 Willis Avenue Chlorobenzene Site Revised Remedial Investigation Report prepared by O'Brien & Gere. The replacement pages include:

- Revised cover page for the binder
- Revised spine for the binder
- Revised inside cover
- Revised Table of Contents
- Revised Executive Summary
- Page 11 and revised page 12
- Revised Section 9
- Revised figure 34

A full electronic copy of the revised report on CD is also included. Please contact Tom Conklin of O'Brien & Gere at (315) 956-6408 or me if you have any questions or comments.

Sincerely,

John P. McAuliffe by CCC

John P. McAuliffe
Program Director, Syracuse

Attachments (2 copies, 1 CD)

cc:	Robert Nunes	USEPA (2 copy, 5 CD)
	Harry Warner	NYSDEC Region 7 (1 copy, 1 CD)
	Maureen Schuck	NYSDOH (ltr only)
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REVISED REPORT

Willis Avenue Chlorobenzene Site
Remedial Investigation
Geddes, New York

Honeywell

March 2014, revised September 2014

O'BRIEN & GERE

1163|44042

Willis Avenue Chlorobenzene Site Remedial Investigation Geddes, New York

Honeywell

CHRISTOPHER C. CALKINS, VP
O'BRIEN & GERE OF NORTH AMERICA

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M Bedrock Flow References (on CD)
N Pattern Recognition Analysis for PCDD/Fs Analytical Data (on CD)
O Soil Vapor Survey Report (on CD)

LIST OF ACRONYMS AND ABBREVIATIONS

006MA	Mounded Area near Outfall 006
AEN	American Environmental Network
AOS	Areas of Study
ASP	Analytical Services Protocol
ASTM	American Society for Testing and Materials
BEHP	Bis(2ethylhexyl)phthalate
BERA	Baseline Ecological Risk Assessment
bgs	Below Ground Surface
BTEX	Benzene, Toluene, Ethylbenzene, and Total Xylenes
CCTV	Closed Circuit Television
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CHSA	Chlorobenzene Hot-Spots Area
CIPP	Cured-in-Place Pipe
CLP	Contract Laboratory Program
COC	Constituent of Concern
COPC	Chemical of Potential Concern
COPEC	Constituent of Potential Ecological Concern
cPAH	Carcinogenic Polycyclic Aromatic Hydrocarbon
CPOI	Chemical Parameter of Interest
CR	Cancer Risk
CRS	Cultural Resources Survey
CSO	Combined Sewer Overflow
CT	Central Tendency
cy	Cubic Yards
DNAPL	Dense Non-aqueous Phase Liquid
Eco-SSL	Ecological Soil Screening Level and Guidance
EH	Reduction-Oxidation Potential

EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ERAGS	Ecological Risk Assessment Guidance for Superfund
eV	Electron Volts
FEMA	Federal Emergency Management Agency
FRE	Fiberglass Reinforced Epoxy
FS	Feasibility Study
FWIA	Fish and Wildlife Impact Analysis
GAC	Granulated Activated Carbon
GC	Gas Chromatograph
GPM	Gallons per Minute
GPR	Ground Penetrating Radar
GWTP	Groundwater Treatment Plant
HDPE	High Density Polyethylene
HpCDF	Heptachlorodibenzofuran
HCl	Muriatic Acid
Hg^0	Elemental Mercury
Hg^{2+}	Mercuric or Mercurous
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
I.D.	Inner Diameter
IRM	Interim Remedial Measure
K_{oc}	Organic Carbon Partition Coefficient
K_{ow}	Octanol-Water Partition Coefficient
LCS	Laboratory Control Sample
LHCS	Lakeshore Hydraulic Containment System
LOAEL	Lowest Observed Adverse Effect Level
MeHg	Methylmercury
Metro	Onondaga County Metropolitan Wastewater Treatment Plant
MGD	Million Gallons per Day
MHz	Megahertz
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ND	Non-Detect
NPL	National Priorities List
NTU	Nephelometric Turbidity Unit
NWI	National Wetland Inventory
NYS	New York State
NWMA	Northwest Mounded Area
NYCRR	New York Code of Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
NYSDOT	New York State Department of Transportation
OCDD	Octachlorodibenzo-p-dioxin
OCDWEP	Onondaga County Department of Water Environment Protection
OCWA	Onondaga County Water Authority
PAH	Polycyclic Aromatic Hydrocarbon
PCA	Principal Components Analysis
PCB	Polychlorinated Biphenyl
PCDD/F	Polychlorinated Dibenzo-p-dioxin/Dibenzofuran
PeCDF	Pentachlorinated Dibenzofuran
PCE	Tetrachloroethene
PID	Photoionization Detector
POC	Principal Organic Contaminant

PSA	Petroleum Storage Area
PSARCC	Precision, Sensitivity, Accuracy, Representativeness, Comparability, and Completeness
PVC	Polyvinyl Chloride
PXE	1-Phenyl-1-(2,4-dimethylphenyl)ethane
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RAO	Remedial Action Objective
RD/RA	Remedial Design/Remedial Action
RI/FS	Remedial Investigation/Feasibility Study
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
RPD	Relative Percent Difference
SBSAWP	Supplemental Biota Sampling and Analysis Work Plan
SCG	Standard, Criteria, and Guidance Value
SDI	Supplemental Design Investigation
SLEA	Screening-Level Ecological Assessment
SPDES	State Pollutant Discharge Elimination System
SPDI	Supplemental Pre-Design Investigation
SU	Standard Units
SVOC	Semivolatile Organic Compound
SWMA	Southwest Mounded Area
TAGM	Technical & Guidance Memorandum
TAL	Target Analyte List
TAMS	TAMS Consultants
TCDF	Tetrachlorinated Dibenzofuran
TCE	Trichloroethene
TCL	Target Compound List
TCLP	Toxicity Characteristics Leaching Procedure
TEF	Toxicity Equivalency Factors
TEQ	Toxicity Equivalents
TOC	Total Organic Carbon
TOGS	Technical & Operational Guidance Series
Total CBs	Total Chlorinated Benzenes
TPH	Total Petroleum Hydrocarbons
UFPO	Underground Facilities Protection Organization
USEPA	United States Environmental Protection Agency
VCP	Vitrified Clay Pipe
VOC	Volatile Organic Compound

EXECUTIVE SUMMARY

Introduction

This document is the revised Remedial Investigation (RI) Report for the Willis Avenue Chlorobenzene Site (the Site) in Geddes, New York. The RI was performed pursuant to the Administrative Consent Order (R7-0201-87-08) between the New York State Department of Environmental Conservation (NYSDEC) and Honeywell International, Inc. (Honeywell) dated August 12, 1990 (NYSDEC, 1990),and in accordance with the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988) and Part 300.68 of the National Contingency Plan, CERCLA as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986.

This document includes discussion of data collected during the four phases of the RI. It also contains data collected during the multiple interim remedial measures (IRMs) implemented on-site.

These data were used to develop the understanding of the Site including the nature and extent of chemical parameters of interest (CPOIs) and identification of potential source areas. Based on the findings of the RI, a series of IRMs were implemented to mitigate potential impacts from the Site. The implementation of these IRMs has resulted in the mitigation of the majority of potential Site impacts to human health and the environment. The remaining potential risks will be addressed during Site-wide remedial action.

Site Description

As described in the Order, the Site is comprised of the Willis Avenue Plant Study Area, the Petroleum Storage Area (PSA) and the Chlorobenzene Hot-spots Area (CHSA). During Phase 1, monitoring wells were also installed and sampled on the Onondaga lakeshore property downgradient of the Willis Avenue Plant Area. Based on NYSDEC comments on the May 1995 RI Report, Outfalls 006 and 004 were added to Phase 2 RI sampling activities.

Subsequent to the 2002 RI submittal, a groundwater treatment plant (GWTP) was constructed on-site as part of the Willis/Semet IRM (Willis/Semet GWTP), and material excavated from Tributary 5A and other areas associated with the Willis Avenue Site have been staged in two piles on the Willis Avenue Plant Area (**Figure 2**).

For the purposes of this report, the study areas have been divided into two main categories: the Plant Study Area and additional areas of study (AOS: CHSA and PSA). The Willis Avenue Plant Study Area consists of the fenced Plant Area, the Outfall 004 area situated to the north of the Plant Area, the Outfall 006 area located to the south of Plant Area, the Onondaga lakeshore property, and the I690 Storm Drainage System. Additional AOS include the PSA and the CHSA. The various areas are presented on **Figure 2**.

At the request of NYSDEC, Tributary 5A, which was originally studied as part of the Semet Residue Ponds RI (O'Brien & Gere, 1991), was considered during performance of the Willis Ave Chlorobenzene Site Ecological Risk Assessment (ERA). A description of the results of the Tributary 5A sampling conducted as a component of the Semet Residue Ponds RI and as part of the Willis Avenue Chlorobenzene Site ERA was therefore included in this report. Tributary 5A was added to the Willis Avenue Chlorobenzene Site, and was included in both the Human Health Risk Assessment and Baseline Ecological Risk Assessment. Impacted sediment within Tributary 5A sediment was removed as part of the Semet Residue Ponds Shallow Groundwater Remedial Action. However, the need for any further remedial action with respect to Tributary 5A sediment will be evaluated as part of the Willis Avenue Chlorobenzene Site Feasibility Study. Also, the East Flume has been removed from the Willis Avenue Site and included in the Wastebed B/Harbor Brook Site.

Project Objectives

The objectives of the RI were to:

- Collect sufficient data to identify and characterize former process residuals associated with the Site,

- Investigate Tributary 5A for the presence of Site-related constituents,
- Evaluate and characterize the nature and extent of residuals,
- Evaluate potential residual migration pathways,
- Evaluate potential impacts to human and ecological receptors, and
- Gather sufficient data to support the Feasibility Study (FS).

Human Health and Ecological Risk Assessments

The risk assessments were performed using conservative regulatory methodologies prescribed in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) guidance and other applicable or relevant and appropriate requirements (ARARs). Currently, both the HHRA and BERA Reports have been submitted and approved by the NYSDEC. The final HHRA was approved by the NYSDEC on August 10, 2010 and included a detailed discussion of the results from this risk assessment. The final BERA Report was approved by the NYSDEC on May 21, 2013 and included a detailed discussion of this risk assessment.

HHRA

As part of the Willis Avenue HHRA, current and future land use scenarios were identified. Potential receptors were identified based on land use scenarios and evaluated using current EPA risk assessment guidance. Unacceptable cancer risks and non-cancer hazards were identified above the regulatory threshold from the following constituents and media:

- Cancer risk above the regulatory threshold in soils was driven by exposure to benzene and 2,3,7,8-TCDD.
- Non-cancer hazards above the hazard index threshold in soils were driven by exposure to 2,3,7,8-TCDD, benzene, xylenes, PCBs, manganese, mercury, and nickel.
- The non-cancer hazard above the hazard index threshold identified in groundwater was driven by exposure to benzene and chlorobenezne.
- Although hypothetical and an extremely unlikely exposure scenario, the calculated cancer and non-cancer risk for the future adult resident and child resident at the hypothetical drinking water source area were above the regulatory thresholds, attributable primarily to exposure to the maximum detected concentration of benzene in groundwater.

BERA

The Willis Avenue BERA identified current and future habitat use and potential ecological receptors at the Site. Based on the ecological receptors identified, unacceptable risk was present for the following constituents and media.

- Constituents in soil accounting for the majority of risk to receptors at the plant area included mercury, methyl mercury, zinc, chromium, iron, lead, manganese, selenium, 4,4-DDE, 1,4 Dichlorobenzene, chlorobenzene, total PCBs, and dioxins.
- Constituents in soil accounting for the majority of risk to receptors at the PSA included mercury, methyl mercury, iron, selenium, endrin, endrin ketone, aldrin, and 4-methylphenol.
- Constituents in soil that accounted for the majority of risk to receptors at the Chlorobenzene Hot-Spot Area included mercury, iron, endrin, endrin aldehyde, endrin ketone, aldrin, hexachlorobenzene, and total PCBs.

Conclusions

The evaluation of the analytical data and field observations from the RI and subsequent IRM investigations indicates that the sources of impacted Site media are related to historic production processes on the Plant Study Area and former Main Plant Site. These included the mercury cell process, chlorinated benzene products production, and the Solvay Process.

The following conclusions were developed based on the investigations.

- Site geology varied between the Plant Area, CHSA, and PSA.
  - Plant Study Area geology consists of fill material, marl/peat layer, silt and clay, fine sand and silt, sand and gravel, till, and bedrock.
  - The overburden geology in the CHSA consists of fill, lacustrine sediments, and till underlain by bedrock
  - The PSA geology was a thin layer of fill (up 10 ft thick) overlying the bedrock or glacial till.
- The unconsolidated hydrogeologic units identified for the Plant Study Area, CHSA, and PSA varied significantly.
  - Plant Study Area: fill unit, Solvay waste, a low permeability silt and clay unit, and the deep unit consisting of the fine grained sand and silt and basal sand and gravel layers.
  - CHSA: fill unit and lacustrine sediments.
  - PSA: shallow fill unit.
- Shallow groundwater flow is generally towards Onondaga with some component discharging to Tributary 5A and drainage ditches.
- Intermediate and deep groundwater flows north towards the lake from the Plant Study Area (no intermediate or deep units present for the CHSA or PSA).
- The intermediate unit is separated from the deep unit throughout the Plant Study Area by a low permeability silt and clay layer, which acts as a confining layer for the deep hydrogeologic unit.
- The vertical hydraulic potential is downward from the fill to the native sediments across the majority of the Plant Study Area, CHSA, and PSA.
- On the lakeshore property of the Plant Study Area, there is an upward vertical hydraulic head between the intermediate and deep monitoring wells and Onondaga Lake.
- Hydraulic conductivities for the hydrogeologic units are:
  - Plant Study Area
    - Shallow groundwater: 2.3×10^{-2} cm/sec to 8.6×10^{-5} cm/sec, with $.9 \times 10^{-2}$ cm/sec to 2.1×10^{-3} cm/sec for the lakeshore property.
    - Intermediate groundwater: 3.9×10^{-4} cm/sec to 2.8×10^{-5} cm/sec, with 7.2×10^{-5} cm/sec to 5.0×10^{-5} cm/sec for the lakeshore property.
    - Deep silt and sand unit: 1.1×10^{-4} cm/sec to 2.0×10^{-3} cm/sec.
    - Deep sand and gravel unit: 4.8×10^{-2} cm/sec to 3.8×10^{-1} cm/sec.
  - CHSA: 3.5×10^{-6} cm/sec to 2.8×10^{-2} cm/sec for the fill and lacustrine sediments.
  - PSA: 2×10^{-5} cm/sec to 3.8×10^{-3} cm/sec.
- Source areas for the Plant Study Area are:
  - On-site areas associated with the production of chlorinated benzene products or storm water conveyance for chlorinated benzenes,
  - The footprint of the former Mercury Cell Building for elemental and other forms of mercury,
  - Transformers that supported production facilities for PCBs, and
  - Free product that migrated from the Plant Area to the lakeshore property.

- The main source area for the CHSA was the former pipe that transported cooling water from the Para building to the former Main Plant site pump house.
- The key source areas for the PSA were the former distillation facility on-site that produced benzene, toluene, xylenes, and naphthalene, benzene pipeline to the Plant Area, and former storage tanks for No. 2 fuel oil.
- Plant Study Area CPOIs include BTEX compounds, chlorinated benzenes (mono-, di-, and tri- isomers), PAHs (primarily naphthalene), phenolic compounds, Aroclors 1254 and 1260, PCDD/Fs, mercury, iron, and Solvay Process-related parameters (calcium, magnesium, potassium, and sodium).
- The CHSA CPOIs include Benzene, BEHP, chlorinated benzenes (mono-, di-, tri-, and hexa- isomers), PAHs, Aroclor 1254, mercury, iron, and Solvay Process-related parameters (calcium, magnesium, potassium, and sodium).
- The PSA CPOIs include BTEX compounds, chlorinated benzenes (mono-, di-, and tri- isomers), naphthalene, phenolic compounds, mercury, iron, and Solvay Process-related parameters (calcium, magnesium, potassium, and sodium).
- The Tributary 5A CPOIs include BTEX compounds, chlorinated benzenes (mono- and di- isomers), PAHs, phenolic compounds, BEHP, Aroclors 1248,1254, and 1260, and metals, including mercury Solvay Process-related parameters (calcium, magnesium, potassium, and sodium).
- The Willis/Semet Barrier Wall IRM and DNAPL IRM address the groundwater migration of dissolved organic parameters and DNAPL towards Onondaga Lake.
- The extent of the lakeshore property DNAPL was further delineated by the TarGOST® probing investigation, and this information was used to design the DNAPL collection system footprint.
- The Semet Residue Ponds Shallow Groundwater Remedial Action addressed shallow groundwater contamination through the construction and operation of a groundwater collection system and treatment of the collected groundwater at the Willis Avenue Wastewater Treatment Facility. This remedial action also addressed impacted sediment within Tributary 5A through removal. However, as Tributary 5A is part of the Willis Avenue Chlorobenzene Site, the need for any further remedial action with respect Tributary 5A sediment will be evaluated as part of the Willis Avenue Chlorobenzene Site Feasibility Study.

The HHRA and BERA, performed using the conservative regulatory methodologies prescribed within CERCLA and ARAR guidance, identified unacceptable risk in site soils and groundwater for both human health and ecological receptors at the Willis Avenue Site. The nature and extent of the CPOIs has been well defined, and the ecological and human health risk assessments have been formally approved by the NYSDEC. No further Site characterization is warranted.

Preliminary Remedial Action Objectives

A list of preliminary RAOs was developed based on the April 14, 1999 meeting between Honeywell, NYSDEC and O'Brien & Gere and the July 5, 2002 and June 18, 2014 comment letters from the NYSDEC to Honeywell. These preliminary RAOs are presented below; however, the IRMs discussed in Section 1.5 were performed to address these preliminary RAOs and will be further evaluated within the FS.

Soil/Fill/Sediment/Surface Water RAOs for Public Health Protection

- Prevent, or reduce to the extent practicable, ingestion/direct contact with contaminated soil/fill, sediment, and surface water.
- Prevent, or reduce to the extent practicable, inhalation of or exposure from contaminants volatilizing from contaminants in soil/fill.
- Soil/Fill/Sediment/Surface Water RAOs for Environmental ProtectionPrevent, or reduce to the extent practicable, migration of contaminants that would result in groundwater, sediment, or surface water contamination.

- Prevent, or reduce to the extent practicable, impacts to biota from ingestion/direct contact with contaminated soil/fill or sediment causing toxicity or impacts from bioaccumulation through the terrestrial food chain.

Groundwater RAOs for Public Health Protection

- Prevent ingestion of groundwater with contaminant levels exceeding drinking water standards.
- Prevent contact with, or inhalation of volatiles from, contaminated groundwater.

Groundwater RAOs for Environmental Protection

- Restore groundwater aquifer to pre-disposal/pre-release conditions, to the extent practicable.
- Prevent, or reduce to the extent practicable, the discharge of contaminants to sediment and surface water.
- Remove, or reduce to the extent practicable, the source of groundwater, surface water, or sediment contamination.

Soil Vapor RAO

- Mitigate impacts to public health resulting from existing, or potential for, soil vapor intrusion into buildings at site.

Future Activities

The RAOs will be evaluated within the context of alternatives within the FS. Also, the Federal Emergency Management Agency (FEMA) floodplain mapping for the Site area will be utilized to evaluate if the Site is within the FEMA defined 100-year and 500-year floodplains. If it is determined that the remedial measures proposed for the Site may impact identified floodplain areas, a Floodplain Assessment Report will be prepared and submitted as part of the FS Report.

1. INTRODUCTION

1.1. PROJECT BACKGROUND

This report presents the findings of the Remedial Investigation (RI) performed at the Willis Avenue Chlorobenzene Site (the Site) in Geddes, New York (**Figure 1**). A Site plan is presented on **Figure 2**. The RI was performed by O'Brien & Gere Engineers, Inc. (O'Brien & Gere) on behalf of Honeywell (formerly AlliedSignal) pursuant to Consent Order R7-0201-87-08 (the Order) between Honeywell and the New York State Department of Environmental Conservation (NYSDEC) dated August 12, 1990 (NYSDEC, 1990). The Site has been classified as an inactive hazardous waste site as defined in ECL 27-1301(2) and has been listed as a Class 2 site in the Registry of Inactive Hazardous Waste Disposal Sites in New York State as Site Number 7-34-026. The Site is also a sub-site of Onondaga Lake, which is listed on the United States Environmental Protection Agency (USEPA) National Priorities List (NPL; Comprehensive Environmental Response, Compensation, and Liability Information System [CERCLIS] ID number NYD 986913580; 1994).

The RI was performed in accordance with the procedures set forth in the NYSDEC Technical and Administrative Guidance Memorandum (TAGM), Guidelines for Remedial Investigations/Feasibility Studies, HWR-89-4025, March 1989 (NYSDEC, 1989a), and the USEPA Guidance for Conducting Remedial Investigations and Feasibility Studies Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; USEPA, 1988).

The RI was conducted in four phases. Phase 1 included activities described in the November 1990 Remedial Investigation/Feasibility Study (RI/FS): Willis Avenue Plant, Petroleum Storage Facility and Associated "Hot-spots" Work Plan (O'Brien & Gere, 1990a). Phase 2 (Supplemental RI) included activities described in the August 1997 Willis Avenue Chlorobenzene Site Supplemental RI Work Plan (O'Brien & Gere, 1997a) and Phase 3 included activities described in the Phase 3A, 3B and 3C sampling plans. The Phase 3A and 3B plans were dated August 21, 1998 and incorporated modifications presented in the September 23, 1998 letter from NYSDEC. The Phase 3C sampling plan was dated February 23, 1999 and incorporated comments received from NYSDEC by telephone on March 30, 1999. The fourth phase included activities described in the August 1999 Baseline Ecological Risk Assessment (BERA) Work Plan (O'Brien & Gere, 1999a) and the October 19, 1999 letter from Honeywell to the NYSDEC. The NYSDEC provided a red-line/strikeout response letter to Honeywell on October 29, 1999. Honeywell provided a response to comment letter to the NYSDEC on November 5, 1999. The NYSDEC then provided further comment on January 29, 2000. Phase 4 field efforts related to the BERA for the Site are further described in Supplemental Biota Sampling and Analysis Work Plan (O'Brien & Gere, 2001a) dated June 2001 and subsequent associated correspondence between Honeywell and the NYSDEC.

Phase 1 of the RI was initiated in 1991, and the RI Report was originally submitted to NYSDEC in January 1993. In response to NYSDEC comments, additional work was performed and the report resubmitted in May 1995. Phase 2 of the RI was initiated in September 1997 in response to comments received from NYSDEC regarding the May 1995 report. Results of Phases 1 and 2 were summarized in a report submitted to NYSDEC in March 1998. Comments on this report were presented in a letter from NYSDEC dated July 21, 1998. Based on the comments contained in this letter and subsequent conference calls between Honeywell, NYSDEC and O'Brien & Gere, the scope of Phase 3 was developed. Phase 3 field activities were performed in the fall of 1998 and spring of 1999. The fourth phase of sampling was conducted in October and November of 1999 as part of the BERA field effort. This revised report incorporated site changes which have occurred due to the implementation of various interim remedial measures (IRMs), and the modification of the site definition (i.e., the removal of the East Flume and the addition of Tributary 5A). The report also incorporates the final, approved BERA and HHRA.

Five areas in close proximity to the Site are currently being studied pursuant to separate consent orders:

- Onondaga Lake
- the Semet Residue Ponds
- the Ballfield Site

- the Wastebed B/Harbor Brook Site
- Wastebeds 1-8

In addition, other areas are being remediated under interim remedial measure (IRM) Consent Orders as components of the Willis Avenue Chlorobenzene Site RI/FS and consent orders related to other sites:

- the Onondaga lakeshore property chlorinated benzenes recovery IRM,
- Willis/Semet Hydraulic Containment System IRM,
- Willis Avenue Groundwater Treatment Plant IRM,
- the I-690 Storm Drainage System Investigation and Rehabilitation (eastern and western portions) IRM,
- I-690 Storm Drain System –State Fair Boulevard Drainage Ditch groundwater collection system
- the East Flume IRM (with rerouting of the State Pollutant Discharge Elimination System [SPDES] discharge point Outfall 015),
- Ballfield/Willis/Semet Ponds Site Improvements,
- Tributary 5A under the Semet Residue Ponds Groundwater Remedial Alternative, and
- Willis Avenue Soil Pile Consolidation, Soil Cover Placement, and Seeding.

A more detailed description of these efforts is presented in Section 1.5.

1.2. PROJECT OBJECTIVES

The objectives of the RI were to:

- Collect sufficient data to identify and characterize former process residuals associated with the Site,
- Investigate Tributary 5A for the presence of Site-related constituents,
- Evaluate and characterize the nature and extent of residuals,
- Evaluate potential residual migration pathways,
- Evaluate potential impacts to human and ecological receptors, and
- Gather sufficient data to support the FS.

1.3. SITE BACKGROUND

1.3.1. Site Description

As described in the Order, the Site is comprised of the Willis Avenue Plant Study Area, the Petroleum Storage Area (PSA) and the Chlorobenzene Hot-spots Area (CHSA). During Phase 1, monitoring wells were also installed and sampled on the Onondaga lakeshore property downgradient of the Willis Avenue Plant Area. Based on NYSDEC comments on the May 1995 RI Report, Outfalls 006 and 004 were added to Phase 2 RI sampling activities.

Subsequent to the 2002 RI submittal, a groundwater treatment plant (GWTP) was constructed on-site as part of the Willis/Semet IRM (Willis/Semet GWTP), and material excavated from Tributary 5A and other areas associated with the Willis Avenue Site have been staged in two piles on the Willis Avenue Plant Area (**Figure 2**).

For the purposes of this report, the study areas have been divided into two main categories: the Plant Study Area and additional areas of study (AOS: CHSA and PSA). The Willis Avenue Plant Study Area consists of the fenced Plant Area, the Outfall 004 area situated to the north of the Plant Area, the Outfall 006 area located to the south of Plant Area, the Onondaga lakeshore property, and the I690 Storm Drainage System. Additional AOS include the PSA and the CHSA. The various areas are presented on **Figure 2**.

At the request of NYSDEC, Tributary 5A, which was originally studied as part of the Semet Residue Ponds RI (O'Brien & Gere, 1991), was considered during performance of the Willis Ave Chlorobenzene Site Ecological Risk Assessment (ERA). A description of the results of the Tributary 5A sampling conducted as a component of the Semet Residue Ponds RI and as part of the Willis Avenue Chlorobenzene Site ERA was therefore included in this report. Tributary 5A was added to the Willis Avenue Chlorobenzene Site, and was included in both the Human Health Risk Assessment and Baseline Ecological Risk Assessment. However, the Tributary 5A sediment was addressed as part of the Semet Ponds Shallow Groundwater Remedial Action but the need for further remedial action will be evaluated as part of the Willis Avenue Chlorobenzene Site Feasibility Study, and the need for further remediation will be considered under the Willis Avenue Chlorobenzene Site. Also, the East Flume has been removed from the Willis Avenue Site and included in the Wastebed B/Harbor Brook Site.

Areas addressed as part of this report are described in further detail below.

1.3.1.1. Willis Avenue Plant Study Area

The Willis Avenue Plant Study Area consists of the fenced Willis Avenue Plant Area (Plant Area), Outfall 006, and the associated drainage ditch and mounded area, Outfall 004 and the associated drainage ditch, and the lakeshore property (**Figure 2**). Discussion of the various IRMs and remedial actions associated with the Willis Avenue Site are included in Section 1.5 to provide additional information regarding the conditions in the Plant Study Area.

Plant Area. The Plant Area is bounded by State Fair Boulevard to the north, Willis Avenue to the east, CSX railroad tracks to the south, and the Semet Residue Ponds Site to the west (**Figure 2**). The Plant Area is sparsely vegetated except for the grassy area near the former office/laboratory (now demolished). The Plant Area is classified as an urban vacant lot covertype. Surface materials consist primarily of concrete building foundations, associated debris, asphalt, and gravel. Shallow subsurface materials (approximately 0 to 30 ft) consist of fill materials composed of sand and gravel, ash, cinders, brick fragments and Solvay waste. The Plant Area is completely surrounded by an 8 ft high chain link fence, and the only point of access is a gate that can only be opened by Honeywell personnel. The Plant Area is shown on **Figures 3 and 4**.

The principal activity of the plant was the production of chlorinated benzene products from benzene. The facility began operation in 1918 and continued in operation until 1977(O'Brien & Gere, 1990b). From 1971 to 1975, the Willis Avenue Plant produced an annual average of 6,809 tons of monochlorobenzene (chlorobenzene), 3,351 tons of orthodichlorobenzene (1,2-dichlorobenzene), 450 tons of metadichlorobenzene (1,3-dichlorobenzene), and 4,260 tons of paradichlorobenzene (1,4-dichlorobenzene). Muriatic acid (HCl) was also produced at this facility as a by-product (O'Brien & Gere, 1990b). According to Honeywell records, it was projected that in 1969 that an estimated 22,240 tons of muriatic acid would be produced at the facility.

Additional operations that reportedly took place at the plant included Solvay Process for the production of caustic potash, caustic soda, and chlorine gas. Caustic potash was a saleable product while the chlorine gas was utilized as a raw material in the chlorobenzene production process. The caustic soda was produced for internal use at the Syracuse Works. Caustic potash (potassium hydroxide) and chlorine were produced by the electrolysis of potassium chloride brine solution. Initially, this was done in diaphragm cells, but in 1947, the existing 102 mercury cells were replaced with 59 new mercury cells when the plant converted from sodium chloride brine to potassium chloride brine to manufacture these products (O'Brien & Gere, 1990b). The process operations that took place at this facility have been described in detail in the History of the Willis Avenue Plant, Petroleum Storage Facility, and Associated "Hot-spots" Report (O'Brien & Gere, 1990b). This report is included as **Appendix A**. Solvay waste was generated during the Solvay Process and is a non-hazardous combination of process residuals, unreacted material, and mineral salts taken out as a chloride-rich slurry exhibiting an elevated pH (10 to 12 std. units [SU]). The chemical characteristics of the Solvay waste are presented below in Table 1-1.

Table 1-1 Chemical Characteristics of Solvay Process Waste

Analyte	Characteristic (%)	Analyte	Characteristic (mg/kg)
Group A		Group B	
$CaCO_3$	20	**Aluminum**	4,800
2 CaO SiO_2	17	**Arsenic**	16
H_20 of hydration	12	**Cadmium**	2
$Mg(OH)_2$	10	**Chromium**	9
CaO $CaCl_2$	8	**Copper**	10
SiO_2	7	**Iron**	4,520
Sodium Chloride	6	**Lead**	30
$CaCl_2$	6	**Mercury**	0.04
R_2O_3	6	**Nickel**	13
$Ca(OH)_2$	4	**Zinc**	60
$CaSO_4$	4	**Cyanide**	0.04
		Alkalinity (as $CaCO_3$)	9,380

Notes:
Group A: R_2O_3 where R = Aluminum, Iron. Data unavailable regarding sampling and analysis procedures. Kulhawy, *et al*. 1977. Geotechnical Behavior of Solvay Process Waste.
Group B: Calocerinos & Spina. 1980. Proceedings of the Conference on Geotechnical Practice for Disposal of Solid Waste Materials. Analysis conducted on sample composed of 10 grams of Solvay waste and 90 grams of H_20. Since Solvay process and constituents added to the waste have remained relatively consistent, volumes of waste throughout the area should have similar properties.

Outfall 006, Drainage Ditch, and Mounded Area. Outfall 006 is situated to the south of the fenced Plant Area, approximately 30 ft north of the CSX railroad tracks (**Figure 2**). A shallow drainage ditch (1 to 2 ft in depth) extends from the outfall north towards the Plant Area. The above ground portion of the drainage ditch is approximately 75 ft in length, and the remainder is below ground. Historic information gathered from SPDES discharge permit sampling indicates that the ditch is dry throughout the year. Due to the lack of flow through Outfall 006, the outfall has been removed from Honeywell's SPDES permit NY0002275. However, this area may have received surface run-off during the period in which the Plant was in operation. The mounded area is the area extending from the southern Plant Area boundary back to the CSX railroad tracks. The area is a maximum of approximately 350 ft (north-south) by 200 ft (east-west), and vegetation is patchy with scattered pioneer grasses, wild flowers and tree saplings (classified as brushy cleared land). Access to this area is not restricted; however, the area is remote and generally only accessed by railroad or utilities workers.

Outfall 004 and Drainage Ditch. Outfall 004 is situated approximately 25 ft north and 200 ft west of the northwest corner of the Plant Area fence, near State Fair Boulevard (**Figure 2**). A shallow drainage ditch (1 to 1.5 ft in depth) runs in the east-west direction parallel to, and approximately 10 ft south of State Fair Boulevard. The ditch starts at the corner of Willis Avenue and continues west until it intersects Tributary 5A near Crucible Specialty Metals. Covertype in this area is classified as mowed roadside/pathway which consists of grasses, sedges, vines and low shrubs. Access to this area is not restricted. If flow were to occur in the drainage ditch, it

would discharge via Outfall 004 to the I-690 Storm Drainage System. No flow has been observed in the ditch during the period that the SPDES discharge permit was in place and has been removed from Honeywell's SPDES permit NY0002275. However, this area may have received surface run-off during the period in which the Plant was in operation.

Lakeshore Property. The lakeshore property is situated to the north of the Plant Area, between the southern shore of Onondaga Lake and the west bound lane of I-690 (**Figure 2**). The lakeshore property is bounded by Onondaga Lake to the north and the fence along I-690 to the south. The extent of the lakeshore property to the west is defined by extending the western boundary of the Plant Area fence to the lake, and the eastern extent is defined by monitoring well cluster WA-3. The area consists of a narrow strip of mowed lawn to the north of I-690 and an access road. The lakeshore property widens as it approaches the western end of the former East Flume. The area is surrounded by 8 ft high chain link fence with a locked gate. The area historically contained a causeway used as a docking facility for barges transporting products and supplies for Allied-Signal during plant operations.

The original investigative work at the lakeshore property was performed by Geraghty & Miller between 1979 and 1984. During this period, 28 monitoring wells were installed in the Plant Area and on the lakeshore property. Analytical results indicated the presence of BTEX (benzene, toluene, ethylbenzene, and total xylenes) and chlorinated benzenes in groundwater in the vicinity of the lakeshore property. Based on the results of this investigation and the Phase 1 RI work performed by O'Brien & Gere, an IRM Consent Order between Honeywell and NYSDEC was issued in 1992 (NYSDEC, 1992). The objective of the IRM was to develop a system to capture chlorinated benzenes dense non-aqueous phase liquid (DNAPL) at the lakeshore property. The IRMs associated with the lakeshore property are discussed in detail in Section 1.5.

I-690 Storm Drainage System. The I-690 Storm Drainage System downgradient of the Willis Avenue Plant Area consists of an eastern portion and a western portion that flow to Onondaga Lake. The system consists of 18 catch basins (10 on the eastern portion and eight on the western portion), three manholes on the lakeshore property, approx. 2,700 ft of storm water conveyance pipe, and the 1,950 ft drainage ditch that runs along State Fair Blvd. north of the Willis Avenue Plant Area. The system is currently part of an IRM that is discussed in detail within Section 1.5.

1.3.1.2. Additional Areas of Study

Petroleum Storage Area. The PSA is located to the southwest of the former Willis Avenue Plant (**Figure 2**). It is bounded to the north by the CSX railroad tracks, to the southeast by a railroad siding (opposite the former Ammonium Chloride and present Sodium Nitrite Plants) and to the west by the Suez (formerly Trigen) soft coal storage area. The PSA is mostly covered by concrete and asphalt and is sparsely vegetated. Access to the area is restricted to the south by fencing, but is not restricted to the north. The close proximity of the CSX railroad tracks to the north limits recreational use of this area.

This facility was operated from 1915 to 1970. Prior to its demolition in 1973, the facility fractionally distilled coke light oil to produce benzene, toluene, xylenes, and naphthalene. In addition to the shipment of these products to locations outside the area, pure benzene was piped above ground over the trestle to the Plant Area for use in the production of chlorinated benzene products (**Figure 2**). Most recently, this area was used for the storage of No. 2 fuel oil.

The storage tanks were dismantled during closure of the Honeywell facility. Three monitoring wells were installed in the area in the early 1980s to detect possible petroleum product leakage. A study of the PSA was conducted by Groundwater Technology in 1984, and a report was issued in 1995 (Groundwater Technologies, 1985). No. 2 fuel oil was not detected in the groundwater during the study; however, benzene, toluene, xylenes, and naphthalene were detected.

Chlorobenzene Hot-Spots Area. The CHSA is situated to the south of the Plant Area and the PSA and adjacent to Suez (formerly Trigen) (**Figure 2**). The area is mainly covered with industrial buildings, concrete and asphalt. A narrow strip of sparsely vegetated land is present between Industrial Drive and the chain link fence, which

borders the Suez (formerly Trigen) property to the south. Access is restricted to the north by fencing but is not restricted to the south.

Based on previous studies (Blasland & Bouck, 1987a, 1987b, 1989a), benzene and chlorobenzene were detected in monitoring wells MW-111 and R-5P. These residuals were attributed to leakage from a former pipeline that transported chlorobenzene residual waste from the Willis Avenue Plant to approximately 50 ft south of MW-111 (O'Brien & Gere, 1990b). This pipeline ran from the Willis Avenue Plant area to the pump house on the Main Plant site. The pipeline ran above ground on existing pipe bridges except across plant driveways where it traveled below ground. The exact pathway is not known for portions of the line but an estimated path is presented on **Figure 2**. The pipe transported decanted cooling water from a waste tank associated with the former Para building.

East Flume. The East Flume was situated to the northeast of the Plant Area along the southern shore of Onondaga Lake (**Figure 2**) and discharged to the lake. The East Flume was addressed by the East Flume IRM and the Wastebed B/Harbor Brook RI/FS.

The East Flume was originally an excavated drainage ditch that primarily received process cooling waters from the Main Plant and Willis Avenue Plant. In the Onondaga Lake RI, a combination of cooling water, sanitary waste, Solvay waste, mercury wastes, and organic wastes were discharged into the lake via the East Flume (NYSDEC/TAMS Consultants [TAMS], 2002). The East Flume also received storm water from the Village of Solvay, General Chemical Corp., and Landis Plastics and process waters from Solvay Paperboard and Suez (formerly Trigen).

Tributary 5A. Tributary 5A originates from a culvert north of the railroad tracks on the west side of Willis Avenue. It proceeds in an east-west direction parallel to the railroad tracks until just west of the Semet Residue Ponds Site western fence line and then proceeds in a northeast direction towards Onondaga Lake. The tributary is considered an industrial effluent stream defined as a stream "in which the temperature, chemistry, or transparency of the water is significantly modified by discharge of effluent from an industrial, commercial or sewage treatment plant" (Reshke, 1990). The tributary receives discharge from twelve outfalls from Crucible Specialty Metals, as well as surface water run-off and shallow groundwater discharge from the Semet Residue Ponds, Willis Avenue Site and the former Church and Dwight facility. According to the Crucible SPDES Permit, Tributary 5A formerly carried a New York State (NYS) stream classification of "D"; however, the tributary has been declassified. As a result, the tributary assumes the class of the surface water to which it discharges (Onondaga Lake) which is a Class C surface water. Compliance with Class C standards will be evaluated through the collection of surface water at the confluence of the tributary and Onondaga Lake.

1.4. PREVIOUS STUDIES

Together with historical usage of the Site, previous geologic and hydrogeologic studies provided the framework for the selection of sampling locations and the initial analytical parameters for samples collected during the RI. These studies, which are described in the Site History (**Appendix A**), include:

- Installation of 28 wells in the Willis Avenue Plant Study Area by Geraghty & Miller and Groundwater Technologies, Inc. between 1979 and 1984 (Groundwater Technology, 1984a),
- Installation of ten monitoring wells in the PSA by Groundwater Technologies, Inc. in 1984 (Groundwater Technology, 1984b), and
- Installation of 28 borings, eight monitoring wells, and one piezometer in the CHSA by Blasland and Bouck in 1987.

1.5. COMPLETED AND ON-GOING INTERIM REMEDIAL MEASURES

During the RI, it became evident that portions of the Site had been impacted by previous operations. Due to the nature of materials and potential exposure routes, it was decided to implement a series of IRMs to mitigate risk from the Site. The IRMs discussed below describe the remedial efforts implemented to date.

1.5.1. Onondaga Lakeshore Property Chlorinated Benzenes Recovery IRM

Groundwater Technology, Inc. was retained to delineate the extent of chlorinated benzenes DNAPL in this area. A report summarizing this effort was issued in April 1993 (Groundwater Technologies, 1993). The investigation involved the advancement of 8 soil borings (SB-1 through SB-8) along the lakeshore property. The borings were initiated near the western end of the East Flume and extended to the west approximately 1,200 ft. Split spoon samples were collected continuously from each boring. Individual samples were screened using a portable gas chromatograph and select samples were submitted for laboratory analysis. Borings were advanced to the silty sand unit situated beneath the marl unit. Boring depths ranged from 40 ft to 47 ft. Results of this effort revealed that DNAPL was present in three areas within the marl unit, one area each near borings SB-3, SB-4 and SB-7. The three areas did not appear to be connected horizontally or vertically, suggesting that the DNAPL is present in localized "pockets". DNAPL thickness in each of the three areas was approximately 2 ft to 2.5 ft. The estimated volume of DNAPL associated with the three areas ranged from 11,500 gallons to 19,000 gallons.

To further delineate the extent of DNAPL in the lakeshore area, seven additional soil borings were advanced in 1995 (SB-9 through SB-15). Three of these borings (SB-10, SB-12, and SB-15) were completed as temporary groundwater monitoring wells. Based on these findings, ten recovery wells were installed. These recovery wells were utilized for the initial DNAPL Recovery System constructed for Honeywell in 1995 by GT Engineering. The system consisted of eleven vaulted recovery wells, a force main, a collection tank, pre-fabricated building, magnet drive gear pumps and associated electronics. The magnet drive gear pumps had an intermittent pumping rate of 0.1 gallons per minute (GPM). The product was intermittently pumped to a holding tank located inside the equipment building situated on the lakeshore property. The DNAPL storage tank contents were removed every 90 days at a minimum and were transported off-site for disposal at a permitted facility.

At the request of NYSDEC, a DNAPL and groundwater monitoring plan for the lakeshore property was submitted to NYSDEC in June 1998 (letter from Al Labuz to Don Hesler, June 1998). DNAPL monitoring consisted of the monthly evaluation of 15 wells (SB-10, SB-12, SB-15, MW-A1, MW-A2, MW-A3, WA-1S, I, and D, WA-2S, I, and D and WA-3S, I, and D) for the presence of DNAPL, pumping of DNAPL (if present) from the wells, and transferring of DNAPL to the holding tank located in the equipment building. Groundwater monitoring consists of the semi-annual collection of groundwater samples from five wells (SB-10, SB-12, MW-A1, MW-A2 and MW-A3) if no free product was present and laboratory analysis of select volatile organic compounds (VOCs) by USEPA Method 8260B. This plan was initiated in December 1998. Based on the first few monitoring events, the frequency of DNAPL monitoring for the above mentioned wells was increased to once per week. The wells produced 0.5 to 1 gallon of DNAPL per week with the exception of MW-A1 and MW-A2 which produced approximately 3 and 13 gallons per week, respectively. Due to the continual presence of DNAPL within these wells, the semi-annual groundwater monitoring was not been performed, in concurrence with the NYSDEC.

In the fall of 2000, the NYSDEC sent a letter to Honeywell requesting that monitoring wells containing DNAPL be equipped with automated pumping equipment. In April 2001, Honeywell submitted a DNAPL Recovery System Modifications Work Plan (O'Brien & Gere, 2001b) to address this request. Based on NYSDEC comments, the Work Plan was revised and submitted in October 2001 (O'Brien & Gere, 2001c). The NYSDEC requested modifications to the October 2001 Work Plan based on results of work performed in November 2001 and January 2002 as part of the Semet Ponds and Willis Avenue Sites Pumping Tests (O'Brien & Gere, 2002a). On April 16, 2002, IRM Consent Order #D7-006-01-09 was signed by Honeywell and the NYSDEC (NYSDEC, 2002a). The revised Work Plan was submitted to the NYSDEC in May 2002 (O'Brien & Gere, 2002b) and an addendum (O'Brien & Gere, 2002c) to this Work Plan was submitted in July 2002. DNAPL Recovery System Modifications were initiated in August 2002 and were completed in October 2002.

These 2002 modifications consisted of the installation of nine additional recovery wells, a force main, and associated electrical and controls. These modifications were performed pursuant to an IRM Consent Order #D7-006-01-09 between Honeywell and the NYSDEC.

Additional expansion of the DNAPL recovery system was required by the NYSDEC based on the extent of the DNAPL observed in near shore lake sediments and the resultant changes to the Willis barrier wall alignment.

This expansion of the existing DNAPL system included consolidation of the force main, electrical, and control systems and installation of new DNAPL collection wells. A Supplemental Pre-Design Investigation (SPDI; Honeywell, 2011) was performed to verify the presence of DNAPL in the area behind the barrier wall using TarGOST® probing and evaluate the recoverability of DNAPL from the Solvay waste, Solvay waste/marl interface, and marl/trans-marl. Based on the SPDI, a three dimensional model was developed using RockWorks© to aid in the selection of the number of new recovery wells and their location. Figure 2 from the SPDI letter report is presented in **Appendix B-1**; this figure shows Investigation Areas 1 and 2 on the lakeshore property, as well as the probing locations and the investigation observations. Based on this SPDI, a design was developed and submitted to the NYSDEC on March 31, 2011 and approved by NYSDEC on May 9, 2011. Construction of the new system was completed between June 2011 and May 2012. During start-up activities, a leak in the force main was detected. This was repaired and the system was brought on-line in December 2012.

1.5.2. Semet Ponds and Willis Avenue Sites Pumping Tests

The Semet and Willis Avenue pumping tests were performed between November 2001 and January 2002 under Consent Order #D7-001-01-05. The purpose of the tests were to document hydraulic properties (*e.g.*, transmissivity/hydraulic conductivity and storativity) of subsurface materials located along the Onondaga Lake shore downgradient of the Semet Ponds and Willis Avenue Sites. As part of this work, four soil borings (TB-1 to TB-4) were advanced and were converted into observation wells OW-4 to OW-7. In addition, seven more observation wells (OW-1 to OW-3 and OW-8 to OW-11) and four test wells (TW-1 to TW-4) were installed. Samples were collected during the installation of the borings to evaluate the corrosivity of the subsurface soils. Additionally, water quality samples were collected during the pump tests for VOCs, semivolatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), metals, and cyanide. A sample location figure is included in **Appendix B-2**. Three long-term pumping tests (48-hours of pumping followed by a recovery period) and 11 specific capacity tests were performed. Based on this work, hydraulic conductivities were refined (Table 2; **Appendix B-2**).

1.5.3. Semet Ponds and Willis Avenue Sites IRM Groundwater Model

In 2004, S.S. Papadopulos & Associates and O'Brien & Gere revised the Honeywell groundwater flow model that simulates flow beneath and within the vicinity of the southwestern part of Onondaga Lake. The purpose of this revision was to evaluate the effectiveness of the groundwater collection system discussed in Section 1.5.4. Revisions to the model included development and inclusion of a three-dimensional representation of groundwater density variations, use of a different computer code (SEAWAT-2000) to simulate groundwater flow, and use of the computer program PEST to perform the model calibration. Based on this revised model, the simulated performance of the IRM groundwater collection system demonstrated that it would extract groundwater at rates exceeding the baseline flow rate and effectively prevent groundwater from the Willis Avenue and Semet Ponds Sites from discharging to Onondaga Lake.

1.5.4. Willis/Semet Hydraulic Containment System IRM

The Willis Avenue barrier wall and associated groundwater collection system were installed as part of the Lakeshore Hydraulic Containment System (LHCS). The Willis Avenue portion of the LHCS was installed as part of the Willis-Semet IRM Consent Order D-7-00004-01-09. This portion of the IRM consisted of the installation of 1,288 linear feet of barrier wall and groundwater collection system, and placement of approximately 43,000 cubic yards (cy) of light-weight aggregate behind the barrier wall. This work was completed between October 2006 and May 2007. Additionally, a high density polyethylene (HDPE) liner system along portions of the barrier wall subject to flooding during high lake water events and a tie-back anchorage system to mitigate deflection of the barrier wall in areas with deep water present outboard of the wall were installed between January 2012 to May 2012. The location of the barrier wall is presented on **Figure 2**. Spoils generated during installation of the collection trench were staged at the Willis Avenue Site (**Figure 2**) in Soil Pile #2 and data for these soils is presented in **Appendix B-3**.

1.5.5. Willis Avenue Groundwater Treatment Plant

The Willis-Semet IRM included the design and construction of a groundwater treatment system. To effectively manage the anticipated combination of groundwater and construction waters associated with the various proximal Honeywell sites, the treatment system was designed for phased expansion. The design treatment capacity of the facility for Phase 1 was 150 GPM. This was constructed and commissioned during 2005/2006. At the time, subsequent expansions of the GWTP were envisioned to increase the GWTP capacity to a maximum

of 450 GPM via the addition of two parallel 150 GPM treatment trains implemented as Phase 2 and Phase 3 expansions. To accommodate the expansions, a building was constructed with sufficient unoccupied floor space to house the two additional future trains. The Phase 2 treatment train was installed in 2010 using physical-chemical treatment similar to Phase 1 and was subsequently sized to handle 225 GPM (based on updated flow information) to increase the current treatment capacity to approximately 375 GPM.

In response to the robust performance of the 225 GPM Phase 2 treatment train, the Phase 3 train substantially utilized the same unit operations. This new train was sized to treat 375 GPM of groundwater based on updated flow information. The Phase 3 treatment train was constructed and commissioned during 2012/2013. Following the commissioning of the Phase 3 treatment train, portions of the Phase 1 treatment train were to be decommissioned and removed. This decommissioning has been postponed, and the Phase 1 train may be retained as back-up to the newer trains. Simultaneous operation of the Phase 2 and Phase 3 trains will provide a maximum total plant throughput of approximately 600 GPM (0.864 million gallons per day [MGD]).

The GWTP provides treatment of the groundwater prior to discharge to the Onondaga County Department of Water Environment Protection (OCDWEP) Metropolitan Wastewater Treatment Plant (Metro). The GWTP capabilities include the removal of metals and solids via precipitation, clarification, and filtration. The VOCs and SVOCs are removed via a combination of air stripping and granular activated carbon (GAC) adsorption. The GWTP effluent water receives enhanced ammonia removal at Metro. During wet weather events, the discharge of treated effluent to Metro may be temporarily suspended and the effluent directed to Onondaga Lake via Outfall 15A. Treatment of the vapors from the air stripper and process tank vents is by thermal oxidation and acid gas scrubbing. Phase 3 modifications to the Phase 1 thermal oxidizer and scrubber system were limited to tie-ins of new tank vents to the collection header.

1.5.6. I-690 Storm Drainage System Investigation and Rehabilitation (Eastern and Western Portions) IRM

The I-690 Storm Drainage System Investigation and Rehabilitation is being performed pursuant to an IRM Consent Order between Honeywell and NYSDEC dated November 11, 1996 (NYSDEC, 1996). The investigation was directed at two portions (eastern and western) of storm drains situated north of the Plant Area that collect surface water runoff from State Fair Boulevard and I-690 and some groundwater (via taps and open joints) in this area. The initial IRM involved three phases of investigation, preparation of a conceptual design report, preparation of technical specifications and contract drawings, two phases of construction, and post-construction monitoring. Subsequent to the post-construction monitoring, it was decided that underdrain water needed to be separated from storm water and a pilot program was initiated. Subsequent to the pilot program, two additional phases of construction were under taken and discussed below.

Prior to initiation of the IRM, NYSDEC collected sediment samples from select catch basins of the eastern and western portions of the system and water samples from Outfalls 040 and 041. The samples were analyzed for target compound list/target analyte list (TCL/TAL) parameters. Sediments from catchbasins in the eastern portion of the system contained BTEX, chlorinated benzenes, Aroclor 1254, and mercury. Sediments from catchbasins in the western portion of the system contained nondetectable concentrations of TCL/TAL parameters. Water samples collected from Outfalls 040 and 041 contained BTEX, chlorinated benzenes, and mercury.

Phases 1 and 2 of the investigation completed in December 1996 involved hydraulic cleaning and closed circuit television (CCTV) inspection of the eastern portion of the system. Results of Phases 1 and 2 were presented in a summary report submitted to NYSDEC in January 1997 (O'Brien & Gere, 1997b). The CCTV inspection identified taps and open joints through which water was infiltrating the sewer. Water that was collected during cleaning of the eastern portion of the system was found to contain organics (*i.e.*, BTEX and chlorinated benzenes) and mercury above sewer discharge limits. This water (approximately 120,000 gallons) was staged at the lakeshore property, treated, and subsequently discharged to the East Flume. A lesser volume of this water was transferred to the LCP Bridge Street Site to avoid accidental release during freezing conditions. This water was subsequently disposed by transport to an approved disposal facility. In addition, a v-notch weir was installed near Outfall 041, and flow measurements were collected over a period of 8 weeks, beginning in April 1997.

Typical dry weather flow was approximately 10 GPM, and a maximum flow of approximately 290 GPM was obtained during a storm event.

Upon completion of Phases 1 and 2, a Conceptual Design Report (O'Brien & Gere, 1997c) was prepared presenting the proposed rehabilitation methodology for the eastern portion of the system. Following review by the NYSDEC and New York State Department of Transportation (NYSDOT), and addendum to this report was issued in October 1997.

Phase 3 of the investigation involved hydraulic cleaning and CCTV inspection of the western portion of the system and collection of water samples from five points of infiltration in the eastern portion of the sewer and from Outfalls 040 and 041. A report summarizing Phase 3 efforts was submitted to NYSDEC in December 1997 (O'Brien & Gere, 1997d). For the western portion of the system, taps and open joints were not identified. However, an offset joint was observed downgradient of catch basin DR-40. It is likely that the offset joint is the source of the residuals detected in the water samples from Outfall 040.

Water samples were collected once during February, April, and May 1997. On each occasion, NYSDEC collected split samples. Analytical results from water samples collected during Phase 3 indicated the presence of BTEX, chlorinated benzenes, phenols, polycyclic aromatic hydrocarbons (PAHs), and mercury (O'Brien & Gere, 1997d). These constituents were detected at the points of infiltration and at Outfall 041 for the eastern portion of system, suggesting that water infiltration was the source of these residuals.

The western portion of the system was monitored from November 1997 through November 1998 to evaluate whether water was infiltrating the system. The monitoring program involved the twice monthly measurement of the elevation of groundwater at Willis Ave monitoring well WA-7S and the surface of Onondaga Lake. During periods of high groundwater and surface water elevation, catchbasins comprising the western portion of the system were checked for the presence of increased flow. Increased flow in the system (in the absence of storm water flow) would indicate infiltration of groundwater into the system. No increased flow within the system during periods of high groundwater and surface water elevation was observed. In August 1998, an attempt was made to collect water samples from the catch basins of the western portion of the system. The lack of flow within the catch basins precluded collection of the samples. However, samples were collected from Outfall 040. Samples were analyzed for VOCs, SVOCs, PCBs/Pesticides, and metals. The predominant detected constituents included BTEX, chlorobenzene, 1,2- and 1,4-dichlorobenzene, assorted phenols, naphthalene, and mercury.

Following regulatory acceptance of the Phase 3 report and the Conceptual Design Report, Technical Specifications and Contract Drawings were prepared (O'Brien & Gere, 1998a). The contract was awarded to Insitu form-Metropolitan in August 1998, and rehabilitation was initiated in November 1998. The rehabilitation involved in situ chemical grouting of open joints and sealing of catchbasins with cementitious liner material within the eastern portion of the I-690 storm drainage system to minimize infiltration of water. The offset joint in the western portion of the system was slip lined concurrent with the rehabilitation of the eastern portion of the system. Two manholes (manholes #1 and #2) were also installed near Outfall 040 and 041 to act as permanent sampling ports. Construction was discontinued in January 1999 when it was determined that the portion of sewer between manhole #1 and catchbasin DR-42x could not be cleaned and grouted using the methods prescribed. An alternate cleaning method was selected that involved the use of a hydraulic impact drill nozzle, and construction was resumed in May 1999. Rehabilitation of this reach included installation of Insitu form lining from DR-42 to manhole #1, rerouting a tap directly to DR-42, and installation of an 18-inch cast iron pipe between DR-42x and DR-42. The rehabilitation was completed in November 1999.

Subsequent to rehabilitation, a quarterly monitoring program was initiated. Concentrations of soluble residuals in water within the system after rehabilitation have been summarized in a series of quarterly reports. These reports show a reduction in discharge of soluble residuals to Onondaga Lake from the sewer system. However, soluble residuals are entering the storm water system and it is believed that these residuals are entering the system via the underdrains.

Once post-construction monitoring was performed and the effectiveness of the rehabilitation in limiting water infiltration into the system evaluated, it was decided that a pilot program needed to be initiated to study the isolation of the underdrain flow from the storm water within the eastern portion of the system. An I-690 Storm Drainage System Underdrain Isolation Pilot Study Work Plan was submitted to the NYSDEC in September 2000 (O'Brien & Gere, 2000a). Based on comments from the NYSDEC, a Revised Work Plan (O'Brien & Gere, 2002d) was submitted to the NYSDEC for review in March 2002. The Work Plan (O'Brien & Gere, 2002e) was finalized in July 2002 after the issuance of replacement pages requested by the NYSDEC. In August 2002, Honeywell submitted a Bid Specification, which included technical specifications and contract drawings, to the NYSDEC for review (Honeywell, 2002). The NYSDEC comments on this document were received on September 13, 2002. The revised Bid Specification was submitted to NYSDEC in October 2002. The first phase of underdrain pilot program consisted of separating underdrain water from storm water by installing underdrain isolation piping in the eastern storm drainage system. Subsequent to post- construction sampling a second phase of the underdrain pilot program was initiated that consisted of rerouting two taps, one downgradient of DR-44 and one downgradient of DR-46, back to their nearest catch basins and tied into the underdrain isolation system. The underdrain pilot program was completed in July 2005.

Based on the underdrain sampling, it was decided to install a permanent underdrain isolation system. This is referred to as I-690 Phase 3 Storm Drain Modification which involved decommissioning of the underdrain isolation pilot study system in the eastern storm drain system, and installation of cured in-place pipe (CIPP) and permanent underdrain conveyance piping in portions of the eastern storm drain system. Also, CIPP was installed in a portion of the western storm drainage system from catch basins DR-39 to DR-40 and DR-40A to DR-40.

The May 22, 2009 letter from Honeywell to NYSDEC regarding the Willis Ave/Semet Tar Beds IRM I-690 Storm Drain Modifications Phase 3 – Post Construction Inspection and Sampling summarized the results of the post-construction sampling and presented recommendations for corrective actions. The recommendations were for further inspection of manhole MH-1, corrective action for catch basins DR-41 and DR-45, and additional sampling. These corrective actions were performed in the summer and fall of 2009. A letter was submitted to the NYSDEC on May 3, 2010 summarizing the repair work and presenting recommendations for additional sampling. The NYSDEC approved this work plan on July 8, 2010.

The Phase 3 – Post Construction repair sampling included additional storm water samples being collected in the eastern and western storm drainage systems in August 2010. The storm water samples were found to contain benzene, chlorinated benzenes, and mercury. These data were submitted to the NYSDEC in a letter dated October 21, 2010. The sampling results and CCTV inspection showed that water was entering into the storm water system via infiltration into the catch basins and directly from the State Fair Boulevard drainage ditch.

A bench scale study and field pilot study were conducted in the summer and fall of 2011 to evaluate the effectiveness of multiple catch basin lining and coating systems. The field pilot comprised the installation of the most effective pilot test coating system in catch basin DR-44. Catch basin DR-44 was inspected in the spring of 2012 and appeared to have no visual groundwater infiltration. The results of the pilot study were used to refine the Phase 4 design originally submitted in May 2011 and finalized and approved in September 2011.

In the fall of 2012, the following Phase 4 efforts were completed:

- Cleaning and CCTV of eastern and western portions of system including sediment sumps in catch basins
- Epoxy coating of 16 catch basins and 3 manholes to address groundwater infiltration into these structures

During the summer of 2013, the remaining Phase 4 completed included:

- Re-cleaning and CCTV of eastern and western portions of system
- CIPP lining of remaining unlined portions of the eastern system

- CIPP lining of the remaining unlined portions of the western system

Also associated with the Phase 4 I-690 work is the installation of a 1,942 ft groundwater collection trench beneath the State Fair Blvd. drainage ditch that included the removal of soils, installation of a geomembrane and stone, and connection to the Tributary 5A collection vault installed at the end of reach 2 as part of the remedial action discussed in Section 1.2.7. This work was completed in September 2012. The soils excavated during this work were placed on the Willis Avenue Plant Area in Soil Pile #2 (**Figure2**). The data associated with these soils are provided in **Appendix B-3**.

1.5.7. East Flume IRM

The East Flume IRM is being completed in two phases. The purpose of the first phase of East Flume IRM –Storm Sewer Outfall Relocation and Modifications Project was to redirect storm water and process water flow that discharged to the East Flume directly to Onondaga Lake so that the East Flume could be eliminated as part of the lakeshore restoration. This was done by installing a 48" steel outfall pipe on the existing 72" storm sewer that discharged into the East Flume and redirecting the flow through the existing steel barrier wall to allow for discharge directly into Onondaga Lake. The East Flume previously discharged to Onondaga Lake via Outfall 015 as part of the SPDES Permit # NY0002275. In addition to the Storm Sewer Relocation, the existing 60" storm sewer was sliplined with two 12" pipes, one 6" pipe and one 4" pipe that will serve as future use conduits under I-690. The 72" storm sewer and portions of the 60" storm sewer were rehabilitated using slip-lining technology to reduce the potential of contaminants from infiltrating into the storm sewer. Hazardous soils generated during this work were sent off-site for incineration and non-hazardous soils were staged at the Site (**Figure 2**) in Soil Pile #2.

The second phase of the East Flume IRM –Storm Sewer Outfall Relocation and Modifications Project originally consisted of abandoning the 42" P.A. Sewer system was originally included in the scope of this project. However, several companies discharged storm water (as does the Village of Solvay) and non-contact cooling water to the 42" P.A. Sewer and the main sewer at the time construction was to occur. These companies would have been burdened without this means of discharge, so it was agreed that an alternative storm and process water system would be designed to bypass the 42" P.A. Sewer so that Honeywell can eventually abandon it. The completion of the 42" P.A. Sewer was completed July 2014. The soils generated during this effort are being staged on the Willis Avenue Plant Area and incorporated into Soil Pile #2 (**Figure 2**). The data associated with these soils are provided in **Appendix B-3**.

1.5.8. Willis/Semet Berm Site Improvements

The Ballfield, Willis Avenue, and Semet Ponds Sites extend in this order from east to west along I-690 and State Fair Blvd., which are two roads that together accommodate approximately 55,000 vehicles per day (Syracuse Metropolitan Traffic Council, 2003-2008). As motorists pass by these sites, they viewed extensive areas dominated by invasive species with low aesthetic value. Hence, the overall goal of the Site Improvements Project was to increase the aesthetic and ecological value of the I-690 corridor in the vicinity of the project sites.

Soil samples were collected at the three sites to help refine the Landscape Improvements Design and develop an excavation plan for impacted soils within these areas. This includes the soil sampling data collected per the May 9, 2011 Landscape Restoration Berm Surface Soil Letter Work Plan and subsequent email addendums to this work plan dated August 31, 2011, October 7, 2011, and November 2, 2011. Based on these results, it was decided that berm material needed to be excavated and replaced with clean fill/top soil prior to implementation of the berm improvements project. A letter was submitted to the NYSDEC on February 21, 2012 presenting the proposed area of excavation and associated confirmation sample collection locations (**Figure 2**). This plan was accepted by the NYSDEC on February 24, 2012. The work was completed during May 2012. The soils generated during the removal were staged on the Willis Avenue Site in Soil Pile #2 (**Figure 2**). The data associated with these soils are provided in **Appendix B-3**.

1.5.9. Tributary 5A (Semet Ponds Shallow Groundwater Remedial Action)

This Remedial Construction/Remedial Action was completed as part of the Groundwater Remedial Alternative for the Semet Residue Ponds Site located in the Town of Geddes, New York in accordance with the Remedial Design/Remedial Action (RD/RA) Order of Consent (Index # D7-0005-01-09) between Honeywell International Inc. (Honeywell) and the NYSDEC in January, 2004. The site was remediated in accordance with the remedy selected by the NYSDEC in the December 2008 95% Remedial Design Report, Semet Residue Ponds Groundwater Remedial Alternative (O'Brien & Gere, 2008) and subsequent modifications to the design submitted in the August 31, 2009 and November 20, 2009 letters that contain responses to NYSDEC comments, revised Contract Drawings, and additional and revised technical specifications (Honeywell, 2009a and Honeywell, 2009b).

To achieve the remedial action objective, the integrated remedial design included a shallow groundwater collection system, remediation of sediments by excavation, installation of an isolation layer, and substrate within the tributary limits. The major elements of the remedial action were:

- Construction of shallow sand filled groundwater collection trench with a slotted Fiberglass Reinforced Pipe (FRP) groundwater collection pipe
- Construction of two groundwater pumping stations
- Installation of FRP force main piping
- Relocation of Semet material from the stringer ponds
- Installation of isolation layer
- Culvert cleaning and inspection
- Site grading and restoration of surfaces

This work began in May 2010 and was completed in January 2013. The soils generated during the remediation of Tributary 5A were staged on the Willis Avenue Site in Soil Pile #1 (**Figure 2**). Data for these soils is included in **Appendix B-3**. Data for soils remaining in Tributary 5A under the liner are included in **Appendix B-4**.

1.5.10. Willis Avenue Soil Pile Consolidation, Soil Cover Placement, and Seeding

The NYSDEC requested that the existing soil piles be re-covered with a liner to prevent erosion and contain the prevent exposure to these materials. Honeywell proposed to consolidate the soil piles into two piles, regrade the piles so the side slopes were no steeper than 3 vertical to 1 horizontal, and install of a 6-inch soil cover. This work was initiated in June 2012 and was completed in August 2012. The soil piles are presented on **Figure 2**. An area on the eastern side of Soil Pile 2 was not covered with top soil and temporary poly was used for cover. This was done so the pile could receive additional soils from the Willis/Semet ditch remediation and collection trench installation completed in September 2012 and the soils to be generated as part of the 42-inch P.A. Sewer abandonment and bypass installation.

1.5.11 Deep Groundwater Investigation

The Deep Groundwater Investigation (DGWI) was performed to evaluate deep groundwater of the Main Plant Site and adjacent sites to address potential impacts to the Onondaga Lake Remedy. The DGWI was conducted pursuant to the Willis Avenue/Semet Ponds IRM Consent Order D-7-0004-01-09 between the NYSDEC and Honeywell dated April 10, 2000, and as described in the *October 16, 2007 Deep Groundwater Investigation Work Plan* (O'Brien & Gere, 2007) and the *March 1, 2010 Deep Groundwater Investigation Work Plan* (O'Brien & Gere, 2010a). The DGWI was submitted to the NYSDEC in January 2011 (O'Brien & Gere 2011).

The objectives of the deep groundwater investigation were to evaluate whether the site overburden and bedrock groundwater zones constitute a historical or current pathway for the migration of benzene to downgradient sites, and to collect the data necessary to evaluate and characterize the nature and extent of Site-related CPOIs. In order to achieve these objectives, subsurface and groundwater samples were collected across

two phases from several sites upgradient of Onondaga Lake. Areas sampled as part of the DGWI related to the Willis Avenue Chlorobenzene Site included the Willis Avenue Plant Study Area, CHSA, and PSA.

Subsurface soil samples collected pertinent to the Willis Avenue Chlorobenzene Site Remedial Investigation include:

- Two sample from two locations on the Plant Area during Phase 1 of the DGWI
- Seven samples from six locations on the PSA during Phase 1 of the DGWI
- Four samples from three locations on the CHSA during Phase 1 of the DGWI
- Four samples from four locations on the CHSA during Phase 2 of the DGWI

Groundwater screening samples collected to aid in the installation bedrock monitoring wells during the DGWI pertinent to the Willis Avenue Chlorobenzene Site Remedial Investigation include:

- One sample from one location on the Plant Area during Phase 1 of the DGWI
- One sample from one location on the PSA during Phase 1 of the DGWI
- Five samples from five locations on the CHSA during Phase 2 of the DGWI

Groundwater samples collected from monitoring wells during the DGWI pertinent to the Willis Avenue Chlorobenzene Site include:

- Nine samples from nine locations on the Plant Area during Phase 1 of the DGWI
  - Eight samples from eight locations from the deep groundwater zone
  - One sample from one location from the bedrock groundwater zone
- Four samples from four locations on the PSA during the Phase 1 of the DGWI
  - Two samples from two locations from the shallow groundwater zone
  - One sample from one location from the deep groundwater zone
  - One sample from one location from the bedrock groundwater zone
- Eight samples from eight shallow groundwater locations on the CHSA during Phase 1 of the DGWI
- Nine samples from nine locations on the CHSA during Phase 2 of the DGWI
  - Eight samples from eight locations from the shallow groundwater zone
  - One Sample from one location from the bedrock groundwater zone

During the DGWI, chemical parameters of interest (CPOIs) from the Plant Area deep groundwater zone included benzene, chlorobenzene, and chlorinated benzenes (1,2-dichlorobenzene, 1,3-dichlorobenzene, and 1,4-dichlorobenzene). These parameters were detected above NYS Class GA Groundwater Standards and Guidance at several wells. These CPOIs were not detected in the bedrock groundwater zone sample, with only sodium and magnesium exceeding Class GA criteria. This indicates that there is no vertical migration of CPOIs. Subsurface soil samples collected in the Plant Area did not have detections for the CPOIs identified in the deep groundwater zone, and had no detections that exceeded NYSDEC part 375.6 Industrial Use Soil Cleanup Objectives.

Samples from the PSA shallow groundwater zone identified naphthalene, phenol, benzene, ethylbenzene, and total xylenes as CPOIs, with all five CPOIs exceeding Class GA criteria. These CPOIs were not detected in deep and bedrock groundwater zones of the PSA. This indicates that there is no vertical migration of CPOIs between groundwater zones. Subsurface soil samples collected as part of the DGWI confirmed stratification of the CPOIs identified in depth ranges that included the shallow groundwater zone only. PSA CPOIs were detected in the

shallower subsurface soils, however these detections did not exceed NYSDEC part 375.6 Industrial Use Soil Cleanup Objectives.

CHSA shallow groundwater zone CPOIs include chlorobenzene, chlorinated benzenes, benzene, and chlorophenols. These CPOIs were detected above Class GA criteria at five of the eight shallow monitoring wells on the CHSA. Benzene and chlorobenzene were the only CPOIs detected in the bedrock groundwater zone, with only benzene exceeding Class GA criteria. The benzene result was several orders of magnitudes less than the average detected benzene concentration in shallow wells on the CHSA (2.1 µg/L compared to a detected average of 1159.7 µg/L in the shallow groundwater zone). This indicates that there is limited vertical migration of contaminants between groundwater zones of the CHSA. Subsurface soil samples collected from the PSA were all collected from within the shallow groundwater zone. Subsurface soil samples reaffirmed the shallow groundwater findings, with similar CPOIs detected. The only subsurface soil exceedance of NYSDEC part 375.6 Industrial Use Soil Cleanup Objectives was 1,4-dichlorobenzene at one location.

Data tables for pertinent data collected during the DGWI are presented in **Appendix B-6**. A sample location figure is presented as **Figure 4A.** DGWI data were comparable to data collected previously as part of the Willis Avenue Chlorobenzene Site RI. Variations between the two data sets were likely caused by changes in laboratory methods, and not systemic changes to site conditions. Soil boring and groundwater data were incorporated into the appropriate summary statistics tables for detected parameters presented in Section 4 of this report.

1.6. REPORT ORGANIZATION

The remainder of this report is organized as follows:

- Section 2 details the RI program including a description of field methods, data analysis methods and the baseline risk assessment;
- Section 3 presents a discussion of the physical characteristics of the Site including climate, regional and site geology, and hydrogeology;
- Section 4 presents the nature and extent of residuals in various environmental media based on data collected during the RI and previous studies;
- Section 5 describes the fate and transport of residuals in various environmental media at the Site;
- Section 6 presents a comparison of analytical results to applicable standards and/or guidance values;
- Section 7 summarizes the Human Health Risk Assessment;
- Section 8 summarizes the Baseline Ecological Risk Assessment; and
- Section 9 presents the conclusions of the RI and preliminary remedial action objectives (RAOs).

2. REMEDIAL INVESTIGATION PROGRAM

This section describes the field methods used to characterize the Willis Avenue Plant Study Area and additional AOS. As mentioned in Section 1, the RI was performed in four phases. Phase 1 included field activities conducted between 1991 and 1995. Phase 2 (Supplemental RI) included additional field activities conducted in the fall of 1997, and Phase 3 included field activities conducted in the fall of 1998 and spring of 1999. Phase 4 field activities associated with the BERA were conducted in the fall of 1999.

The following field efforts were performed as part of Phase 1:

- Utilities clearance,
- Ground penetrating radar survey,
- Soil vapor survey,
- Subsurface soil sampling (soil borings, test pits, and exploratory excavations)
- Surface soil sampling (soil borings and surface soils),
- Tributary 5A surface water and sediment sampling,
- Monitoring well installation,
- Temporary well installation via hydropunch,
- Hydraulic conductivity testing,
- Groundwater sampling (Round 1 - March and April, 1992; Round 2 - September and October, 1992; Round 3 - January and March, 1995), and
- Groundwater elevation measurements.

Phase 2 (Supplemental RI) field efforts included the following:

- Site reconnaissance and utilities clearance,
- Outfall soil/sediment sampling,
- Soil borings,
- Subsurface soil sampling,
- Subsurface utilities bedding sampling,
- Test pit excavations,
- Surface soil sampling,
- Groundwater sampling (October 1997),
- Groundwater elevation measurement, and
- Sewer and intake water sampling.
- Phase 3 field efforts included:
- Site reconnaissance and utilities clearance,
- Outfall soil sampling,
- Soil borings,
- Subsurface soil sampling,

- Surface soil sampling.
- Phase 4 field efforts included:
- Site reconnaissance;
- Surface soil sampling,
- Tributary 5A surface water and sediment sampling.

IRM investigations performed on-site subsequent to the RI and their field efforts included:

- Onondaga lakeshore property chlorinated benzenes recovery IRM/SPDI (2011)
  - TarGOST® probing,
  - Recovery well installation,
  - Recovery well development,
  - DNAPL Accumulation Monitoring, and
  - DNAPL Recoverability Rate Testing.
- Willis/Semet Berm Site Improvements and Berm Excavation Confirmation Sampling
  - Surface and subsurface soils sampling.
- Tributary 5A Supplemental Design Investigation (SDI)
  - Sediment/soil borings in Tributary 5A.

The field methods utilized for the RI and subsequent investigations are described in the following sections.

2.1. SITE CHARACTERIZATION METHODS

2.1.1. Site Reconnaissance, Flagging of Site Features and Utility Clearance

Prior to initiation of Phase 1 through 3 field activities, sampling locations were staked in concurrence with Honeywell and NYSDEC. Off-site utilities were marked by the Underground Facilities Protection Organization (UFPO) locating service (now Dig Safely New York). Locations of on-site utilities were approximated using existing as-built drawings provided by Honeywell and with the assistance of Honeywell personnel. As part of the Phase 2 reconnaissance, the four corners of the foundations of the former Mercury Cell and Chlorination buildings were located using a backhoe and staked for reference purposes.

Sample location IDs are presented with a prefix of "WA-" on the analytical data tables. The sample locations shown on the Site figures and in this report do not contain this prefix for ease of presentation.

2.1.2. Ground Penetrating Radar Survey

On December 4, 1991, a Ground Penetrating Radar (GPR) survey of the Plant Area was performed by Detection Sciences, Inc. under subcontract to O'Brien & Gere. The purpose of the survey was to evaluate the subsurface conditions of the area and to identify possible areas of interest. This information was developed to assist in the selection of locations for the proposed monitoring wells and borings.

The GPR transmits and receives high-frequency electromagnetic waves. The rate at which the waves are transmitted through the subsurface is dependent upon the density, ionic nature, and/or water content of the subsurface materials (*e.g.*, Solvay waste). Time-delays measured in nanoseconds are used to create a profile of the subsurface. Buried debris associated with former manufacturing activities can be detected because its electromagnetic transmitting ability contrasts with that of the surrounding soils.

The survey utilized a commercial GSSI SIR System-8 with various design modifications to increase the penetration depth and improve the clarity and resolution of the radar trace. A 120 megahertz (MHz) radar

antenna towed by a survey van was used to investigate the area. A fifth-wheel odometer attached to the rear of the van automatically logged increments of 5 ft along the survey lines. A total of twelve traverses were spaced 50 ft and 100 ft apart on the survey grid. Locations of the traverses and a detailed explanation of the methodology are provided in the GPR report included as **Appendix C**.

2.1.3. Soil Vapor Survey

A soil vapor survey was conducted in the Plant Area between December 9 and 19, 1991. The purpose of the survey was to evaluate the subsurface occurrence of VOCs and mercury. The field screening data were then used to assist in locating the proposed monitoring wells and borings. The soil vapor survey samples were collected on the grid shown on **Figure 3**. Survey locations were concentrated proximate to the former para-dichlorobenzene, mercury cell, and Allen Moore cell building foundations where mercury and chlorobenzene isomers were produced.

Soil vapor samples were obtained by penetrating the surface with a hollow steel probe through which soil vapor was extracted using a peristaltic pump. Once collected, samples were analyzed for VOCs including dichlorobenzenes using a Photovac 10S70 portable gas chromatograph (GC) equipped with a CPSIL-5 capillary column, isothermal column oven and a 10.6 electron volts (eV) photoionization detector and mercury using a Jerome 411 mercury vapor analyzer.

2.1.4. Subsurface Soil Sampling

Subsurface soil sampling was performed during the RI in the Plant Study Area and additional AOS (CHSA and PSA). The sampling included soil borings, test pits, and exploratory excavation of subsurface utilities. A description of these activities is presented below. A Site-wide sample location plan is presented on **Figure 4**, and area-specific sampling location are presented on **Figure 5, 6, and 7** for the Plant Study Area, PSA, and CHSA, respectively.

2.1.4.1. Plant Study Area

Soil Borings

During completion of the RI, a total of 35 soil borings were advanced in the Plant Study Area. Soil borings advanced and samples collected during each phase of the RI are summarized below and presented on **Figure 5**. At least two intervals from each boring were selected and submitted for laboratory analysis based on the field screening results and other field observations. For each of the three phases, Parratt-Wolff completed the borings under the supervision of an O'Brien & Gere hydrogeologist.

In Phase 1, ten soil borings (WA-B1 through WA-B10) were advanced in the Plant Study Area. These borings were completed between the dates of January 6, 1992 and February 17, 1992. The Phase 1 boring samples were analyzed for VOCs, SVOCs and metals by NYS Analytical Services Protocol (ASP; NYSDEC, 1989b). Based on field observations, additional samples were submitted to the laboratory from WA-6D and WA-2D. The sample from WA-6D was analyzed for VOCs by USEPA Method 8010/8020, and the sample from WA-2D was fingerprinted for petroleum hydrocarbons and analyzed for total petroleum hydrocarbons (TPHs) using USEPA Method 418.1.

Phase 1 borings were extended from the ground surface to the top of the first encountered native material (marl), using hollow stem augers. Soil samples were collected in accordance with American Society for Testing and Materials (ASTM) Method D1586-84 using a 140-lb hammer and 2-ft long split-barrel samplers. Sampling was continuous from the ground surface to the bottom of the borings. As requested by NYSDEC, pertinent field observations from Phase 1 soil boring and monitoring well installation activities are summarized below in Table 2-1.

Table 2-1 Plant Study Area Soil Borings, Phase 1 – Pertinent Field Observations

Boring No.	Note	Elevated Jerome Readings (mg/m^3)	Elevated HNU Readings (ppm)
WA-B1	Petroleum-like odor at 24-26 ft.	0.160-1.999	--
WA-B3	Strong chlorobenzene-like odor at 14-18 ft and 24-26 ft; light brown-yellow fluid (chlorobenzene) observed at 28-32 ft.	--	0.2-433
WA-B4	Light yellow-brown fluid (chlorobenzene) observed at 30-32 ft.	--	0.2-410
WA-B5	Possible product (chlorobenzene) observed at 18-22 ft and 30-36 ft.	--	0.3-439
WA-B6	Strong chlorobenzene-like odor at 0-12 ft; fluid (possible chlorobenzene) observed at 18-28 ft.	--	122-522
WA-B8	Chlorobenzene-like odor 0-2 ft.	--	2.3-283
WA-B9	H_2S odor at 22-24 ft.	--	--
WA-B10	Chlorobenzene-like odor at 16 to 25 ft; light yellow-brown fluid (chlorobenzene) observed at 29-31 ft.	--	0.1-405

Notes:

1. This table contains a summary of information contained on Phase 1 boring logs. Only those borings that contained pertinent information are listed here.
2. Phase 1 logs were completed in 1992.
3. "--" designates that there was no instrument detection.

During Phase 2, 15 soil borings were advanced between the dates of September 29, 1997 and October 16, 1997. Borings MC-B1 through MC-B4, MC-B4A, and MC-B5 through MC-B14 were situated in the vicinity of the former Mercury Cell Building, and borings WA-B3A and WA-B3B were situated near Phase 1 boring WA-B3 and soil vapor sample H01.

Thirty two samples were collected from borings in the vicinity of the former Mercury Cell Building and submitted to O'Brien & Gere Laboratories for mercury analysis by USEPA Method 7471. Samples submitted to the laboratory were selected based on screening results, visual observations, or proximity to various geologic units. It should be noted that samples containing visible elemental mercury were not submitted for laboratory analysis.

For Phase 2, five borings (MC-B1, MC-B2, MC-B4A, MC-B5, and MC-B6) were advanced to the top of glacial till, nine (MC-B3 and MC-B7 through MC-B14) to the top of the silt/clay unit, and one (MC-B4) was terminated within fill materials. Boring MC-B3 was terminated at the silt/clay unit because a small quantity of chlorobenzene DNAPL was encountered from 25.5 to 26 ft. The source of the chlorobenzene DNAPL in this area is unknown. It should be noted that a chlorobenzene waste water line transported waste cooling water from the former Para building at the Willis Avenue Plant to the Main Plant Site. The pipeline ran above ground at the Willis Avenue Plant on a series of pipe bridges to the trestle over the railroad tracks to the Main Plant. At the Main Plant, the pipeline ran above ground except at driveway crossings where it was below ground. This pipeline ran approximately 50 ft south of MW-111 and terminated at the former pump house on the Main Plant. The exact pathway of portions of this pipeline is unknown; however, an approximate path is presented on

Figure 2. Borings MC-B7 through MC-B14 were terminated at the top of silt/clay, in concurrence with Honeywell and NYSDEC, since their objective was to delineate the horizontal extent of the elemental mercury. Boring MC-B4 was terminated at 10.6 ft because of an obstruction, possibly concrete. Pertinent observations from Phase 2 soil boring activities are summarized below in Table 2-2.

Table 2-2 Plant Study Area Soil Borings, Phase 2 – Pertinent Field Observations

Boring No.	Note	Elevated Jerome Readings (mg/m^3)	Elevated HNU Readings (ppm)
MC-B4	Hg droplets at 8 and 10 ft.	0.005 – 0.244	--
MC-B4A	Hg droplets at 8, 10, 16, 18, and 20 ft.	0.013-0.376	0.1-0.5
MC-B7	Free Hg droplets @ 6, 10, 12, 14, 16, 18, 20, 26, 28, and 30 ft.	0.005 – 0.037	0.5-14
MC-B8	Free Hg at 6 and 12 ft.	--	0.5-15.4
MC-B9	Free Hg at 5, 12, and 14 (top 6 inches of spoon).	--	0.5-6.2
MC-B12	Hg droplets at 0, 2, 12, 14, and 28 ft.	0.001-0.261	0.3-7.2
MC-B13	Hg droplets at 16 ft.	0.002-0.214	0.3-6.5
WA-B3B	--	--	0.5-700

Notes:

1. This table contains a summary of information contained on Phase 2 boring logs. Only those logs that contained pertinent information are listed here.
2. Phase 2 logs were completed in 1997.
3. "--" designates that there was no pertinent field observations or instrument detection.

During Phase 3, thirty samples were collected from ten soil borings advanced in the northern portion of the Plant Area. For each of the ten borings, samples were collected from depth intervals of 2 to 3 ft, 3 to 4 ft, and 4 to 5 ft, with the exception of SB-11 (4 to 5 ft) which was damaged in shipment and therefore not analyzed.

Borings FCB-2, FCB-5, FCB-5A, FCB-5B, and FCB-5C were situated in the vicinity of the former Old Chlorination Building and were designed to further delineate the vertical and horizontal extent of polychlorinated dibenzo-p-dioxins/polychlorinated dibenzofurnas (PCDD/Fs) in this area. Borings SB-08, SB-09, SB-10, SB-11, and SB-12 were situated at the centers of triangles on a 200 ft grid system and were designed to evaluate the concentrations of PCDD/Fs across the remainder of the northern portion of the Plant Study Area. Sample locations are presented on **Figure 5**.

Phase 3 shallow soil borings were advanced using direct push drilling techniques (Geoprobe Macrocore). The technique involved advancing a 4 ft by 2 in diameter corer with a Lexan sleeve using a hydraulic drilling mechanism. The core was divided into 1 ft sections, and each section was homogenized placed in sample containers for laboratory analysis. No pertinent observations were recorded during Phase 3 soil borings.

For each of the three phases, Parratt-Wolff completed the borings under the supervision of an O'Brien & Gere hydrogeologist. The NYSDEC was involved in examining the results of these studies and collected split samples from some of the soil borings. The completed boring logs, which include depth, number of blows, percent recovery, description of the soil and other pertinent observations, are included in **Appendix D**. Upon completion of each boring, the borehole was backfilled with a cement-bentonite grout.

Boring samples were screened in the field for VOCs and mercury using a HNu Model P-101 photoionization detector (PID) and a Jerome Model 411 mercury vapor analyzer. For Phases 1 and 2, an aliquot of each sample was placed in a glass jar, and a piece of aluminum foil was placed over the mouth of the jar. After allowing time for equilibration, the headspace was field screened for VOCs and mercury. Results of the field screening are included on the boring logs (**Appendix D**). Phase 3 soil boring samples were submitted to AXYS Analytical Services for PCDD/Fs analysis by USEPA Method 8290 and Severn Trent Laboratories for total organic carbon (TOC) analysis by USEPA Method 9060. The NYSDEC collected split samples from the surface soil intervals at these borings.

Chain of custody records were initiated as the samples were collected and remained with the samples during transport to O'Brien & Gere Laboratories, AXYS Analytical Services (PCDD/F analyses) or American Environmental Network (AEN; TOC analyses). Chains of custody forms are included in **Appendix E**. Samples that were not selected for laboratory analysis were archived at the offices of Honeywell.

The drill rig, split spoons and other tools that came in contact with the soils were decontaminated with high pressure steam prior to and between each boring. In addition, the split spoons were decontaminated between each sample using the procedure outlined in the Quality Assurance Project Plan (QAPP). Decontamination consisted of a soap and water wash, distilled water rinse, 10% nitric acid rinse, distilled water rinse, hexane rinse and final distilled water rinse. Equipment blanks were collected by running distilled water through the decontaminated split spoon and collecting it in appropriate jars.

Test Pits

During Phase 2, test pits were excavated in the northwest mounded area (NWMA), the southwest mounded area (SWMA), and the mounded area near Outfall 006 (006MA) within the Willis Avenue Plant Study Area to evaluate the physical and chemical characteristics of subsurface materials. The three areas, test pits designations, and test pit dimensions are summarized below. Sample locations were selected in the field in concurrence with Honeywell and NYSDEC. Locations are presented on **Figure 5**. No test pits were excavated during Phases 1 and 3 of the RI.

In the mounded area in the northwest portion of the Plant Area, two test pits (NWMA TP1 and NWMA TP2) were excavated, and one composite sample was collected from each. In the mounded area in the southwest portion of the Plant Area, one test pit (SWMA TP1) was excavated, and one composite sample was collected. In the mounded area near Outfall 006, four test pits (006 MA TP1, 006 MA TP2A, 006 MA TP2B, and 006 MA TP2C) were excavated, and three samples were collected. Samples were not collected from 006 MA TP2C. Test pit samples were submitted to O'Brien & Gere Laboratories for VOCs, PCBs/Pesticides (including hexachlorobenzene), and mercury analyses. The NYSDEC collected split samples from NWMA TP1, NWMA TP2 and 006 MA TP1.

Test pit NWMA TP1 was excavated in an east-west direction parallel to and approximately 30 ft south of the jog in the fence in the northwest portion of the Plant Area (**Figure 5**). The pit was 150 ft in length, 3 ft in width and 6 ft deep. In the depth interval from 0 to 5 ft, sand and gravel intermixed with ash and construction debris, mainly brick fragments (fill materials), were observed. At 5 ft below ground surface (bgs), Solvay waste was encountered. The sample collected from this test pit was obtained from a point 70 ft east of the western end of the test pit and was a composite of materials from 3 to 5 ft. Test pit NWMA TP2 was excavated in an east-west direction parallel to and 60 ft south of NWMA TP1. The pit was 160 ft in length, 3 ft in width and 7 ft deep. The subsurface materials observed were consistent with those found in NWMA TP1, except that the fill materials extended to 7 ft bgs. The sample from NWMA TP2 was collected from 25 ft east of the western end of the pit and was a composite of materials from 5 to 7 ft bgs.

The test pit in the southwest corner (SWMA TP1) of the Plant Area was initiated just to the south of the access road which runs through the Site in an east-west direction and which provides entry into the Semet Residue Ponds Site. Test pit SWMA TP1 was excavated in a southwesterly direction toward the southern property boundary (**Figure 5**). The subsurface consisted of a 1 ft layer of sand and gravel, followed by ash and construction debris, mainly crushed brick from 1 to 10 ft, underlain by slag. The pit was 245 ft in length, 3 ft in width and had a maximum depth of 15 ft (average depth = 10 ft). Within the slag material, a rotten egg odor was

noted which may be the result of anaerobic conditions associated with the former wash and locker building in this area.

Four test pits were excavated in the mounded area near Outfall 006, which is situated between the southern boundary of the Site and CSX railroad tracks. Two samples were collected from these test pits and analyzed for VOCs, PCBs/Pesticides, and mercury. The first test pit (006 MA TP1) was excavated in an east-west direction and was situated 45 ft south of the southern property boundary. The test pit was 100 ft in length, 3 ft in width, and 10 ft in depth. Subsurface materials encountered at this location included sand and gravel from 0 to 1 ft, light brown to tan ash from 1 to 3 ft, Solvay waste from 3 to 6 ft and sand and gravel intermixed with slag, cinders, and brick fragments from 7 to 10 ft. Sample 006 MA TP1 was a composite of materials from 2 to 8 ft and included materials from each of the strata observed in the pit.

Three additional test pits (006 MA TP2A, 2B, and 2C) were advanced in the southern portion of the mounded area near Outfall 006. Test pit 006 MA TP2A was initiated along the southern boundary of the mounded area and was excavated in a northwesterly direction. The test pit was 40 ft in length, 3 ft in width, and 12 ft deep. Gray powder-like ash and construction debris were observed throughout the depth of the excavation. Sample 006 MA TP2A was collected from this area and analyzed for mercury. Test pit 006 MA TP2B was initiated along the western border of the mounded area, near the section of rail track that enters the southwest corner of the Plant Area in a north-south direction. The pit was 70 ft in length, 3 ft in width, and 10 ft deep. Subsurface materials observed included gray ash, gravel, and stones from 0 to 3 ft and Solvay waste, gray ash, gravel, and stone from 3 to 10 ft. A lens of Semet material was encountered approximately 20 ft east of the western end of the pit with approximate dimensions 30 ft in length and 3 ft deep. Sample 006 MA TP2B was collected from the Semet lens and was analyzed for VOCs. To evaluate the extent of the Semet material in the north-south direction, test pit 006 MA TP2C was excavated. This pit was located 60 ft north of and parallel to 006 MA TP2B. The pit was 50 ft in length, 3 ft in width, and 12 ft deep. Sand and gravel was observed from 0 to 2 ft and gray ash with slag and brick fragments was observed from 2 to 12 ft. No Semet material was observed. No sample was collected from test pit 006 MA TP2C.

Test pits were excavated using a rubber tire, extended reach backhoe. Excavated materials were staged on the ground adjacent to the pit until after such time as the pit was visually inspected by O'Brien & Gere and NYSDEC and samples were collected. After inspection and sampling were completed, the test pits were backfilled with the excavated materials. For test pits where chemical odors were noted, the breathing zone was screened with a PID. Test pit logs containing dimensions and observations made during excavation are presented in **Appendix F**. The backhoe was decontaminated between test pits using a steam cleaner.

For each test pit sample, a composite of soils from the test pit was collected using a decontaminated trowel and transferred to a mixing bowl. For locations where the test pit depth was greater than 6 ft bgs, samples were retrieved using the backhoe bucket or collected directly from the staged materials. The NYSDEC collected split samples from these test pits. A representative sample was placed in a sample container for VOC analysis by USEPA Method 8260. The remainder of the sample was homogenized using a trowel, and aliquots of homogenized sample were then placed in sample containers for PCBs/Pesticides (including hexachlorobenzene) and mercury analyses by USEPA Methods 8080 and 7471, respectively. The samples were placed in a cooler containing ice and transported to O'Brien & Gere Laboratories for analysis. The NYSDEC samples were sent to Chemtech Consulting Group for VOC, PCBs, and mercury analyses.

Exploratory Excavations of Subsurface Utilities

During Phase 2, exploratory excavation and sampling of pipe bedding materials were performed for various subsurface utilities to evaluate the potential for these utilities to act as residual migration pathways. Utilities evaluated included the Plant Area sanitary sewer (active portion), the P.A. Sewer/Main Sewer, and the Niagara Mohawk gas line. Exploratory excavation locations were selected in the field in concurrence with Honeywell and NYSDEC and are presented on **Figure 5**. Exploratory excavations were not performed during Phases 1 and 3 of the RI.

One sample was collected at each excavation location and submitted to O'Brien & Gere Laboratories for VOCs, PCBs/Pesticides (and hexachlorobenzene), and mercury analysis by USEPA Methods 8260, 8080, and 7471, respectively. Logs for exploratory excavations are presented in **Appendix F**.

The subsurface utilities were exposed using a rubber tire, extended reach backhoe. The exploratory excavation consisted of removing soils from above and around a selected portion of the pipe to allow for visual inspection and sampling of pipe bedding materials. The backhoe was decontaminated between excavations using a steam cleaner. A diagram showing depth of pipe, condition of pipe, characteristics of pipe bedding materials and other pertinent observations was constructed by a representative of O'Brien & Gere for each location. These diagrams are included in on the logs in **Appendix F**.

A sample of pipe bedding materials was collected using a decontaminated trowel and transferred to a mixing bowl. For locations where the depth of pipe was greater than 6 ft bgs, samples were retrieved using the backhoe bucket. A representative sample was then placed in a sample container for VOC analysis by USEPA Method 8260. The remainder of the sample was then homogenized using a trowel. Aliquots of homogenized sample were subsequently placed in sample containers for PCBs/Pesticides (including hexachlorobenzene) and mercury analyses by USEPA Methods 8080 and 7471, respectively. The samples were placed in a cooler containing ice and transported to O'Brien & Gere Laboratories.

Sanitary sewer. During this sampling event, the sanitary sewer was exposed and the bedding materials sampled at two on-site locations and one off-site location. The first exploratory excavation or test pit of the sanitary sewer (SS #1) was performed in the central portion of the Plant Area, between the former potash and evaporation buildings (**Figure 5**). The 8-inch diameter vitrified clay pipe (VCP) was found at a depth of 6 ft bgs and was set in medium crushed stone. Materials from 0 to 6 ft consisted of fill that was comprised mainly of ash, cinder, brick, and Solvay waste. Sanitary sewer excavation #2 (SS #2) was performed at a location north of the central portion of the former para finishing building. At this location, the VCP was encountered at 9 ft bgs and was set in crushed stone. Subsurface materials above the pipe consisted of fill. The third sanitary sewer excavation location (SS #3) was situated to the west of the jog in the fence in the northwest portion of the Plant Area (**Figure 4**). The pipe was encountered at 9 ft bgs and was set in crushed stone. Subsurface materials above the pipe consisted of fill. No flow was observed in upstream or downstream manholes at each of the three locations.

P.A. Sewer/Main Sewer. An exploratory excavation of the P.A. Sewer/Main Sewer was performed on the lakeshore property, just north of the fence which borders the property to the south. The excavation location is presented on **Figure 5**, and the excavation log is included in **Appendix F**.

The P.A. Sewer is a 42 inch by 42 inch cast in-place, steel mesh reinforced semi-elliptical pipe which runs from the Main Plant Site through the eastern portion of the Plant Area and enters the Main Sewer at a point near the corner of Willis Avenue and State Fair Boulevard. The Main Sewer, which is a 60 inch by 60 inch semi-elliptical pipe of the same construction as the P.A. Sewer, runs from the Main Plant Site in a northwest direction to the corner of Willis Avenue and State Fair Boulevard, where it combines with the P.A. Sewer and proceeds north to its point of discharge (Outfall 015) at the lakeshore area (**Figure 2**). At the point of excavation, the top of the pipe was encountered at 11 ft bgs and was covered with medium crushed stone. Water was observed at approximately the same depth as the top of the pipe. The presence of crushed stone on the sides and underneath the pipe was not verified due to large diameter of the pipe and its proximity to groundwater. Materials from the ground surface to the top of the pipe consisted of fill materials, including ash, cinders and brick fragments. The sample from this excavation (P.A.S. #1) was collected from materials around the top of the pipe at 11 ft bgs.

Niagara Mohawk Gas Line. Exploratory excavation of the Niagara Mohawk gas line was performed to evaluate the composition of pipe bedding materials. The Niagara Mohawk gas line is a 10-inch diameter wrapped steel pipe which runs in an east-west direction in the drainage ditch between and parallel to the northern Site boundary and State Fair Boulevard. The pipe is located 2 to 3 ft bgs and is set in sand and gravel. The pipe is situated above the shallow groundwater aquifer. Groundwater was encountered at approximately 1 ft below the bottom of the pipe. A 115-ft section of the gas line was exposed using a rubber tire backhoe. Excavation was initiated at Outfall 004 and proceeded 70 ft to the west and 45 ft to the east. A representative of Niagara Mohawk was present during excavation activities. One sample of materials was collected from both the western

and eastern portions of the excavation. NIMO #1 was collected 30 ft west of Outfall 004, and NIMO #2 was collected 25 ft east of Outfall 004. Both samples were collected from 3 ft bgs. The NYSDEC collected a split sample from NIMO #1 (3 ft). Sample locations are presented on **Figure 5**. Excavation logs are included in **Appendix F**. These samples were analyzed for VOCs, PCBs/Pesticides, and Mercury.

2.1.4.2. Additional AOS

Soil boring samples were collected from soil borings advanced in the PSA and CHSA during Phases 1 and 3 of the RI to further characterize the subsurface of those areas. A summary of this sampling including number of samples, number of borings, and analyses performed by phase is presented below. Boring logs are presented in **Appendix D**.

Petroleum Storage Area.
During Phase 1 of the RI, four soil borings were advanced in the PSA at the locations (**Figure 6**) to obtain additional data regarding the extent of the free product in the subsurface near MW-101. In boring PS-B1, samples were collected from 2 to 4 ft and 6 to 8 ft depth intervals, in PS-B2 from 0 to 2 ft and 2 to 4 ft, in PS-B3 from 0 to 2 ft and 2 to 4 ft and in PS-B4 from 0 to 2 ft and 4 to 6 ft. Samples were analyzed for TPH by USEPA Method 418.1 and percent solids.

The selection of the intervals submitted for analysis was based on field observations and field screening results. PSA borings extended from the ground surface to the top of the first-encountered groundwater and were performed in a manner similar to those installed in the Plant Area. Drilling procedures were consistent with those utilized during the installation of the Plant Area and lakeshore property borings. Upon completion of each boring, drilling and sampling equipment were decontaminated in accordance with procedures outlined in the QAPP, and the borings were backfilled with cement-bentonite. Table 2-3 below summarizes pertinent field observations for Phase 1 soil borings in the PSA.

Table 2-3 PSA Soil Borings, Phase 1 – Pertinent Field Observations

Boring No.	Note	Elevated Jerome Readings (mg/m^3)	Elevated HNU Readings (ppm)
PS-B3	Petroleum odor at 0-4 ft.	--	--
PS-B4	Petroleum odor at 2-4 ft.	--	58-334

Notes:

1. This table contains a summary of information contained on Phase 1 boring logs. Only those logs that contained pertinent information are listed here.
2. Phase 1 logs were completed in 1992.
3. "--" designates that there was no pertinent field observations or instrument detection.

During Phase 3, four samples, designated PSA#1, PSA#2, and PSA#3 were collected from three borings advanced in the southwestern, northwestern, and eastern portions of the PSA, respectively. These borings were advanced to a depth of 10 ft bgs. Sample locations are shown on **Figure 6**.

For Phase 3, three soil borings were advanced in the PSA to a depth of 10 ft. These borings (PSA#1, PSA#2 and PSA#3) were situated in the southwest, northwest, and eastern portions of the PSA, respectively. Sample locations are presented on **Figure 6**, and boring logs are included in **Appendix D**.

At each location, a composite sample was collected from the 2 to 10 ft depth interval and submitted to O'Brien & Gere Laboratories for TCL/TAL parameter analyses by ASP Methods 95-1, 95-2, 95-3 and 200.7, 245.1, and 335.2. In addition, a sample was collected from the 6 to 8 ft depth interval in boring PSA#3 due to the presence of petroleum staining at this depth.

Chlorobenzene Hot Spots Area.
During Phase 3 of the RI, six soil borings were advanced in the CHSA to a depth of 10 ft. These borings (CHSA#1 through CHSA#6) were situated between Industrial Drive and the fence that borders Trigen to the south. The borings were generally evenly spaced in the east/west direction starting from the vicinity of monitoring well C-15 and extending to the east to the vicinity of monitoring well R-6 MW. Sample locations are shown on **Figure 7**. Boring logs are included in **Appendix D**. In boring CHSA#2, chlorobenzene DNAPL was observed at 4 to 6 ft bgs. The CHSA historic boring logs in **Appendix D** do not include MW-111; this location is historic, and its boring log could not be located.

Phase 3 soil boring samples from the CHSA were collected using direct push drilling techniques (Geoprobe Macrocore). A composite sample of soil from 2 to 10 ft was collected from each boring and submitted to the laboratory for TCL/TAL analyses by ASP Methods 95-1, 95-2, 95-3, 200.7, 245.1 and 335.2.

2.1.5. Surface Soil Sampling

Surface soil samples were collected from various locations in the Willis Avenue Plant Study Area during Phases 2 and 3 of the RI. Surface soil samples were also collected in 1999 from the Willis Avenue Plant Study Area, PSA, CHSA, and off-site (background) areas as part of the BERA.

2.1.5.1. Plant Study Area

Surface soil samples were collected from the Willis Avenue Plant Study Area during Phases 2 and 3 of the RI. Surface soil samples were also collected in 1999 during Phase 4 sampling related to the BERA. A description of the sampling performed during each phase is presented below.

Phase 2

During Phase 2, surface soil samples were collected from the Northwest Ditch, Semet Ponds Ditch, Former Chlorination Building, Outfall 004, and Outfall 006 to evaluate the presence of process residuals. Sample locations are presented on **Figure 5**. Locations were selected in the field in concurrence with Honeywell and NYSDEC.

Northwest Drainage Ditch and Semet Ponds Drainage Ditch. During Phase 2, two samples were collected from the Northwest Ditch. Sample NW Ditch #1 was collected at 15 ft north of the southern end of the ditch, and NW Ditch #2 was collected at 65 ft north of the southern end of the ditch. The samples were collected from 0.5 to 1 ft bgs. The NYSDEC collected split samples from these locations.

One sample (Semet Ditch #1) was collected from the Semet Ponds drainage ditch at a depth of 0.5 to 1 ft bgs and 20 ft from the fence that borders the Semet Ponds to the north. The NYSDEC also collected a split sample from the Semet Ponds drainage ditch.

Surface soil samples from the Northwest Ditch and Semet Ponds Ditch were collected using dedicated plastic spatulas and dedicated aluminum pans. The samples were homogenized, transferred to sample containers provided by the laboratory, and placed in a cooler containing ice. Samples were transported to O'Brien & Gere Laboratories for PCBs and mercury analyses by USEPA Methods 8080 and 7471, respectively. Split samples collected by NYSDEC were sent to Chemtech Consulting Group for PCBs and mercury analysis.

Former Chlorination Building. Two samples (FCB #1 and FCB #2) were collected from within the footprint of the Former Chlorination Building, and three samples (FCB #3 through FCB #5) were collected just outside of the former building foundation. Sample locations are presented on **Figure 5**. The locations were selected in the field in concurrence with Honeywell and NYSDEC. The NYSDEC collected split samples from FCB#3, FCB#4, and FCB#5.

Prior to sampling, the corners of the building foundation were exposed using a backhoe to verify the location of the former building. The foundation was observed at approximately 0.5 ft bgs. As a result, samples were collected from 0.5 to 1 ft bgs to approximate the surface elevation at the time the plant was operational. Collection of samples FCB#1 and FCB#2, which are located within the footprint of the former building, was accomplished by removing bricks from the former floor of the building. Surface soil samples from the vicinity of the Former Chlorination Building were collected using dedicated plastic spatulas and dedicated aluminum pans.

The samples were homogenized, transferred to sample containers provided by the laboratory, and placed in a cooler containing ice. The samples were analyzed for PCDD/Fs and TOC. The PCDD/F analyses were performed by Triangle Laboratories using USEPA Method DFLM01.1 (September, 1991), and TOC analyses were performed by AEN using USEPA Method 9060 (Lloyd Kahn). The NYSDEC split samples were also analyzed for PCDD/Fs and TOC.

Toxicity equivalency factors (TEFs) were applied to the results to develop toxicity equivalents (TEQs) in accordance with the *Interim Procedures for Estimating Risks Associated with Exposure to Mixtures of Chlorinated Dibenzo-p-dioxins and Dibenzofurans* (USEPA, 1989a). The TEFs were taken from Van den Berg *et al*. (2006). The TEQs were also calculated for the NYSDEC split samples.

Outfalls 004 and 006. During Phase 2, four samples were collected from two locations near Outfall 004 and two locations near Outfall 006. At each outfall, samples were collected from two depth intervals (0 to 0.5 ft and 1 to 1.5 ft) at two locations. The Outfall 004 samples were collected from 40 ft east (004A) and 180 ft east (004B) of the outfall weir. For Outfall 006, samples were collected from 20 ft north (006A) and 50 ft north (006B) of the outfall weir. NYSDEC collected split samples from these locations. Sampling locations were selected in the field in concurrence with Honeywell and NYSDEC. Sample locations are presented on **Figure 5**.The NYSDEC collected split samples from each location with the exception of 004B (0-0.5 ft).

Surface soil samples were collected using a decontaminated trowel. After collection, the soil was immediately transferred to a mixing bowl, and prior to mixing, a representative aliquot was placed in an appropriate sample container for VOCs analysis. The soil remaining in the mixing bowl was homogenized using a trowel, transferred to appropriate sample containers, and placed in a cooler containing ice. Samples were transported to O'Brien & Gere Laboratories for PCBs/Pesticides (including hexachlorobenzene) and mercury analyses by USEPA Methods 8080 and 7471, respectively. The NYSDEC samples were sent to Chemtech Consulting Group for PCB/Pesticide and mercury analyses.

Phase 3

Phase 3 surface soil samples were collected from the Plant Area, Northwest Ditch, Outfall 004, Outfall 006, the mounded area near Outfall 006, and lakeshore property. Sampling locations are presented on **Figure 5**.

Plant Area. Thirty seven surface soil samples were collected from 17 sampling locations in the Plant Area. Sampling locations are presented on **Figure 5**. Phase 3 surface soils from the Plant Area were collected by direct push drilling techniques (Geoprobe Macrocore) as described above for Phase 3 soil borings.

Twelve samples (SB-1 [0 to 2 ft] through SB-12 [0 to 2 ft]) were collected from the center of triangles situated on a 200 ft grid across the Plant Area. These samples were submitted to O'Brien & Gere Laboratories for TCL/TAL parameter analyses. The VOCs, SVOCs, PCBs/Pesticides, and metals were analyzed by ASP Methods 95-1, 95-2, 95-3, and 200.7, 245.1 and 335.2, respectively.

Twenty five surface soil samples were collected from the Plant Area and submitted to AXYS Analytical Services for PCDD/Fs analysis by USEPA Method 8290 and Severn Trent for TOC analysis by USEPA Method 9060 (Lloyd Kahn). The 25 samples consisted of the following:

- 15 samples from 0.5 to 1 ft at locations SB-1 through SB-12, FCB-5A, FCB-5B and FCB-5C, and
- 10 samples from 1 to 2 ft at locations SB-8 through SB-12, FCB-2, FCB-5, FCB-5A, FCB-5B, and FCB-5C.

The NYSDEC collected split samples from FCB #2 (1 to 2 ft) and FCB #5A (0.5 to 1 ft). The split samples were submitted to AXYS Analytical for PCDD/Fs analysis by Method 8290.

TEFs were applied to the results to develop TEQs in accordance with the *Interim Procedures for Estimating Risks Associated with Exposure to Mixtures of Chlorinated Dibenzo-p-dioxins and Dibenzofurans* (USEPA, 1989a). The TEQs were also calculated for the NYSDEC split samples.

Northwest Drainage Ditch. Two soil samples were collected from the southern portion of the Northwest Ditch (NW Ditch #3 [0 to 0.5 ft] and NW Ditch #3 [1 to 1.5 ft]). Sample locations are shown on **Figure 5**. These samples were submitted to AXYS Analytical Services for PCDD/Fs analysis by USEPA Method 8290 and Severn

Trent for TOC analysis by USEPA Method 9060 (Lloyd Kahn). The sample location is presented on **Figure 5**. The NYSDEC also collected a sample (NW Ditch #3) at a depth of 0.5 to 1 ft, which was submitted to AXYS Analytical Services for PCDD/Fs analysis and H2M Laboratories for TOC analysis.

Phase 3 surface soil samples from the Northwest Ditch were collected using dedicated plastic spatulas and dedicated aluminum pans. The samples were then homogenized, transferred to sample containers provided by the laboratory, and placed in a cooler containing ice.

TEFs were applied to the results to develop TEQs in accordance with the *Interim Procedures for Estimating Risks Associated with Exposure to Mixtures of Chlorinated Dibenzo-p-dioxins and Dibenzofurans* (USEPA, 1989a). The TEQs were also calculated for the NYSDEC split samples.

Outfalls 004 and 006. During Phase 3, two soil samples (004A [0 to 0.5 ft] and 004A [1 to 1.5 ft]) were collected from the drainage ditch that runs parallel to State Fair Boulevard at a point just east of Outfall 004. NYSDEC also collected a split sample from 004A at a depth of 0.5 to 1 ft. The sample location is presented on **Figure 5**. These samples were submitted to AXYS Analytical Services for PCDD/Fs analysis by USEPA Method 8290 and Severn Trent for TOC analysis by USEPA Method 9060 (Lloyd Kahn).

Outfall 006 Phase 3 sampling consisted of collection of four samples collected from two locations in the drainage ditch associated with Outfall 006. 006A was situated just north of the outfall, and location 006B was situated 40 ft north of 006A. Samples were collected from 006A and 006B at 0 to 0.5 ft and 1 to 1.5 ft bgs. The NYSDEC also collected samples from 006A and 006B but at depths of 0.5 to 1 ft.

The samples were collected using dedicated plastic spatulas and dedicated aluminum pans. The samples were homogenized, transferred to sample containers provided by the laboratory, and placed in a cooler containing ice.

TEFs were applied to the results to develop TEQs in accordance with the *Interim Procedures for Estimating Risks Associated with Exposure to Mixtures of Chlorinated Dibenzo-p-dioxins and Dibenzofurans* (USEPA, 1989a). The TEQs were also calculated for the NYSDEC split samples.

Mounded Area near Outfall 006. Three surface soil samples were collected from 0 to 2 ft bgs from three locations in the mounded area near Outfall 006. 006 M.A. SS#1 was situated in the northern portion of this area, 006M.A. SS#2 in the southwest portion, and 006 M.A. SS#3 in the southeast portion. Sample locations are presented on **Figure 5**.

Phase 3 surface soil samples from the mounded area near Outfall 006 were collected using dedicated plastic spatulas and dedicated aluminum pans. Prior to mixing, a representative aliquot was placed in an appropriate sample container for VOCs analysis. The remaining sample material was homogenized, transferred to sample containers provided by the laboratory, and placed in a cooler containing ice.

The samples were submitted to O'Brien & Gere Laboratories for TCL/TAL parameter analyses. The VOCs, SVOCs, PCBs/Pesticides, and metals were analyzed by ASP Methods 95-1, 95-2, 95-3 and 200.7, 245.1 and 335.2, respectively.

Lakeshore Property. Six surface soil samples from six locations (LS-1 through LS-6) were collected from the lakeshore property during Phase 3 of the RI. In addition, one surface soil sample (BCKGRD) was collected from south of I-690 near the State Fair Boulevard on-ramp for I-690 East. The objective of this sample was to evaluate background concentrations of PCDD/Fs. The depth interval for these samples was 0 to 0.5 ft. Sample locations are presented on **Figure 5**.

Phase 3 surface soil samples from the lakeshore property were collected using dedicated plastic spatulas and dedicated aluminum pans. Prior to mixing, a representative aliquot was placed in an appropriate sample container for VOCs analysis. The remaining sample material was homogenized, transferred to sample containers provided by the laboratory, and placed in a cooler containing ice.

LS-1 through LS-6 were submitted to O'Brien & Gere Laboratories for TCL/TAL analyses and to AXYS Analytical Services for PCDD/Fs analysis. The VOCs, SVOCs, PCBs/Pesticides, and metals were analyzed by ASP Methods 95-1, 95-2, 95-3, and 200.7, 245.1 and 335.2, respectively. LS-1, LS-3, LS-5, and BCKGRD were also submitted to AXYS Analytical Services for PCDD/Fs analysis by USEPA Method 8290. TEFs were applied to the results to

develop TEQs in accordance with the *Interim Procedures for Estimating Risks Associated with Exposure to Mixtures of Chlorinated Dibenzo-p-dioxins and Dibenzofurans* (USEPA, 1989a).

Phase 4 (1999 BERA Sampling)

Phase 4 surface soil samples were collected from one location in the Plant Area (MPS-SS), Northwest Ditch (NWD-SS), Outfall 006 (006-SS), and Former Chlorination Building (FCB-SS). Each sample was collected from the 0 to 0.5 ft depth interval. A regular sample and field duplicate were collected from NWD. Sampling locations are presented on **Figure 5**.

These surface soil samples were collected using dedicated plastic spatulas and dedicated aluminum pans. Prior to mixing, a representative aliquot was placed in an appropriate sample container for VOC analysis. The remaining sample material was homogenized, transferred to sample containers provided by the laboratory, and placed in a cooler containing ice.

The samples were submitted to O'Brien & Gere Laboratories for analysis by NYS ASP methods. TCL/TAL parameter analyses was performed using Methods 95-1, 95-2, 95-3, 200.7, 245.1 and 335.2 for VOCs, SVOCs, Pesticides/PCBs (including Aroclor 1268), metals, mercury and cyanide, respectively. The samples were also sent to AXYS Analytical Services for PCDD/Fs analyses by USEPA Method 8290 (USEPA, 1996) and to Severn Trent for TOC analysis by Lloyd Kahn Method. TEFs were applied to the results to develop TEQs in accordance with the *Interim Procedures for Estimating Risks Associated with Exposure to Mixtures of Chlorinated Dibenzo-p-dioxins and Dibenzofurans* (USEPA, 1989a).

2.1.5.2. Additional AOS

Surface soils were collected from the PSA and CHSA during Phase 3 of the RI and the Phase 4 1999 sampling associated with the BERA. The Phase 3 surface soil samples were collected by direct push drilling techniques (Geoprobe Macrocore) concurrently with the subsurface samples collected in these areas. The Phase 4 1999 samples were collected using dedicated plastic spatulas and dedicated aluminum pans. Prior to mixing, a representative aliquot was placed in an appropriate sample container for VOCs analysis. The remaining sample material was homogenized, transferred to sample containers provided by the laboratory, and placed in a cooler containing ice.

Petroleum Storage Area

Three surface soils were collected from three locations (PSA#1 [0 to 2 ft] through PSA#3 [0 to 2 ft]) in the PSA during Phase 3. Sample locations are presented on **Figure 6**, and boring logs are included in **Appendix D**. The samples were submitted to O'Brien & Gere Laboratories for analysis by NYS ASP methods. TCL/TAL parameter analyses was performed using Methods 95-1, 95-2, 95-3, 200.7, 245.1, and 335.2 for VOCs, SVOCs, Pesticides/PCBs (including Aroclor 1268), metals, mercury, and cyanide, respectively.

For Phase 4, one surface soil sample (PSA-SS) was collected from one sampling location from the 0 to 0.5 ft depth interval. The sampling location is presented on **Figure 6**. The sample was submitted to O'Brien & Gere Laboratories for analysis by NYS ASP methods. TCL/TAL parameter analyses was performed using Methods 95-1, 95-2, 95-3, 200.7, 245.1 and 335.2 for VOCs, SVOCs, Pesticides/PCBs (including Aroclor 1268), metals, mercury, and cyanide, respectively.

Chlorobenzene Hot Spots Area

The Phase 3 surface soil samples (0 to 2 ft) were collected from the six soil borings CHSA#1 through CHSA#6 (discussed above), which were situated between Industrial Drive and the fence that borders Trigen to the south. Sample locations are shown on **Figure 7**, and boring logs are included in **Appendix D**. The samples were submitted to O'Brien & Gere Laboratories for analysis by NYS ASP methods. TCL/TAL parameter analyses was performed using Methods 95-1, 95-2, 95-3, 200.7, 245.1, and 335.2 for VOCs, SVOCs, Pesticides/PCBs (including Aroclor 1268), metals, mercury, and cyanide, respectively.

For Phase 4, one surface soil sample (CHSA-SS) was collected from one sampling location in the CHSA from the 0 to 0.5 ft depth interval. The sampling location is presented on **Figure 7**. The sample was submitted to O'Brien & Gere Laboratories for analysis by NYS ASP methods. TCL/TAL parameter analyses was performed using

Methods 95-1, 95-2, 95-3, 200.7, 245.1 and 335.2 for VOCs, SVOCs, Pesticides/PCBs (including Aroclor 1268), metals, mercury and cyanide, respectively.

2.1.6. Sediment and Surface Water Sampling

At the request of NYSDEC, surface water and sediment sampling was performed in Tributary 5A during the Semet Residue Ponds RI (O'Brien & Gere, 1991) and in 1999 during the sampling related to the BERA. Tributary 5A sampling associated with the SDI is discussed below in Section 2.1.12.

2.1.6.1. Tributary 5A Surface Water

Two rounds of surface water were collected from Tributary 5A and Onondaga Lake as part of the Semet Residue Ponds RI/FS. The three Round 1 samples were collected from the surface water directly above the three sediment sample locations (T5A-UP, T5A-MID, and T5A-DN). Surface water samples were collected by immersing the sample containers into the tributary and submitted to O'Brien & Gere Laboratories. The samples were analyzed for TCL parameters in accordance with NYS ASP procedures. Three Round 2 samples were collected from these locations on June 25, 1991. Round 2 samples were analyzed for TCL VOCs. It should be noted that these locations were selected based on their proximity to the Semet Ponds not the Willis Avenue Chlorobenzene Site. Sample locations are presented on **Figure 8**.

Surface water was collected from Tributary 5A in November 1999 as part of the BERA. Samples were collected from four locations (5A-1, 5A-2, 5A-3, and 5A-4). Sample locations are presented on **Figure 8**. Surface water samples were collected by immersing the sample containers into the tributary and submitted to O'Brien & Gere Laboratories. Samples were analyzed for TCL/TAL parameters in accordance with NYS ASP methods.

2.1.6.2. Tributary 5A Sediment

Concurrent with the two rounds of 1991 Tributary 5A surface water samples, a sediment sample was collected from the upstream (T5A-UP), midstream (5A-MID) and downstream (5A-DN) locations. Sample locations are presented on **Figure 8**. Sediment samples were collected using dedicated metal scoops or trowels and submitted to O'Brien & Gere Laboratories. Round 1 samples were analyzed for TCL/TAL parameters in accordance with NYS ASP, and Round 2 samples were analyzed for TCL/TAL VOCs.

Sediment samples were also collected in November 1999 as part of the BERA. Samples were collected at four locations (5A-1, 5A-2, 5A-3, and 5A-4; **Figure 8**). Sediment samples were collected using dedicated metal scoops or trowels and submitted to O'Brien & Gere Laboratories. The samples were analyzed for TCL/TAL parameters in accordance with NYS ASP methods. The samples were also sent to AXYS Analytical Services for PCDD/Fs analyses by USEPA Method 8290. TEFs were applied to the results to develop TEQs in accordance with the *Interim Procedures for Estimating Risks Associated with Exposure to Mixtures of Chlorinated Dibenzo-p-dioxins and Dibenzofurans* (USEPA, 1989a).

2.1.7. Monitoring Well Installation

Twenty-five monitoring wells were installed during Phase 1 of the RI to evaluate hydrogeologic characteristics such as flow direction (both horizontal and vertical), hydraulic conductivity, and hydraulic gradient. Three additional monitoring wells WA-8S, WA-8I and WA-8D and three temporary wells were completed as part of Phase 1 between December 5, 1994 and December 15, 1994. The monitoring wells were installed by Parratt Wolff, Inc. under the supervision of an O'Brien and Gere hydrogeologist.

2.1.7.1. Plant Study Area

In the Plant Study Area, eight monitoring well nests and three temporary shallow wells were installed during Phase 1 at the locations shown on **Figures 4 and 5**. Each well nest consisted of a shallow, intermediate, and deep well except for WA-6, which consisted of only two wells due to the shallow depth to till and depth of the water table. The NYSDEC agreed to this change in the Work Plan. Seven of the well clusters (WA-1, WA-2, WA-3, WA-4, WA-5, WA-6, and WA-8) were installed along the perimeter of the Plant Study Area in both upgradient and downgradient directions. Well cluster WA-7 was installed near the center of the Plant Study Area to evaluate the extent of residuals which may be present in the subsurface groundwater. The data associated with well nests WA-3 and WA-8 have become part of the Wastebed B/Harbor Brook Remedial Investigation at the request of the NYSDEC and are discussed in the Wastebed B/Harbor Brook RI Report.

The shallow monitoring wells were installed such that they intersected the water table or slightly below the water table at the base of the porous artificial fill (WA-1S and WA-2S). These two wells were installed slightly deeper in comparison to the other wells to sample a zone in the fill that had elevated PID readings and was possibly conducting material with a density greater than that of water. The screened depth intervals for WA-1S and WA-2S were set so compounds less dense than water would still be detected slightly below the water table due to their water solubility. The NYSDEC agreed with the change in the Work Plan to place the well screens for WA-1S and WA-2S below the water table rather than to intersect the water table.

The intermediate wells were installed with their screens in or partially in the marl that separates the fill and Solvay waste from the glacio-lacustrine sands and silts. This zone also had elevated PID scans. The proposed depth for each of the intermediate wells was discussed and agreed to with NYSDEC. Although well WA-6I was installed at the top of till, it is considered an intermediate well because of the elevation of the well screen.

The deep wells were installed within the overlying glacio-lacustrine sediments at the top of the till or bedrock.

Pertinent observations related to the installation of the monitoring wells in the Plant Area are located in Table 2-4.

Table 2-4 Plant Study Area Monitoring Well Installation, Phase 1 – Pertinent Field Observations

Boring No.	Note	Elevated Jerome Readings (mg/m^3)	Elevated HNU Readings (ppm)
WA-1D	Chlorobenzene-like odor at 8-14 ft; H_2S odor at 16-32 ft; brownish-red fluid observed at 32-38 ft.	--	0.5-453
WA-2D	Black petroleum-like odor at 8 ft; chlorobenzene-like odor at 14 ft; brown fluid observed in marl at 26-34 ft.	--	0.3-1272
WA-2S	Petroleum odor at 8-10 ft.	not analyzed	not analyzed
WA-3D	Chlorobenzene-like odor at 2 ft; some product (chlorobenzene) at 6 ft.	--	0.2-340
WA-5D	Strong H2S odor at 32-34 ft	--	--
WA-6D	Strong toluene-like odor at 2-8 ft.	--	0.0-256

Notes:

1. This table contains a summary of information contained on Phase 1 monitoring well logs. Only those monitoring wells that contained pertinent information are listed here.
2. Phase 1 logs were completed in 1992.
3. "--" designates that there was no instrument detection.

2.1.7.2. Petroleum Storage Area

During Phase 1, four monitoring wells were installed in the PSA at the locations shown on **Figure 6**. Three of the monitoring wells (PS-1, PS-2, and PS-3) were shallow wells that intersected the water table and situated around the perimeter of the area in both upgradient and downgradient hydraulic directions. Monitoring well PS-3D is a deep well in a hydraulically downgradient direction that was screened in the till immediately above the bedrock. Pertinent observations associated with the borings from the PSA are located in Table 2-5.

Table 2-5 PSA Monitoring Well Installation, Phase 1 – Pertinent Field Observations

Boring No.	Note	Elevated Jerome Readings (mg/m^3)	Elevated HNU Readings (ppm)
PS-1	Slight mothball-like odor at 2-4 ft.	--	--
PS-2	Slight mothball-like odor at 2-4 ft.	--	--
PS-3D	Heavy sheen and petroleum-like odor at 6-8 ft; petroleum and mothball-like odors 8-10 ft; mothball-like odors at 10-12 ft.	--	0.2-57.2

Notes:

1. This table contains a summary of information contained on Phase 1 monitoring well logs. Only those monitoring wells that contained pertinent information are listed here.
2. Phase 1 logs were completed in 1992.
3. "--" designates that there was no instrument detection.

2.1.7.3. Chlorobenzene Hot-Spots Area

One shallow well (HR-1) was installed in the CHSA during Phase 1. The well was located midway between R-5P and MW-111 along the path of a previous pipeline (**Figure 7**).

2.1.7.4. Drilling Procedures

Borings for the deep monitoring wells were drilled and sampled using ASTM Method D1586-84 with a 140-lb hammer, 2-ft split barrel samplers, and hollow stem augers. Sampling was continuous from the ground surface to the bottom of the boring. Well logs for the deep borings were kept that recorded a description of the soil, number of blows, depth, percentage recovered, and other pertinent observations and are included in **Appendix D**.

A representative portion of each sample was placed in a glass jar. After being allowed to warm to room temperature, the headspace of each sample was scanned with a PID and Jerome mercury vapor analyzer. Results of these scans are included on the well logs. Soil samples collected from the screened interval of each well were selected and tested to evaluate the grain size distribution. Samples selected for grain size distribution analyses are listed in **Table 1**. Results of the analyses are in **Appendix G**.

An attempt was made to collect Shelby tubes in the native sediments from the borings for the deep monitoring wells. Those successfully recovered were submitted to Parratt Wolff Laboratory and tested for vertical hydraulic conductivity of the sediments. The laboratory results for the Shelby tubes recovered are recorded in **Appendix G**.

The intermediate and shallow monitoring wells in each nest were drilled without continuous sampling. One or two samples were collected in some of the wells if there was a need to obtain a sample for grain size analysis or to verify the stratigraphy obtained while drilling the boring for the deep monitoring well.

The rig and all equipment that came in contact with the soil were decontaminated with high pressure steam prior to and between each well installation.

2.1.7.5. Hydropunch Sampling

Seven hydropunch samples were collected from four locations in the eastern portion of the lakeshore property in December 1994. These samples were collected based on a NYSDEC review of the 1993 RI Report and the correspondence between Honeywell and NYSDEC dated November 29, 1994. These hydropunch samples were used to select the location of the WA-8 well cluster (**Figure 5**).

The hydropunch was used in the groundwater sampling mode in which a sample is collected from a discrete interval. An attempt was made to collect two samples at each location. The shallow sample was collected near the estimated depth of the water table, and a second sample was collected near the estimated boundary between the fill and the underlying marl. At each location, the hydropunch assembly was pushed or hammered to the required depth and then the assembly was pulled back a few inches to drop the shoe and expose the screen. After waiting an appropriate time for the collection chamber to fill, the assembly was retrieved and the sample was collected in laboratory containers and placed in a cooler with ice and immediately transported to the laboratory. The chains of custody are presented in **Appendix E**. The hydropunch assembly and any other equipment which had come in contact with the sediments were cleaned with high pressure steam between each sampling attempt. Seven hydropunch samples were collected at four different locations and submitted for analysis by USEPA Method 624 for VOCs. The data associated with these hydropunch locations have become part of the Wastebed B/Harbor Brook Remedial Investigation at the request of the NYSDEC and are discussed only in the Wastebed B/Harbor Brook RI Report.

2.1.7.6. Monitoring Well Completion

The monitoring wells were constructed of 2-inch inner diameter (I.D.) riser casing connected to 10 ft of 0.01-inch slotted well screen. The riser casing was extended about 2 ft above the ground surface. The casings for WA-1D, WA-2D, and WA-3D extended more than 2 ft above the ground surface because water elevations greater than 2 ft above the ground surface were encountered in these wells. The well material for wells HR-1, PS-1, PS-2, PS-3 and PS-3D was polyvinyl chloride (PVC). Fiberglass reinforced epoxy (FRE) was used as the well material for well nests WA-1 through WA-8 because of its resistance to degradation by organics and chlorides.

A washed silica sand pack was installed in the annulus between the edge of borehole and the well screen. The sand pack extended from 2 to 5 ft above the top of the well screen, depending upon the well depth. A bentonite seal at least 3 ft thick was installed in the annulus above the sand pack to prevent water from moving vertically along the borehole. Dry bentonite pellets were used if the water column through which the bentonite pellets had to settle was sufficiently shallow so as not to impede their settling. If the water column was deeper, a slurry of bentonite pellets was installed above the sand pack using a tremie pipe. The remainder of the borehole annulus was sealed to the surface with a Portland cement-bentonite grout.

To protect the monitoring wells and to prevent unauthorized access, a steel guard pipe was installed around each well casing and was extended approximately 2 to 3 ft above grade. The top of the guard pipe was secured with a cover and keyed-alike locks. A concrete pad was installed around each guard pipe to direct precipitation away from the borehole.

2.1.7.7. Well Development

Following installation and prior to sampling, each monitoring well was developed to remove material that had settled in and around the well screen during installation. Previously installed monitoring wells that were to be re-sampled for this study were re-developed. For existing wells that were to be used for water elevation readings, sufficient water was removed to demonstrate that they were responsive to changes in groundwater elevations. Prior to bailing the wells, plastic sheeting was placed on the ground surface to prevent the removed groundwater from infiltrating into the soils.

Water was removed from the monitoring wells with both bailers and a centrifugal pump, and drummed for disposal. Wells WA-8S, WA-8I, and WA-8D were developed using a bailer and a down hole pump or impeller pump. The development water from those wells was allowed to drain onto the ground in the vicinity of the wells, because groundwater samples collected by hydropunch and from the open borehole had not detected contaminants related to the Site. Bailers were decontaminated by either high pressure steam or with soap, distilled water, 10% nitric acid and hexane according to the protocols outlined in the QAPP. If bailed, clean polypropylene rope was used for each well. Clean polyethylene tubing was used for each well in which a pump was used. A dedicated foot-valve was used for those wells in which a pump was used. Due to the fine grained materials encountered in both the native and artificial fill, most wells could not be developed such that the water contained a turbidity of 50 nephelometric turbidity unit (NTU) or less. At least ten well volumes were removed from each well except in the case of WA-1I, WA-2I and WA-7I. Less than ten well volumes were removed from these wells due to the presence of free product. Sufficient water was removed to assure the well was developed and that there did not appear to be a further decrease in turbidity.

2.1.8. Hydraulic Conductivity Tests

In-situ hydraulic conductivity tests were performed to estimate the horizontal hydraulic conductivity of the unconsolidated deposits near the well screen. The Bouwer and Rice method (Bouwer and Rice, 1976) was used to evaluate the field data and to estimate the horizontal hydraulic conductivity of the sediments. These calculations are included in **Appendix H**, and the hydraulic conductivities are summarized on **Table 2**. In addition to the hydraulic conductivity tests, recent pump tests and specific capacity tests (O'Brien & Gere, 2002) were completed in the vicinity of the Plant Study Area.

Hydraulic conductivity tests were performed on most of the wells installed during Phase 1 of the RI to estimate the horizontal hydraulic conductivity of the sediment near the well screen. Tests were not performed on WA-1I and WA-2I because of the free product in these wells. Tests were not performed on wells WA-2D and WA-7D because they intercepted sands, and the wells responded too quickly to perform a slug test. In addition, hydraulic conductivity tests were not conducted on WA-8S, WA-8I, and WA-8D since hydraulic conductivity information at this location would not be usable at the Plant Area. Due to the rapidity with which many of the wells recovered, a pressure transducer was used to measure changing water levels; data were stored on a data logger.

The insertion or removal of a clean PVC slug into the well caused a rapid change in the water level. Time and depth data were collected as the level recovered to the static level. Data were recorded at each well after both the insertion and removal of the slug (**Appendix H**).

2.1.9. Groundwater Sampling

Groundwater sampling was performed to evaluate and characterize the nature and extent of residuals in groundwater. Phase 1 groundwater sampling was performed in three distinct rounds: Round 1 in March and April 1992; Round 2 in September and October 1992; and Round 3 in January and March 1995. Phase 2 groundwater sampling was performed in October 1997.

2.1.9.1. Phase 1 Groundwater Sampling

Round 1

Round 1 groundwater samples were collected between March 30 and April 6, 1992 at the Plant Area and lakeshore property, between May 4 and 5, 1992 at the CHSA, and on April 8, 1992 at the PSA. This time frame was selected since high groundwater elevations were expected.

Round 1 groundwater samples were collected from the newly installed monitoring wells and monitoring well nest SP-3, which was installed during the Semet Residue Ponds RI. Well nest SP-3 is located along the west border of the Plant Area. Monitoring wells sampled during Round 1 are as follows:

- Willis Avenue Plant Study Area: WA-1S, WA-1I, WA-1D, WA-2S, WA-2I, WA-2D, WA-4S, WA-4I, WA-4D, WA-5S, WA-5I, WA-5D, WA-6S, WA-6D, WA-7S, WA-7I, and WA-7D
- PSA: PS-1, PS-2, PS-3, and PS-3D.
- CHSA: HR-1, C-1, C-11, C-15, MW-111, R6-MW, and PW.

Wells were evacuated and sampled in accordance with the QAPP (O'Brien & Gere, 1990c). The volume of water in each well was calculated from the measurements of well depth and groundwater elevation taken prior to evacuation. Three well volumes of water were purged from the wells prior to sampling unless the well went dry during the purging. If the well went dry, purging was discontinued and the well allowed to recover before sampling.

Evacuation was accomplished either with a decontaminated stainless steel bailer and dedicated polypropylene rope or dedicated Waterra® foot valve pump and polyethylene tubing. The bailers were decontaminated with a soap and distilled water wash, distilled water rinse, 10% nitric acid rinse, distilled water rinse, hexane rinse, and final distilled water rinse before and after each well was sampled. Temperature, pH and specific conductivity were measured after evacuation of the wells prior to sampling. Turbidity, odor, color and other pertinent observations of the physical appearance of the groundwater were recorded at the commencement of evacuation and during sampling. The complete sampling logs are included in **Appendix I**. Table 2-6 contains a summary of

pertinent observations from the groundwater sampling logs for Round 1. A chain of custody was initiated as the samples were collected and was submitted with the samples to O'Brien & Gere Laboratories, Inc. Chains of custody forms are presented in **Appendix E**. The samples were sealed with evidence tape, placed on ice, stored in coolers, and submitted to O'Brien & Gere Laboratories for analysis.

Table 2-6 Monitoring Well Sampling, Phase 1 – Pertinent Field Observations

Well No.	Note	Date Collected
R6-PW	Pit around well was filled with water with a petroleum-like odor; black staining also was noted on inside of well casing.	none listed
MW-111	Dark gray with solvent like odor; slight sheen; appearance of material from well (steel) that has deteriorated in the water.	5/4/92
SP-3B	Light red brown color; organic decay odor; much degassing of water during sampling.	3/31/92
WA-1S	Red brown product; strong odor; emulsified.	4/7/92
WA-2I	Red brown product; strong odor.	4/7/92
WA-4I	Yellow; strong H_2S odor.	3/30/92

Notes:

Only those logs that contained pertinent information are listed here.

Samples were analyzed according to NYSDEC ASP Methods for TCL VOCs, SVOCs, metals, and cyanide. Because turbidity was greater than 50 NTU, both filtered and unfiltered samples were submitted for metals analysis in the monitoring wells except for SP-3A where the turbidity was less than 50 NTU. Major anion and cation analyses were also completed on the samples to aid in the evaluation of both vertical and horizontal groundwater flow across the Site.

The analysis of both total and filtered samples during Phase 1 allowed the two samples to be compared to each other, as well as to the NYSDEC Class GA Ambient Water Quality Standards or Guidance Values (NYSDEC, 1998). This analysis allowed for the interpretation of whether inorganic parameters are dissolved into the groundwater or are associated with elevated turbidity and sediment content.

Filtering may also remove a portion of the metals of concern (that which is sorbed to the lower end of the range of particles) that are able to migrate within the groundwater system. Therefore, in an attempt to minimize turbidity without filtering, samples collected during Phase 2 were obtained using low flow sampling techniques.

Quality control samples were also submitted for laboratory analysis. A trip blank for VOCs was transported with each cooler. Two equipment blanks were collected by rinsing the decontaminated bailers with deionized water supplied by the laboratory; these samples were used as a check against possible cross contamination by sampling equipment. Four sets of blind duplicates, matrix spikes (MSs), and matrix spike duplicates (MSDs) were collected and submitted as a laboratory quality control check.

Round 2

Round 2 sampling took place between September 24 to October 15, 1992 to verify Round 1 sampling results. Sampling followed the same protocols as the first round and collected samples from the same monitoring wells as Round 1 (listed above). Consistent with the Work Plan, the second round of sampling focused on site-specific parameters selected with the concurrence of the NYSDEC. Round 2 samples were submitted to O'Brien & Gere Laboratories for analyses by USEPA method 601/602 VOCs (extended to include xylenes. Table 2-7 contains a summary of pertinent observations from the groundwater sampling logs for Round 2.

Table 2-7 Monitoring Well Sampling, Phase 2 – Pertinent Field Observations

Well No.	Note	Date Collected
SP-3B	Water degassing as sampled; yellow brown color; strong H_2S odor.	10/13/92
WA-1I	Clear water with red-brown product; strong odor; product bubbles.	10/15/92
WA-2I	Red-brown product with strong odor; some product in initial samples; was resampled.	10/14/92
WA-4I	Yellow brown color; strong H_2S odor.	10/9/92
WA-5	Foam observed.	10/9/92
WA-7I	Dark red-brown color; strong odor; water was degassing and foaming.	10/12/92

Notes:

Only those logs that contained pertinent information are listed here.

Round 3

Round 3 groundwater samples from MW-111 on the CHSA and monitoring well cluster WA-8 (data included only in Wastebed B/Harbor Brook RI) were collected in March 1995. On March 8, 1995, the groundwater sample was collected from MW-111. During collection of the sample, an organic odor was noted, and a surface sheen was observed. The well was evacuated with a decontaminated stainless steel bailer. The purge water was contained and left on-site. Samples were collected and transported to O'Brien & Gere Laboratories. The WA-8 samples were analyzed for VOCs, SVOCs, and metals by NYS ASP Methods 91-1, 91-2, and TAL inorganics, respectively, while the MW-111 sample was only analyzed for VOCs. The chain of custodies and sampling logs are included in **Appendices D and G**, respectively.

2.1.9.2. Phase 2 Groundwater Sampling

Groundwater samples were collected from lakeshore property monitoring wells WA-1S, WA-2S, and CHSA wells C-13, C-14, C-15, and MW-111 during Phase 2 of the RI. Samples from lakeshore wells were analyzed for mercury and samples from the CHSA were analyzed for VOCs and mercury. This sampling was performed between the dates of October 27 and October 29, 1997. During collection of the sample from monitoring well MW-111, an organic odor was noted and a surface sheen was observed.

Phase 2 samples were collected using low flow purging techniques in accordance with an August 26, 1997 letter from NYSDEC to Honeywell. Low flow purging involved placing a decontaminated stainless steel Grundfos® pump (Rediflow) and dedicated Teflon tubing within the screened interval of the well and purging at a rate of less than 0.5 liters/min. During purging, groundwater quality parameters including pH, conductivity, temperature, reduction-oxidation potential (EH), turbidity, and dissolved oxygen were monitored continuously using an in-line meter. Water levels were monitored to ensure that dewatering did not occur. The groundwater samples were collected directly from the Teflon tubing. The pump was decontaminated between wells in accordance with the procedures presented in the QAPP. Sampling logs are included in **Appendix I**.

After collection, the samples were placed in a cooler containing ice. The samples were transported along with chain of custody documentation to O'Brien & Gere Laboratories for analysis. Samples from CHSA wells were analyzed for VOCs and mercury by USEPA Methods 8260 and 245.1, respectively, and samples from the lakeshore property wells were analyzed for mercury by USEPA Method 245.1.

2.1.10. P.A. Sewer and Mill Water Intake Sampling

During Phase 2 of the RI, water samples were collected from the P.A. Sewer and the Mill Water Intake to evaluate the potential for these subsurface utilities to act as residual migration pathways. Samples were collected from one upgradient and one downgradient location of the P.A. Sewer. The upgradient sample (P.A.S. Up) was

collected from a manhole situated along the southern boundary of the Plant Area adjacent to monitoring well 44. The downgradient sample (P.A.S. Down) was collected from a manhole near the corner of Willis Avenue and State Fair Boulevard. In addition, the NYSDEC collected a sample (P.A.S. Middle) from a manhole situated in the central portion of the Plant Study Area.

Two samples were collected from access points of the water intake. The Mill Water Intake is a 72 inch diameter cast iron pipe which runs from the Main Plant to Onondaga Lake in a north-south direction west of and parallel to the western boundary of the Plant Study Area. One sample (LSWI) was collected from an access point at the Mill Water Intake pipe along the lakeshore property, and the other from an access point on the Semet Residue Ponds Site (SPWI). Sample locations are presented on **Figures 4 and 5**. The NYSDEC collected a split sample from SPWI.

Samples were collected by attaching a dedicated glass sampling bottle to the end of a length of string and lowering the bottle into the manhole. Afterwards, collection water was transferred to laboratory sample containers and placed in a cooler containing ice. The samples were transferred to O'Brien & Gere Laboratories for analysis. Samples from the P.A. Sewer were analyzed for VOCs, PCBs/Pesticides (including hexachlorobenzene), and mercury by USEPA Methods 8260, 8080, and 245.1, respectively. Samples from the Mill Water Intake were analyzed for TCL/TAL parameters.

2.1.11. Onondaga Lakeshore Property Chlorinated Benzenes Recovery IRM/SPDI

This work was presented to the NYSDEC in the *Willis Avenue/Semet Lakeshore IRM Phase 1 DNAPL Recovery System Modification – 100% Design Document* (Honeywell, 2011a) with NYSDEC approval provided on May 9, 2011. Figure 2 generated for the SPDI and the Design Document from the TarGOST® probing is included in **Appendix B-1**.

2.1.12. Willis/Semet Berm Site Improvements and Berm Excavation Confirmation Sampling

Soil samples were collected from the berm along the sites as part of the Willis/Semet Berm Site Improvements in 2011 and Berm Excavation Confirmation Sampling in 2012. Surface soils (0 to 2 ft bgs) were collected in June 2011 from the topographically lower areas of the Site berm to characterize these areas for VOCs and mercury prior to initiating the landscaping and restoration work. Subsequent deeper samples were collected from 2 to 3 ft bgs for mercury in September 2011. These samples were collected from BFWS-SS-09, 10, and 12 (**Figure 5**) and submitted to Life Science Laboratories, Inc. for VOCs and mercury analyses via Method 8260 and 7471, respectively. A summary of the soil sampling was sent to the NSYDEC on July 20, 2011 (Honeywell, 2011b).

The March 2012 surface soil (0 to 2 ft bgs) and subsurface soil (2 to 2.5 ft bgs) samples were collected as part of the Berm Excavation Confirmation Sampling. These samples were submitted to Lancaster Laboratories and analyzed for Method 7471 mercury. A summary of this work was sent to the NYSDEC on April 19, 2012 (Honeywell, 2012). Surface soils were collected from PCS-03 to PCS-06, PCS-10, and PCS-19 to PCS-28, while subsurface soils were collected from PCS-01, PCS-02, and PCS-07 to PCS-09 (**Figure 5**)

2.1.13. Tributary 5A SDI

The field investigation and analytical results were submitted to the NYSDEC in the *Semet Residue Ponds Ground Water Alternate Remedial Design Supplemental Design Investigation Data Summary Report* (Honeywell, 2009c). During the field investigation, twelve samples were collected from five locations and submitted to TestAmerica Laboratories for VOCs, SVOCs, PCBs, mercury, and TOC analyses via USEPA Methods 8260, 8270, 8082, 7470, and Lloyd Kahn, respectively. The analytical data for these samples is included in **Appendix B-4**. It should be noted that some of these samples were collected below the regraded depth of Tributary 5A and were considered when performing the Tributary 5A sediment data evaluation in Section 4.

2.2. DATA ANALYSIS

2.2.1. Laboratory Methods

Phase 1, Phase 2 and Phase 3 RI analyses were performed by O'Brien & Gere Laboratories of East Syracuse, New York. Samples were analyzed in accordance with the Methods for Chemical Analysis of Water and Waste, USEPA 600/4-83-020, Test Methods for Evaluating Solid Wastes, SW-486.

Round 1 samples collected during completion of Phase 1 were analyzed for TCL/TAL parameters (excluding PCBs/Pesticides) and major cations and anions. Round 2 samples were analyzed for VOCs by USEPA Method 601/602. Round 3 samples were analyzed for VOCs, SVOCs, and inorganics using NYSDEC ASP 91-1, 91-2, and TAL inorganics.

The majority of samples collected during completion of Phase 2 of the RI were analyzed for VOCs, PCBs/Pesticides (including hexachlorobenzene), and mercury by USEPA Methods 8260, 8080, and 7471 for soils and 245.1 for waters, respectively. In addition, water samples collected from the Mill Water Intake were analyzed for TCL/TAL Parameters by NYSDEC ASP-91. Surface soil samples collected from the vicinity of the former chlorination building were analyzed for PCDD/Fs by Triangle Laboratories using USEPA Method DFLM01.1 and for TOC by AEN using the Lloyd Kahn method.

The majority of Phase 3 soil and sediment samples collected in the Plant Area, Outfalls 004 and 006, Northwest Ditch, and lakeshore property were analyzed for PCDD/Fs by AXYS Analytical Services using USEPA Method 8290 and for TOC by Severn Trent using the Lloyd Kahn Method. Subsurface and surface soil samples collected from the CHSA and PSA were analyzed for TCL/TAL parameters by ASP Methods 95-1, 95-2, 95-3, 200.7, 335.2 and 245.1 for VOCs, SVOCs, PCBs, Pesticides, metals, cyanide, and mercury, respectively.

During the Phase 4, samples of surface soils from the Willis Avenue Plant Study Area, CHSA, and PSA were analyzed for TCL/TAL parameters by Methods 95-1, 95-2, 95-3, 220.7, 335.2 and 245.1 for VOCs, SVOCs, PCBs/Pesticides, metals, cyanide, and mercury, respectively. TOC was analyzed by Method 9060 (Lloyd Kahn). Surface soils from the Plant Study Area were also analyzed for PCDD/Fs by USEPA Method 8290.

Sediments from Tributary 5A were analyzed for TCL/TAL parameters by Methods 95-1, 95-2, 95-3, 220.7, 335.2, and 245.1 for VOCs, SVOCs, PCBs/Pesticides, metals, cyanide, and mercury, respectively. Sediments were also analyzed for PCDD/Fs by USEPA Method 8290, methyl mercury by USEPA Method 1630, TOC by Method 9060 (Lloyd Kahn) and grain size by ASTM D422 and D1140. Surface water samples from Tributary 5A were analyzed for TCL/TAL parameters by Methods 95-1, 95-2, 95-3, 220.7, 335.2 and 245.1 for VOCs, SVOCs, PCBs/Pesticides, metals, cyanide, and mercury, respectively. Surface water samples were also analyzed for hardness, total suspended solids and total alkalinity by Methods 2340B, 160.2 and 310.1, respectively.

2.2.2. Data Management

Analytical results for the Phase 1 RI were manually entered into a database to allow for development of tables summarizing results and for use in the data validation and human health risk assessment.

Phase 2, Phase 3, and Phase 4 (1999 BERA sampling) results were received from the laboratory in hardcopy and electronic formats. The electronic data were used to establish a database for use in developing summary tables for the report, data validation, and human health and ecological risk assessments.

The data were migrated into the Locus Technologies EIM™ environmental data management system, which is relational database management system. This data management system was used in developing summary reports for this report and as the comprehensive database for project deliverables.

2.2.3. Data Validation and Usability Assessment

The data validation reports for Phases 1, 2, and 3 are presented in **Appendix J**. The NYSDEC data validation reports are also included in **Appendix J**.

2.2.3.1. Phase 1 Data

Analytical data from Phase 1 sampling were validated to assess their completeness and usability. As specified in the project QAPP (O'Brien & Gere, 1990c), the 1989 version of NYSDEC Contract Laboratory Program (CLP) ASP and appropriate USEPA guidance material were used as a basis for the validation. The assessment was performed in two steps. During the first step, data were compared to relevant validation materials referenced in the project QAPP (O'Brien & Gere, 1990c); during the second step, the quality of the data was evaluated with respect to the data quality objectives established prior to sampling.

Approximately 98% of the Phase 1, round 1 (March and April 1992), round 2 (September and October 1992) and round 3 (January and March 1995) analytical data were found to be useful for either qualitative or quantitative purposes following validation. This high percentage was achieved by maintaining strict adherence to the quality control procedures outlined in the project QAPP. Constant communication was maintained with the laboratory while samples were being analyzed in an effort to evaluate the laboratory's performance and any difficulties with the analysis which required correction. In most instances, corrective actions were taken by the analytical laboratory immediately after an excursion with quality assurance/quality control (QA/QC) criteria was identified. Specific examples of these actions are presented in the laboratory case narrative (**Appendix J**).

Data were rejected in several instances. Rejected data were generally confined to inorganic parameters and detection limits. These rejections were due, for the most part, to interferences resulting from analyses of the complex soil matrix (a combination of fill, ashes, and Solvay waste materials) often encountered during sampling. In other instances, detection limits were rejected for both organic and inorganic parameters due to excursions from surrogate recovery criteria. The rejected organic parameters involved samples from monitoring wells WA-7S, WA-2D, and C-15. Rejected detection limits for inorganics involved barium, cyanide, and zinc; these inorganics were not target parameters of the program and did not reflect former production processes in any of the three areas from which the samples were obtained.

In summary, although some qualifications and excursions were identified during the validation of the data, they do not affect the overall quality of the analytical program. As noted earlier, the complex matrix of many samples led to some difficulties with matrix and surrogate recoveries, as well as elevated detection limits resulting from dilutions.

2.2.3.2. Phase 2 Data

Phase 2 data were validated to assess their completeness and usability. Data completeness is defined as the percentage of sample results that have been determined to be usable during the data validation process. Overall, 100% of the pesticide/PCB, and TOC data and approximately 97.3% of the VOC data, 98.4% of the SVOC data, and 98.2% of the metal data were determined to be usable for qualitative and quantitative purposes.

The samples collected during Phase 2 were evaluated based on QA/QC criteria established by NYSDEC ASP Methods or USEPA Methods as listed in Section 1-2, by the Region II guidelines, or the USEPA National Functional data validation guidelines, and by the QAPP (O'Brien & Gere, 1990c) established for this project. Major deficiencies in the data generation process resulted in data being rejected, indicating that the data is considered unusable for either quantitative or qualitative purposes. Minor deficiencies in the data generation process resulted in some sample data being characterized as approximate. Identification of a data point as approximate indicates uncertainty in the reported concentration of the chemical, but not its assigned identity. The use of approximated analytical data for quantitative uses is consistent with the guidance presented in the USEPA Risk Assessment Guidance for Superfund (USEPA, 1992).

The following paragraphs present the adherence of the data to the precision, sensitivity, accuracy, representativeness, comparability, and completeness (PSARCC) parameters.

Precision is measured through the evaluation of field duplicate samples and MS/MSD samples. For the metal analyses, 1.8% of the data were qualified as approximate due to laboratory duplicate excursions.

Sensitivity is established by reported detection limits which represent measurable concentrations of analytes which can be determined with a designated level of confidence. Sensitivity requirements were met for the sample data in this project.

Matrix spike samples, internal standard recoveries, surrogate recoveries, laboratory control sample (LCS) recoveries, and initial and continuing calibration criteria indicate the accuracy of the data.

Comparability is not compromised provided that the analytical methods did not change over time. A major component of comparability is the use of standard reference materials for calibration and QA/QC. These standards are compared to other unknowns to verify their concentrations. Since standard analytical methods and reporting procedures were consistently used by the laboratory, the comparability criteria for the analytical data were met.

Overall, 100% of the pesticide/PCB, and TOC data and approximately 97.3% of the VOC data, 98.4% of the SVOC data, and 98.2% of the metal data were determined to be usable for qualitative and quantitative purposes.

2.2.3.3. Phase 3 Data

Phase 3 data were validated to assess their completeness and usability. Data completeness is defined as the percentage of sample results that have been determined to be usable during the data validation process. Overall, 100% of the metals and TOC data, and approximately 99.6% of the VOC data, 98.8% of the SVOC data, 99.1% of PCB/Pesticides and 99.8% of PCDD/Fs data were determined to be usable for qualitative and quantitative purposes.

The samples collected during Phase 3 were evaluated based on QA/QC criteria established by NYSDEC ASP Methods or USEPA Methods as listed in Section 1-2, by the Region II guidelines, or the USEPA National Functional data validation guidelines, and by the QAPP (O'Brien & Gere November 1990) established for this project. Major deficiencies in the data generation process resulted in data being rejected, indicating that the data were considered unusable for either quantitative or qualitative purposes. Minor deficiencies in the data generation process resulted in some sample data being characterized as approximate. Identification of a data point as approximate indicates uncertainty in the reported concentration of the chemical, but not its assigned identity. The use of approximated analytical data for quantitative uses is consistent with the guidance presented in the USEPA Risk Assessment Guidance for Superfund (USEPA, 1992).

The following paragraphs present the adherence of the data to the PSARCC parameters. Precision is measured through the evaluation of field duplicate samples and MS/MSD samples. For the analyses, none of the data were rejected due to laboratory duplicate excursions. Field duplicates were not collected as part of this project.

Sensitivity is established by reported detection limits which represent measurable concentrations of analytes which can be determined with a designated level of confidence. Sensitivity requirements were met for the sample data in this project.

Matrix spike samples, internal standard recoveries, surrogate recoveries, LCS recoveries, and initial and continuing calibration criteria indicate the accuracy of the data. For the VOC analyses, 0.4% of the data were rejected due to internal standard area excursions. For the SVOC analyses, 1.05% of the data were rejected due to internal standard area excursions, and 0.1% of the data were rejected due to initial calibration response factor excursions.

Holding times, sample preservation, blank analysis and compound identification and quantification are indicators of the representativeness of the analytical data. For the PCB/pesticide analyses, 0.9% of the data were rejected due to compound identification excursions. For the PCDD/Fs analyses, 0.2% of the data were rejected due to compound identification excursions.

Comparability is not compromised provided that the analytical methods did not change over time. A major component of comparability is the use of standard reference materials for calibration and QA/QC. These standards are compared to other unknowns to verify their concentrations. Since standard analytical methods and reporting procedures were consistently used by the laboratory, the comparability criteria for the analytical data were met.

Overall, 100% of the metals and TOC data, and approximately 99.6% of the VOC data, 98.8% of the SVOC data, 99.1% of PCB/Pesticides and 99.8% of PCDD/Fs data were determined to be usable for qualitative and quantitative purposes.

2.2.3.4. Phase 4 1999 BERA Data

The data validation report for this 1999 BERA data and all subsequent data collected during the BERA process were submitted concurrent with the BERA Report.

2.2.4. Statistical Comparison of Analytical Data to NYSDEC Split Sample Analytical Data

During completion of the RI, NYSDEC provided field oversight, including selection of sampling locations in concurrence with Honeywell and collection of environmental samples from select soil and water locations. The NYSDEC collected 19 samples during Phase 2 and 6 samples during Phase 3 of the RI. Of these samples, 20 were

split samples and 5 were unique samples with respect to either location or depth interval. A summary of the samples collected by NYSDEC and analyses performed is presented in **Appendix K**, Table K-1.

As requested by NYSDEC, a statistical comparison of analytical results for Honeywell and NYSDEC split samples was performed. The purpose of the statistical comparison was to evaluate the comparability of the two data sets, as it relates to calculation of conservative risks within the HHRA. To accomplish this objective, three statistical comparisons were performed:

Comparison 1: Calculation of the relative percent difference (RPD) between detected analytes for each sample where a corresponding split sample was collected (soils and water data).

Comparison 2: Calculation of the minimum, median, and maximum concentration and RPD for each detected analyte (soils data only due to small number of NYSDEC split samples for waters).

Comparison 3: Calculation of the minimum, median, and maximum concentration and RPD for target analytes (soils data only due to small number of NYSDEC split samples for waters).

Results of these statistical comparisons are presented in **Appendix K**, Tables K-2, K-3, and K-4, respectively. In each of the three tables, each analyte was qualified with either an "M" meaning the Honeywell concentrations were higher and therefore more conservative when used to calculate risk or an "L" meaning the NYSDEC concentrations were higher and therefore Honeywell results were less conservative.

- Results of Comparison 1 indicate that 69% (45 of 88 observations) of the analytes had a RPD > 30% and 51% of the analytes were qualified "M".
- Results of Comparison 2 indicate that 92% of the analytes had a median RPD > 30% and 52% (13 of the 25) detected analytes were qualified "M".
- Results of Comparison 3 indicate that 100% (7 of 7 of target analytes had an RPD > 30% and 50% (5 of 10) of the target analytes were qualified "M".

Based on the results of the three statistical comparisons, it can be concluded that:

- The two data sets exhibit a pattern of random variability (*i.e.*, no specific trends were identified).
- Honeywell sample results were detected in a greater number of samples and, in general, have higher concentrations, especially for target analytes.
- Use of Honeywell sample results only in the risk assessments will provide conservative estimates of risk.
- At present, the HHRA and BERA have been formally approved by the NYSDEC.

2.3. PATTERN RECOGNITION ANALYSIS OF PCDD/FS ANALYTICAL DATA

2.3.1. Introduction

A pattern recognition analysis of detected PCDD/Fs in soils and sediments at and in the vicinity of the Site was performed. The focus of this analysis was to evaluate the observed patterns of PCDD/F congeners in soil and sediment samples collected from the Plant Study Area, CHSA, and PSA, assess similarities and differences in congener patterns in samples from different areas, and compare the congener patterns with the congener patterns of reference samples. Based on the observed congener patterns, Site history, and spatial distribution of detected PCDD/Fs, the potential sources and possible migration pathways for PCDD/Fs were evaluated.

2.3.2. Methods

A summary of the methods used to complete the pattern recognition analysis are presented below.

1. Site history and production processes were reviewed to assess the potential historical sources of PCDD/Fs at the Site.
2. A literature review was performed to evaluate potential sources of PCDD/Fs at the Site. Technical papers and other literature pertaining to PCDD/Fs congener patterns in soils and sediment impacted by chloralkali processes and anthropogenic sources was compiled, reviewed, and summarized. Anthropogenic sources

evaluated included combustion, sewage, combined sewer overflows (CSOs), urban run-off, and fossil fuel incineration. A complete list of literature reviewed during this evaluation is presented in **Appendix N**.

3. Pattern recognition/similarity evaluation, including:

- Principal Components Analysis (PCA) was used to examine patterns or "clusters" in the Site soil and sediment data in comparison with the observed clustering of anthropogenic source data;
- Box-plots were used to graphically compare the relative congener pattern in different areas and assess the similarities/differences with the patterns observed from reference sources;
- A *relative similarity* index was developed and applied as a quantitative comparison of site samples with each other and with reference sources.

2.3.3. Reference Data

A sub-set of the literature data representing the available data associated with the most likely potential source contributors to the detected chlorinated dioxin and furan residues, and for which the concentrations of 2,3,7,8-substituted congeners was available was selected as "reference" samples for the pattern recognition analysis. The following samples were selected as reference samples for the pattern recognition analysis. A more detailed summary of the reference samples utilized in the analysis is presented on Table N-1. A complete listing of the literature sources utilized for this analysis is presented in **Appendix N**.

Chloralkali sludge (graphite electrode sludge) -	5 samples
Chloralkali soils (mixed soil/ graphite sludge) -	4 samples
CSO/Sewage/Urban runoff	
CSO -	4 samples
Sewage sludge -	3 samples
Urban run-off -	7 samples
Soot from Fossil Fuel Combustion	
Coal Oven -	6 samples
Oil Oven -	7 samples
Oil Central Heating -	21 samples
Wood Oven -	9 samples
Wood/Coal Oven -	2 samples
Wood Central Heating -	4 samples
Wood Fireplace -	1 sample

2.3.4. Results

Results of the pattern recognition are summarized below. PCA score plots, box plots and similarity index graphs are included in **Appendix N**.

PCA

- Most soils from the Plant Area are grouped with "chloralkali process" reference samples.
- Most soils from the northwest ditch and Outfalls 004 and 006 cluster fairly closely with the Plant Area soils and "chloralkali process" reference samples.
- Some soils from the Plant Area tend to cluster with the "combustion" reference samples.

Box Plots

- Tetrachlorinated dibenzofuran (TCDF), pentachlorinated dibenzofurans (PeCDFs), and heptachlorinated dibenzofurans (HpCDFs) are the predominant congeners in most soils from the Plant Area, which is characteristic of chloralkali process reference samples.

Similarity Indices

- The percent similarity between the Plant Area soils and chloralkali process reference samples is 95%.
- The percent similarity between Plant Area soils and combustion reference samples is 50%.

2.3.5. Conclusions

It can be concluded that the chloralkali process and combustion of chlorobenzenes are the primary source for PCDD/Fs in most Plant Area soils, Northwest Ditch, and Outfalls 004 and 006. It can also be concluded that fossil fuel soot is a source of PCDD/Fs in some Plant Area soils.

Based on qualitative evaluation of the lakeshore property surface soil samples and the background sample, octachlorinated dibenzo-p-dioxin (OCDD) is the predominant congener in these samples. This congener pattern most closely resembles that of urban runoff/CSO reference samples.

2.4. BASELINE RISK ASSESSMENT

2.4.1. Human Health Risk Assessment

The HHRA was performed as part of the RI performed by O'Brien & Gere Engineers, Inc. (O'Brien & Gere) on behalf of Honeywell International Inc. (Honeywell) pursuant to Consent Order R7-0201-87-08 (Order) between AlliedSignal and the NYSDEC dated August 12, 1990. An HHRA Report was submitted to NYSDEC in June 1999 (**Appendix L** of the RI/FS report; O'Brien & Gere, 1999b). The NYSDEC issued comments on that report on January 25, 2002 and the HHRA report was resubmitted in June 2002 (O'Brien & Gere, 2002f). Comments on the 2002 report were issued by the NYSDEC on July 19, 2004. The HHRA report was resubmitted in October 2004 (O'Brien & Gere, 2004a) and a summary of the revisions was provided to NYSDEC in a letter from Honeywell dated December 2, 2004. The NYSDEC provided comments on the October 2004 HHRA in a letter to Honeywell dated March 13, 2007. This document presents the revised HHRA report that addresses the March 13, 2007 comments of NYSDEC, as well as subsequent comments on RAGS D Tables submitted as interim deliverables. A final HHRA report was submitted to the NYSDEC in July 2010 (O'Brien & Gere, 2010), which was approved by the NYSDEC on August 10, 2010.

The HHRA focused on chemical substances detected in soil, sediment and groundwater at and down gradient of the Site. The assessment does not address Site-related chemical substances that may have migrated to Onondaga Lake since Onondaga Lake was investigated and evaluated under a separate Consent Order.

2.4.1.1. Risk Assessment Guidance

The following USEPA documents were used as principal guidance in the preparation of the HHRA:

- Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A) Interim Final (USEPA, 1989b)
- Guidance for Risk Characterization (USEPA, 1995)
- Exposure Factors Handbook (USEPA, 1997a)

A chemical substance may pose a risk to human health only if receptor populations have the potential to be exposed to the chemical substance in sufficient quantities to affect the health of exposed individuals. As such, a Site-specific health risk assessment involves the following:

- Identification of Site-related chemical substances,
- Identification of potential mechanisms by which human receptors may be exposed,

- Estimation of the concentrations of the chemicals that may be present at locations where receptors may contact them (exposure point concentrations), and
- Evaluation of potential adverse effects that may result from the estimated dose of the chemicals if absorbed by receptors.

2.4.1.2. Approach

Consistent with the cited guidance, the HHRA was conducted in the following phases:

- *Description of Site Areas*. The first step in the assessment was to identify and describe the physical locations and general characteristics of the Site and related AOS.
- *Conceptual Site Model*. The goal of the conceptual Site model was to characterize the Site with respect to its physical characteristics as well as those of the human populations at or near the Site. The output of this step was a qualitative evaluation of the Site and surrounding populations with respect to those characteristics that potentially influence exposure.
- *Data Evaluation*. The objective of the data evaluation step was to organize the data into a form appropriate for use in the assessment, to evaluate the quality of the data for HHRA purposes, and identify chemicals of potential concern (COPCs).
- *Exposure Assessment.* In the exposure assessment, the pathways by which receptors may be exposed to On-Site chemical substances were identified and exposure point concentrations of COPCs were estimated for each complete exposure pathway.
- *Toxicity Assessment.* In the toxicity assessment, available toxicological data for Site-related compounds were gathered and reviewed. Dose-response relationships between the extent of potential exposure and the occurrence/severity of potential adverse health effects were evaluated.
- *Risk Characterization.* In the risk characterization step, the toxicity and exposure assessments were integrated into quantitative estimates of potential human health risk.
- *Uncertainty Analysis*. In this section, the major uncertainties in the calculated risk estimates were discussed.

The final HHRA was submitted to the NYSDEC on August 6, 2010 and approved by the NYSDEC on August 10, 2010. Results of the HHRA are presented in Section 7. The complete HHRA was submitted under a separate cover and is included as **Appendix L** in electronic format (on CD).

2.4.2. Baseline Ecological Risk Assessment

The objectives of the BERA (O'Brien & Gere, 2013) were to document whether actual or potential ecological risks exist at the Site, identify which contaminants present on-site posed an ecological risk, and generate data to be used in evaluating clean-up options. The BERA focused on chemical substances detected in soil and groundwater in the Willis Ave Plant Study Area and additional AOS. The assessment did not evaluate Site-related chemical substances which may have migrated to Onondaga Lake, since Onondaga Lake is being investigated and evaluated under a separate Consent Order.

The BERA was performed in accordance with Ecological Risk Assessment Guidance for Superfund (ERAGS; USEPA, 1997b) and the guidance co-developed by the NYSDEC and USEPA for Onondaga Lake Sites (NYSDEC, 1998a). Additionally, the BERA was performed in accordance with the NYSDEC's *Fish and Wildlife Impact Analysis* (FWIA; NYSDEC, 1994) and the principles presented in USEPA (1998).

Various data and information collection efforts have been performed in support of the BERA. Initially, ecological information concerning the Site was presented in *Habitat Based Assessments* prepared for the Site (O'Brien & Gere, 1993a) and Semet Residue Ponds Site (O'Brien & Gere 1991) located adjacent to and west of the Willis Avenue facility. Subsequently, the *Screening-Level Ecological Assessment* (SLEA) was prepared for the Site (O'Brien & Gere, 1998b). This report was revised to incorporate NYSDEC comments and re-submitted in July of 1999 (O'Brien & Gere, 1999c). The revised SLEA was not approved by the NYSDEC; however, it was agreed that

associated comments would be incorporated into the BERA report. A summary of the SLEA's findings is presented in Section 3 of the BERA.

Based on the results of the SLEA, it was determined that additional investigation into potential impacts to ecological receptors from Site-related constituents identified in the surface soil, surface water and sediment of the Site was warranted. Therefore, a *Baseline Ecological Risk Assessment Work Plan* (O'Brien & Gere, 1999a) was prepared and submitted for NYSDEC's review in August 1999. After telephone conversations and letter correspondences between the project stakeholders (*i.e.,* representatives of Honeywell, O'Brien & Gere, and the NYSDEC), it was agreed that a field effort would be performed in support of the BERA work plan. In the fall (October and November) of 1999, biotic (soil invertebrates and small mammals) and abiotic (surface soil, surface water and sediment) media samples were collected from the Site and three reference areas. A summary of the data and information obtained as part of this field effort was presented to the NYSDEC in March 2000 (O'Brien & Gere, 2000b).

Following the March 1, 2000 meeting held in Albany, New York between the project stakeholders, it was agreed that further revisions to the SLEA and BERA Work Plan were not necessary and significant issues related to these documents could be addressed in the BERA report. Further, it was decided that additional biological data were required from the Site and reference areas to support the study design. Therefore, the *Supplemental Biota Sampling and Analysis Work Plan* (O'Brien & Gere, 2001a; SBSAWP) was prepared and submitted to the NYSDEC in June of 2001. The scope of the field effort, as presented in the SBSAWP, was agreed upon following discussions held during a March 1, 2000 meeting, telephone conversations, and letter correspondences between the stakeholders.

The supplemental field effort was conducted by O'Brien & Gere in the fall of 2001 and spring of 2002 to collect fish, muskrat, and rabbit tissue from the Site and reference areas. Most of the sampling was performed with oversight from the NYSDEC subcontractor TAMS. Additionally, the NYSDEC was informed of the sampling results and provided recommendations for the laboratory analytical parameters for the collected tissue samples.

The draft BERA report was submitted to the NYSDEC on January 30, 2003 (O'Brien & Gere, 2003). The NYSDEC provided comments on the draft BERA on May 7, 2004 (NYSDEC, 2004). Responses to those comments were incorporated into a Revised BERA report submitted to the NYSDEC on November 4, 2004 (O'Brien & Gere, 2004b). The NYSDEC issued comments on the Revised BERA report to Honeywell on May 23, 2011 (NYSDEC, 2011). Based on those comments and subsequent conference calls, the Revised BERA Interim Deliverable was prepared and submitted to NYSDEC on October 17, 2011. The NYSDEC provided comments on the Interim Deliverable on November 15, 2011. Responses to these comments, as well as Site-related changes and modifications resulting from recent remedial activities, have been included in the BERA. Results of the BERA are presented in Section 8.

2.5. CULTURAL RESOURCE SURVEY

A Stage 1A cultural resources survey (CRS) was performed for the Site as part of a larger Stage 1A CRS that will be performed for all of the Honeywell Sites in the area of Onondaga Lake. This survey was performed in 2003 for Honeywell sites in the area of Onondaga Lake (Pratt & Pratt, 2003). Pratt & Pratt (2003) make no reference to cultural resources at the Site. Prior to future ground disturbing activities, a reconnaissance will be performed to identify potential cultural resources on-site. The scope of work for a revised Phase 1B CRS did not include the Willis Avenue Chlorobenzene Site (Public Archaeology Facility, 2009).

3. STUDY AREA PHYSICAL CHARACTERISTICS

3.1. CLIMATE

Onondaga County has a humid, continental climate. Annual precipitation averages about 39 inches. The mean annual temperature is 48°F, with a mean July temperature of 70 °F and a mean January temperature of 23 °F. Record temperatures range from 98°F in June to -26°F in January and February. The frost-free season lasts from 150 to 180 days per year. The National Weather Service Station at Hancock International Airport collects weather data for the area.

3.2. GEOLOGY

3.2.1. Regional Geology

The Willis Avenue Plant Study Area and additional AOS are located at the base of the Onondaga Escarpment which marks the boundary between the Ontario Lowlands and Allegheny Plateau physiographic provinces. Ground elevations range from 363 ft at the surface of Onondaga Lake to an elevation of over 1,000 ft near the top of the cuesta forming the escarpment.

The lowlands are characterized by low relief and unconsolidated glacial-lacustrine and glacial-fluvial sediments deposited in and near the proglacial lake formed during glacial retreat. The unconsolidated deposits vary in thickness from minimal to hundreds of feet. The Silurian age Vernon Shale Formation underlies the unconsolidated deposits near the site.

The uplands feature higher relief and unconsolidated deposits of predominately glacial drift or valley train deposits. The unconsolidated deposits vary in thickness. Bedrock immediately south of the Site changes stratigraphically from the Silurian Vernon Formation at the base of the cuesta through the Syracuse and Helderberg Formations to the Devonian Onondaga Formation found at the top of the cuesta. Each of these formations has a gentle southward dip of 1 to 2 degrees.

3.2.2. Site Geology

The elevation of the Site rises from 370 ft near Onondaga Lake to 410 ft at the CHSA. The former Willis Avenue Plant Study Area is bounded on the west by the Semet Ponds Site and by Willis Avenue to the east. Onondaga Lake is located to the north. The Plant Study Area is separated from the former PSA to the South by Tributary 5A and the CSX railroad tracks. Two geologic cross sections were constructed across the site at the locations shown on **Figure 9**. These west-east and north-south cross sections are presented as **Figures 10 and 11**, respectively. In addition, a cross section for the Plant Area and lakeshore property showing generalized geologic strata and depths of subsurface utilities is presented on **Figure 12**. Overburden in the Plant Area consists of unconsolidated deposits of both natural and artificial origin that range in total thickness from 40 ft to almost 110 ft. Unconsolidated geologic units encountered included the till, basal sand and gravel, fine sand and silt, silt and clay, marl, and fill. The PSA has about 40 ft of till, gravel, and fill overlying the Silurian Vernon Formation, which comprises the bedrock. At the CHSA, the artificial fill and native unconsolidated deposits are approximately 20 to 25 ft thick and include three geologic units (till, lacustrine silts and clays, and fill).

The Plant Area and PSA are underlain by the Silurian Age Vernon Shale. According to earlier studies (Blasland and Bouck, 1987a; 1987b, 1989a; 1989b), this formation also underlies the CHSA. As shown in the **Figure 13**, the elevation of the bedrock surface decreases toward Onondaga Lake, and a bedrock low appears to be present in the bedrock from the lake toward the center of the Plant Study Area.

A well compacted red till composed of a clay and silt matrix with some sand and gravel overlies the bedrock and was encountered in the deep borings completed during the RI except for WA-1D, WA-2D, and WA-3D along Onondaga Lake. Till is also present along the Onondaga Lake shore to the west of the Site (**Figure 10**). The till unit varies in thickness from over 40 ft in the PSA to 1 ft in the CHSA (Blasland and Bouck, 1987a; 1987b, 1989a; 1989b). As shown on **Figures 10 and 11**, the elevation of the top of the till surface varies over the Willis Avenue study area. The elevation changes most likely correlate with the elevations of the bedrock surface.

3.2.2.1. Willis Avenue Plant Study Area

Overlying the till/bedrock in the Site area is a sand and gravel unit (**Figures 10 and 11**). In some areas, this unit is comprised mostly of sand and gravel grading upward to a medium grained sand. In other areas, only a coarse to medium grained sand unit is present. A distinctive basal sand and gravel unit was observed in the boring for WA-1D, where the sand and gravel unit was greater than 15 feet thick immediately on top of bedrock (**Figure 14**). Approximately 4 inches of coarse-grained sand with a little gravel was observed immediately above the till at WA-4D. About 6 inches of a sand and gravel mixed with till was recovered above the till in the boring for WA-7D. One to three feet of basal sand and gravel was reported in the logs (Geraghty and Miller, 1982) of other wells through the center of the Plant Study Area. Wells on the southern and eastern borders of the area either did not encounter the basal sand and gravel unit or it was found as a thin veneer.

In the Plant Study Area, deposits of glaciolacustrine silt and fine grained sand overlie the bedrock and till or the basal sand and gravel unit. There are lenses within the silt and fine sand deposits that contain higher percentages of either sand or silt, but the layers are not distinctive and cannot be correlated. The thickness of the silt and fine grained sand unit varies from close to 30 ft along the lakeshore to less than 5 ft along the southern margin of the Plant Study Area. The lakeward thickening of the glaciolacustrine silt and fine grained sand would be the expected depositional pattern.

In the Plant Study Area, the glaciolacustrine silt and fine grained sand grades upward to a silt and clay unit. The thickness of this silt and clay unit varies from over 20 ft along the lakeshore to 5 to 10 ft on the majority of the Plant Study Area. This unit has been documented across the Site as well as across the Semet Ponds Site to the west. The elevations of the top of this silt and clay unit are depicted on **Figure 15**.

There is a deposit of freshwater marl at the Site above the glaciolacustrine silt and clay. The marl is thickest along the lakeshore (up to 25 ft) and was not present in the boring for WA-6D or in any of the PSA or CHSA borings. This suggests that the shallow lakeshore did not extend to either of these areas during deposition of the marl. The marl is characterized by plentiful shells and carbonate deposition. The unit also grades from sand near the top of the unit to silt and clay at its intersection with the glaciolacustrine silt and clay unit.

Peat was found above the marl in the borings completed within the boundary of the Plant Study Area. The peat is a thin (1 to 2 ft) unit of tightly compacted plant remains that was formed by natural organic plant deposits along the more extensive earlier edge of the present day Onondaga Lake. No peat was found in the PSA or CHSA, which are further from the historic lake edge. Likewise, no peat was found in the borings for the well nests along the present lakeshore as this probably was still covered by lake waters during the deposition of the peat.

In the Plant Study Area, there is fill and Solvay waste above the natural sediments. The combination of fill and Solvay waste varies in thickness from 5 ft to almost 40 ft and also varies in composition. The fill is very heterogeneous in both composition and grain size. The fill consists of broken brick, cinders, gravel, crushed limestone, sand, and ash. In some locations, the fill and Solvay waste are interlayered, while in other locations, a discrete layer of Solvay waste was observed beneath the fill.

3.2.2.2. Petroleum Storage Area

There is a thin layer of fill that is approximately 10 ft thick overlying the bedrock or glacial till in the PSA. It consists of fly ash, sand and gravel, and re-worked red till. The Willis Avenue area deposits of glaciolacustrine sand and gravel, fine grained sand and silt, and silt and clay as well as the freshwater marl units do not extend to the PSA. These units pinch out along the southern edge of the Plant Area (**Figure 11**).

3.2.2.3. Chlorobenzene Hot Spot Area

The overburden geology in the CHSA consists of fill, lacustrine sediments, and till underlain by bedrock. The lacustrine sediments are variable in texture and include sand, silty sand, and clay. The lacustrine sediments are not continuous and, where the sediments are absent, fill directly overlies the till. Fill overlies the lacustrine sediments in the CHSA and is more homogeneous than other areas. The fill consists of sand, gravel, cinders, crushed brick, and other anthropomorphic debris. This fill in part represents material used to fill the Erie Canal,

which followed a course somewhat parallel to that of the chlorobenzene pipeline (**Figure 2**). The fill and underlying native lacustrine sediments have an average thickness of 20 to 25 ft above till and bedrock.

3.3. HYDROGEOLOGY

3.3.1. Regional Hydrogeology

Regionally, surface and groundwater flow is from the south at the Onondaga Escarpment to the north toward Onondaga Lake (Kantrowitz, 1970; Winkley, 1989). Onondaga Lake acts as an area of regional groundwater discharge (Kantrowitz, 1970). Well nests WA-1, WA-2, WA-3, WA-7, and WA-8 have consistently shown upward hydraulic gradients (**Table 2**). In fact, the groundwater elevations in WA-1D, WA-2D, and WA-3D are above the ground surface. The water elevations of all the deep wells on the Site are also at least 10 feet higher than the surface water elevation of Onondaga Lake. These data demonstrate that groundwater flow in the unconsolidated deposits is upward to Onondaga Lake. Groundwater found in the overburden enters the site from several sources. These sources are upgradient groundwater flow, local recharge from precipitation and upward discharge from the bedrock.

The available literature on the area indicates that groundwater flow from both the unconsolidated deposits and the bedrock flow are upward toward Onondaga Lake. Winkley states on page 82 "Discharge from a regional groundwater system underlying the Appalachian Uplands is probably focused along the southern edge of the lake plain, immediately adjacent to the border scarp zone .... Evidence includes marked increases in the chloride and dissolved solids content of baseflow within this narrow area ...., the presence of flowing artesian wells ...., and numerous fens." (**Appendix M**).

Kantrowitz indicated that an upward hydraulic gradient exists from the bedrock to the unconsolidated deposits in the vicinity of the site. The Kantrowitz report documented three bedrock wells on the main portion of the Honeywell facility (**Appendix M**). One of these wells (303-613-1) reportedly encountered bedrock at a depth of 30 ft below the surface “and had a groundwater level at a depth of 10 ft." These data indicate that the hydraulic gradient is upward between the bedrock and the unconsolidated deposits. While the other two wells had groundwater levels below the top of bedrock, the reported groundwater elevation for well 303-612-1 was only 5 ft below the top of bedrock and was above the water level of Onondaga Lake.

Onondaga Lake is a significant topographic low and discharge point in the area. Winkley's Plate 5 shows that shallow groundwater around Onondaga Lake discharges to the lake. A similar groundwater flow pattern would be expected for the bedrock.

Some wells and springs in this area produce naturally salty water (Kantrowitz, 1970). The Syracuse and Salina Formation salt beds are the origin of the naturally occurring salty water. The Kantrowitz report states that "fresh water moves down and dissolves the rock salt from the middle shale unit and then discharges along a relatively narrow area near the northern edge of the Appalachian Upland." The Plant Study Area is located at the northern edge of the Appalachian Upland. High chloride and sodium concentrations are found in the deep wells installed as part of this RI. Some of the chloride and sodium found in the near-bedrock wells is derived from the upward groundwater discharge from the underlying bedrock.

Based on the above information, contaminants associated with the Plant Study Area would not be expected to extend into the bedrock. However, based on the detection of residuals in groundwater samples collected from monitoring wells WA-1D and WA-2D, it is possible that DNAPLs have migrated against the hydraulic gradient (downward) into bedrock. However, the extent to which this may have occurred is not known.

3.3.2. Site Hydrogeology

The unconsolidated hydrogeologic units in the Willis Avenue Plant Study Area and AOS include fill (present throughout study area but differing in composition between PSA, CHSA, and the Plant Study Area), lacustrine sediments (present in the CHSA), Solvay waste (present only in the Plant Area), the intermediate marl unit, a low permeability silt and clay unit, and the deep unit consisting of the fine grained sand and silt and basal sand and gravel layers. The intermediate and deep units are found only on the Plant Study Area. The lack of the

intermediate and deep units leaves only the shallow fill unit as the unconsolidated hydrogeologic unit in the PSA and fill and lacustrine sediments as the unconsolidated hydrogeologic units in the CHSA.

Groundwater and surface water elevations in Phase 1 wells and select wells from the Semet Ponds RI (**Table 3**), wells installed during studies prior to the RI (**Table 4**), and several benchmarks in Tributary 5A and Onondaga Lake (**Table 5**) were measured several times through the spring, summer, and fall of 1992 and fall of 1997. Groundwater elevations fluctuated during this period of time, but the general groundwater flow patterns did not appear to change (**Figures 16 through 26**). The groundwater elevation fluctuations appear to be related to seasonal variations in recharge. Upgradient groundwater elevations in artificial fill tend to show greater fluctuation than downgradient wells installed in fine grained units. Throughout the seasonal variations, the deep groundwater elevations along the Onondaga Lake shore showed an upward hydraulic gradient to the shallow groundwater unit and Onondaga Lake.

3.3.2.1. Shallow Flow

The depth to water in the shallow wells varied from about 2 ft to over 20 ft depending upon location. Water was generally found at depths less than 5 ft from the surface in the PSA and the CHSA. Shallow groundwater flow (**Figures 16 through 20**) in the Plant Study Area is generally lakeward with some component discharging to Tributary 5A and ditches.

In the Plant Study Area, there is some shallow groundwater flow eastward from the Semet Ponds Site onto the Site. The majority of groundwater entering the Site from the Semet Ponds Site and via infiltration flows northward toward Onondaga Lake. There is a small component of flow southward towards Tributary 5A. The differing nature of subsurface materials and the relative elevations of the groundwater and surface water indicate that, with regards to the shallow-most subsurface, Tributary 5A acts as a hydrogeologic divide between the Plant Study Area and the region to the south, which includes the PSA and CHSA.

In the PSA, groundwater flow is more localized and is controlled by the presence of surface water drainage ditches bordering the area to the north, south, and east. These ditches cause a somewhat radial groundwater flow pattern in the PSA (**Figures 16, 17 and 20**). Water elevations taken north of the area in Tributary 5A indicate that the tributary is probably also acting as an area of discharge for the shallow groundwater from the PSA. Given the upgradient location of the PSA, it is likely that some of the overburden groundwater migrates downward to the bedrock where it would be expected to flow to the north in the bedrock toward Onondaga Lake.

Shallow groundwater flow in the CHSA is generally northward. In general, the groundwater flowing to the north from the CHSA is expected to have little interaction with the PSA groundwater because of the radial groundwater flow pattern in the PSA. Some interaction of the groundwater may occur in the western portion of the PSA where the radial flow appears to be more limited. In the area of the ditches, the groundwater from both the PSA and the CHSA likely converge and discharge to the ditch. Given the upgradient location of the CHSA, it is possible that some of the overburden groundwater migrates vertically downward to the bedrock where it would be expected to flow to the north in the bedrock toward Onondaga Lake.

3.3.2.2. Intermediate/Deep Flow

For the Site, the intermediate (**Figures 21, 22, and 23**) and deep groundwater (**Figures 24, 25, and 26**) flows north towards the lake. The intermediate and deep hydrogeologic units are not present beneath the PSA or CHSA. Additional information regarding the intermediate and deep units is presented in the area specific discussion below.

3.3.2.3. Vertical Flow

The north-south and east-west geologic cross-sections were modified to present the vertical hydraulic potential and groundwater flow pattern at the Site (**Figures 27a and b**). Across the majority of the Plant Study Area, CHSA, and PSA, the vertical hydraulic potential is downward from the fill to the native sediments. This pattern is expected since these areas are generally in groundwater recharge zones. An upward hydraulic potential within

the unconsolidated deposits does occur in the vicinity of Tributary 5A and along the Onondaga Lake shoreline. In the Plant Study Area, there is an upward vertical hydraulic head between the intermediate and deep monitoring wells and Onondaga Lake. This upward potential is especially visible in the deep monitoring wells along the lakeshore where the groundwater level in deep monitoring wells is above the ground surface. There is an upward hydraulic gradient between the deep wells and the intermediate wells. There is also an upward hydraulic gradient between the deep wells and the shallow wells. There is no consistent pattern in vertical gradients between the shallow wells and intermediate wells. Regional studies (Kantrowitz, 1970 and Winkley, 1989) report an upward hydraulic potential between bedrock and the unconsolidated deposits due to the fact that Onondaga Lake is an area of regional groundwater discharge.

The following sections summarize the groundwater flow and hydraulic properties of the unconsolidated materials present in the CHSA, PSA, and Plant Study Area. Estimates of hydraulic properties are derived from hydraulic conductivity tests (**Table 2**) and recent pump tests and specific capacity tests (O'Brien & Gere, 2002a) that were completed in the vicinity of the Plant Area.

3.3.2.4. Chlorobenzene Hot-Spots Area

In the CHSA, two geologic units (fill and lacustrine sediments) were encountered in the unconsolidated sediments overlying till. The hydraulic conductivity of the lacustrine sediments ranges from 3.5 x 10^{-6} cm/sec to 1.3 x 10^{-3} cm/sec (0.07 gpd/ft^2 to 28 gpd/ft^2). The hydraulic conductivity of the fill ranges from 5.3 x 10^{-5} cm/sec to 2.8 x 10^{-2} cm/sec (1.1 gpd/ft^2 to 593 gpd/ft^2) (**Table 2**). However, groundwater flow considered these as one hydrogeologic unit due to the limited saturated thickness of the fill and lacustrine sediments.

Groundwater elevation contour maps that include the CHSA were constructed from data collected on May 2, 1992 and September 22, 1992. These maps are included as **Figures 16 and 17**, respectively. Groundwater flow in the CHSA is generally northward under a hydraulic gradient ranging from 0.025 ft/ft to 0.036 ft/ft. MW-111 showed a consistently high hydraulic head that was also noted in a previous report (Blasland and Bouck, 1989b). C-3 also showed a high hydraulic head. Although the cause of these elevated groundwater elevations is not known, the former Erie Canal was located in the immediate vicinity of these wells. Activities associated with the construction or filling of the canal may have created heterogeneous hydrogeologic conditions in the vicinity of the canal. These conditions could be the cause of the elevated groundwater elevations at MW-111 and C-3.

3.3.2.5. Petroleum Storage Area

In the PSA, there is one hydrogeologic unit in the unconsolidated sediments. The unit consists of fill comprised of clay, silt, gravel, cinders and brick. Hydraulic conductivities of wells PS-1, PS-2, and PS-3 that are screened in this unit are 3.8 x 10^{-3} cm/sec (81.05 gpd/ft^2), 5.3 x 10^{-5} cm/sec (1.12 gpd/ft^2) and 3.3 x 10^{-3} cm/sec (70.57 gpd/ft^2), respectively. Monitoring well PS-3D is screened in the till below the fill and has a hydraulic conductivity of 2 x 10^{-5} cm/sec (0.42 gpd/ft^2) (**Table 2**).

Three groundwater elevation contour maps (**Figures 16, 17, and 20**) were developed from data collected on May 2-3, 1992 and September 22-23, 1992 and September 18, 1997 in the PSA. Groundwater elevation data indicate some local mounding, which is likely related to the local topography. Groundwater flow is generally toward the railroad tracks and ditches which bound the area to the north, south, and east. The hydraulic gradient ranges from approximately 0.035 ft/ft to 0.075 ft/ft. Flow may be partially directed toward PS-3S because of the presence of a discontinuous unit of gravel and sand that was encountered at a depth of 6 to 8 ft bgs and was reported in several of the wells installed by Groundwater Technology. The sand and gravel unit was also encountered at 2 to 4 ft bgs in PS-B3 and 6 to 8 ft bgs in PS-3D. The gravel was not found during sampling for borings PSA-1, PSA-2, and PSA-4. Water elevations taken north of the area in Tributary 5A, particularly the elevation of Benchmark J, indicate that the tributary is probably also acting as an area of discharge for the overburden groundwater from the PSA.

3.3.2.6. Plant Study Area

In the Plant Study Area, where there is a thick layer of fill and Solvay waste, groundwater was encountered at depths of 15 to 20 ft. The depth to water was approximately 5 ft in the shallow wells along the lakeshore. There

are five hydrogeologic units in the unconsolidated sediments found in the Plant Study Area. The shallow monitoring wells are screened in the uppermost units, which consist of varying amounts of fill and Solvay waste. The shallow monitoring wells document significant heterogeneity in both the horizontal and vertical hydraulic conductivities with measured horizontal conductivity ranging from 2.3 x 10^{-2} cm/sec (579 gpd/ft^2) to 8.6 x 10^{-5} cm/sec (1.8 gpd/ft^2) (**Table 2**). The recent hydraulic conductivity testing performed along the lakeshore identified a range of hydraulic conductivity values for the shallow sand unit of 3.9 x 10^{-2} cm/sec (820 gpd/ft^2) to 2.1 x 10^{-3} cm/sec (45 gpd/ft^2) (O'Brien & Gere, 2002a).

The intermediate unit extends through the marl. The horizontal conductivities of this unit are generally less than the fill unit and range from 3.9 x 10^{-4} cm/sec (8.3 gpd/ft^2) to 2.8 x 10^{-5} cm/sec (0.59 gpd/ft^2) (**Table 2**). The recent hydraulic conductivity testing performed along the lakeshore identified a range of hydraulic conductivity values for the intermediate unit of 7.2 x 10^{-5} cm/sec (1.5 god/ft^2) to 5.0 x 10^{-5} cm/sec (1.1 gpd/ft^2) (O'Brien & Gere, 2002a).

The intermediate unit is separated from the deep unit throughout the Plant Study Area by a low permeability silt and clay layer (**Figures 10 and 11**). The silt and clay layer pinches out on top of till/bedrock along the southern portion of the Plant Area (**Figure 11**). This unit acts as a confining layer for the deep hydrogeologic unit.

The deep hydrogeologic unit consists of the silt and fine grained sand layer and the basal sand and gravel layer. The silt and fine grained sand unit is found on the majority of the Plant Study Area. The basal sand and gravel is found along the lakeshore and near the center of the Plant Area. The texture and thickness of each unit are variable. Both layers pinch out on top of the elevated till/bedrock surface on the southern edge of the Plant Study Area. The recent hydraulic testing performed along the lakeshore identified a range of hydraulic conductivity values for the silt and fine grained sand unit of 1.1 x 10^{-4} cm/sec (2.3 gpd/ft^2) to 2.0 x 10^{-3} cm/sec (42.4 gpd/ft^2) (O'Brien & Gere, 2002a). In addition, a range of hydraulic conductivity values for the basal sand and gravel unit downgradient of the Semet Ponds Site were identified as 4.8 x 10^{-2} cm/sec (1018.1 gpd/ft^2) to 3.8 x 10^{-1} cm/sec (8059.8 gpd/ft^2) (O'Brien & Gere, 2002a). The thickness and grain size of these units varies significantly throughout the area and these ranges of values are likely a reflection of that variability. Horizontal hydraulic conductivity measured in deep wells on the Plant Area ranged from 6.02 x 10^{-3} cm/sec (127.7 gpd/ft^2) along the lakeshore to 3.57 x 10^{-6} cm/sec (0.08 gpd/ft^2) at well WA-4D (**Table 2**). The lower hydraulic conductivity observed in these on-site wells may reflect the localized nature of *in-situ* hydraulic conductivity tests and the finer texture of the deep unit in the southern portion of the Plant Study Area.

Vertical hydraulic conductivities were tested from four Shelby tubes collected from the borings for WA-1D (45 ft to 45.3 ft), WA-2D (51.4 ft to 51.7 ft), WA-4D (68 ft to 68.3 ft) and WA-7D (44.4 ft to 44.7 ft). Samples were analyzed according to the falling head flexible wall permeability test, in accordance with ASTM Method D1587-83. Sample lithologies ranged from silt and sand to silt and clay. The samples were recovered from below the intermediate zone. The sample from WA-4D was recovered directly over the till and contained about 4 inches of coarse grained sand which graded upward into a silt/fine sand/clay. Because of disturbance of the bottom of the tube, the silt/fine sand was the only portion of the tube able to be evaluated. Values ranged from 3.4 x 10^{-6} cm/sec (0.07 gpd/ft^2) to 2.8 x 10^{-8} cm/sec (5.94 x 10^{-4} gpd/ft^2). These values are less than values obtained for horizontal hydraulic conductivity from *in situ* conductivity tests of wells in the intermediate hydrogeologic unit. Since no Shelby tube samples were collected from the shallow and deep units, the vertical hydraulic conductivity of these units was not measured. The alternating layering of coarse and fine grained materials in the shallow zone suggests that there is a heterogeneity between the vertical and horizontal hydraulic conductivities within this unit.

Eleven groundwater elevation contour maps were developed for the Plant Study Area. Groundwater elevation maps (**Figures 16, 17, and 20; 21 to 23, and 24 to 26**) were constructed for the shallow, intermediate and deep aquifers for data collected in May 1992, September 1992, and September 1997 (Phase 2). In addition, two shallow groundwater flow maps were completed for Phase 1, round 3 field work completed in December 1994 and March 1995 (**Figures 18 and 19**). In the Plant Study Area, shallow, intermediate and deep groundwater show slightly different flow patterns, but the general flow direction is toward Onondaga Lake.

The shallow groundwater flow pattern (**Figures 16 through 20**) indicates that some groundwater from the adjacent Semet Ponds Site flows eastward into the Plant Study Area. The shallow groundwater flow in the Plant Area is generally lakeward under a hydraulic gradient of about 0.003 ft/ft although the gradient becomes greater (0.05 ft/ft) between the northern border of the Plant Study Area and the lake's edge.

The shallow groundwater flow pattern also indicates that there is a small component of groundwater flow to the south toward Tributary 5A. The overburden groundwater in the Plant Study Area appears to be hydrogeologically a separate system from the area south of the Plant Study Area. **Figure 11** demonstrates that the peat, marl, silt and clay, and silt and fine grained sand units pinch out at the southern edge of the Plant Study Area. Furthermore, the nature of the fill is different in each area although fill is present beneath both the Plant Study Area and the region to the south. Therefore, the hydrogeology is not continuous between the two areas. The differing nature of subsurface materials and the relative elevations of the groundwater and surface water indicate that, with regards to the shallow-most subsurface, Tributary 5A acts as a hydrogeologic divide between the Plant Area and the area to the south. Like the neighboring Semet Ponds Site, the shallow groundwater flow system for the Plant Study Area largely originates on-site by infiltration of precipitation through the fill. Temporary wells WT-1, WT-2, and WT-3 were installed to help document the component of radial flow, which is presented on **Figure 18**. A slight groundwater mound was observed at WT-3, and this is probably the result the well's proximity to a septic leachfield owned and operated by Blue Circle Cement. This radial flow also affects well nests WA-5, WA-6 and WA-4, and they may reflect water quality of groundwater that originated on the on-site.

The Plant Study Area intermediate groundwater zone also displays a flow pattern that is generally northward (**Figures 21 to 23**) with some tendency for flow toward the center of the area. This may be a reflection of the depth of the intermediate wells and subsurface geology as the Top of Silt Elevation Map (**Figure 15**) depicts a similar pattern. The hydraulic gradient across the Site is about 0.015 ft/ft, and there is no steepening of the gradient as it approaches the lake. This may be partially because of the upward hydraulic potential that was observed in wells along the lakeshore and which can be seen in the hydrogeological cross sections (**Figures 27a and 27b**).

The groundwater elevation contour maps of deep groundwater flow for the Plant Study Area (**Figures 24 through 26**) show that flow is generally toward the lake under a relatively low gradient at approximately 0.007 ft/ft. The orientation of the groundwater flow path is skewed toward the northwest and may reflect the increasing thickness of the basal sand and gravel in that direction (**Figure 14**) or the presence of a top of bedrock low that appears to extend between WA-3 and OW-5 along the lakeshore (**Figure 13**).

3.3.3. Water Chemistry

Major cation and anion analyses were performed during Phase 1 groundwater sampling to evaluate the ionic composition of groundwater in the Plant Study Area, PSA and CHSA. Results of major cation and anion analyses are presented on **Table 6**. These data are presented graphically in the form of Piper Plots on **Figures 28 through 32**. Major anion and cation analyses reveal an increasingly tighter grouping with depth and with distance downgradient.

In the Plant Study Area, the upgradient shallow and intermediate wells (**Figures 30 and 31**) show distinct water types as compared to the downgradient shallow and intermediate wells. Shallow upgradient wells WA-4S, WA-5S, and WA-6S show a calcium-carbonate type water, while downgradient wells WA-1S, WA-2S, and WA-3S show a dominantly sodium-chloride type water. Intermediate depth upgradient wells WA-4I and WA-5I show increasing sodium and chloride content, while downgradient wells WA-1I, WA-2I, and WA-3I show a distinct sodium-chloride type water. The chloride present in the shallow and intermediate zone is most likely derived from the Solvay waste present across the Plant Study Area.

The wells in the CHSA (**Figure 28**) show considerable scatter. This could be due to variable well depth, fill materials within the screened zone, and distance above bedrock. Most of these wells show a high percentage

composition of carbonate and bicarbonate, which is characteristic of shallow wells close to the source of recharge.

The wells in the PSA (**Figure 29**) are grouped and show similarity to the upgradient wells in the adjacent Plant Study Area. Well PS-3D contains a higher concentration of dissolved ions than the shallower wells. This would reflect the longer residence time of the deeper water. The wells in the PSA are dominated by calcium, sulfate, carbonate, and bicarbonate.

The deep upgradient and downgradient wells show a similar composition, generally exhibiting a sodium-chloride type water (**Figure 32**). The upgradient well chemistry is similar to that observed in the intermediate zone, while the downgradient wells show decreasing chloride concentrations as compared to the intermediate zone. The fact that the upgradient groundwater is similar to downgradient and both are dominated by chloride indicates that the water chemistry in the deep zone likely represents native water derived from the bedrock. Highest chloride concentrations are generally found in the deep well at each well nest and reflect a natural source of chloride from the bedrock.

Groundwater from nest WA-8 was not submitted for common anion analysis, but if the percentage meq/l is calculated for the common cations, a trend is evident in which the percentage of calcium decreases as the combined sodium and potassium increases with depth. The calcium dominance in the shallow wells represents the calcium from the Solvay waste. Both the percentage and the actual concentration of sodium and potassium increases with depth. This increase is a result of the upward discharge of water from the bedrock. As discussed in an earlier section, the bedrock derived water tends toward a brine type composition. This is further indication that along the shoreline there is an upward hydraulic gradient, which will limit the migration of dissolved constituents into bedrock within the study area.

3.3.4. Plume Definition: Semet Ponds Area and Plant Study Area

Shallow and intermediate groundwater flow maps (**Figures 16 through 23**) suggest that groundwater flows to the north and northeast from the Plant Study Area. The orientation of Willis Avenue is such that this groundwater flow direction is northeast toward that part of Willis Avenue where it intersects with State Fair Boulevard. Groundwater from the Plant Study Area does not flow directly to the east toward Willis Avenue. However, based on data from wells adjoining the two sites, it appears that shallow groundwater from the Semet Ponds Site does flow into the northwestern corner of the Plant Study Area. Because of the similarity of compounds found on the sites, it is difficult to precisely evaluate the extent of flow from the Semet Residue Ponds. Chlorobenzene was detected in Semet Ponds wells SP-3A and SP-3B with concentrations at least one order of magnitude less than those found in Plant Study Area wells WA-7S and WA-7I. These data indicate that some radial flow from the Plant Area is occurring. There are two pipelines, one 6-inch saran line and a 10-inch chlorine waste water (**Figure 4**), that transported highly chlorinated water to the 72-inch intake line running from the lake to the Former Main Plant Site. It is possible that bedding material associated with these pipelines provided a preferential migration pathway for contaminants.

4. NATURE AND EXTENT OF RESIDUALS

This section presents a discussion of the nature and extent of residuals at the Site based on data collected during Phases 1 through 4 of the RI. Due to the complexity of the Site and its multiple AOS, the nature and extent of residuals are presented on a study area basis for the various media evaluated.

4.1. NATURE AND EXTENT OF RESIDUALS

The GPR survey of the Plant Area performed by Detection Sciences under subcontract to O'Brien & Gere, revealed localized anomalies. Closer study showed some similarities, or patterns of radar responses, among the anomalies.

The anomalies were compared to the chemical results from nearby boring samples to assist in their classification. Subsequently, five profile types (A, B, C, D, and E) were selected as representative of individual anomalies. The profiles were then compared to former building locations, tank storage areas, and other distinguishing Site features in an effort to determine whether further investigation of the anomalies was warranted. Because of their number, probable interferences with subsurface fill and demolition debris, further interpretation was not possible. Consequently, the GPR survey was not useful in disclosing the presence of DNAPL or other areas. Therefore, the objectives of the survey were not met. Detailed results of the GPR survey are provided in the report included as **Appendix C**.

4.2. SOIL VAPOR SURVEY RESULTS

Sixty-two soil vapor samples were collected in the Plant Area and analyzed for VOCs and mercury using a Photovac 10S70 portable GC and Jerome Model 411 mercury vapor analyzer. Sample locations are presented on **Figure 3**. Analytical results for these samples are presented in **Table 7** as concentrations of benzene, chlorobenzene, dichlorobenzene isomers, other VOCs, total VOCs, and mercury. It should be noted that the "other VOCs" were not delineated into individual compounds in the analytical data, and the concentration represents a total of these compounds. Mercury and other VOCs were detected in the majority of the samples; however, the highest concentrations detected were for benzene, chlorobenzene, and dichlorobenzene isomers. Concentrations of benzene and dichlorobenzenes were highest in four samples collected in the northeast corner of the site. Total VOC concentrations by volume in these four samples, designated as DO1, DO2, CO2+28, EO1, and C02, were 1224.6 ppm, 627.2 ppm, 463.5 ppm, 48.96 ppm, and 6.9 ppm, respectively. Concentrations in other samples were less than 10 ppm with concentrations increasing at downgradient locations.

Mercury vapor concentrations ranged from non-detect (ND) to 2.26 mg/m^3. Mercury concentrations were highest in soil vapor samples G07 and H01 collected in the vicinity of the former mercury cell building and in the northwest corner of the Plant Study Area, respectively. The results of the soil vapor survey were used to aid in the selection of soil boring locations. A detailed discussion of the soil vapor survey approach and results is presented in **Appendix O**.

4.3. SOIL/STUDY AREA CHARACTERIZATION

Soils characterization consisted of collection of subsurface and surface soil samples from the Plant Study Area, CHSA, and PSA and characterization samples from the source material that comprises Pile #1 and Pile #2 that were staged on-site. The subsurface soils data included all samples collected from 2 ft bgs or deeper, while surface soil data was for samples collected between 0 and 2 ft bgs; the staged material data for Pile #1 and Pile #2 include only characterization samples from the excavated materials.

The characterization of the soils included calculations of total concentrations for BTEX parameters, chlorinated benzenes (Total CBs), carcinogenic PAHs (cPAHs), and PCBs (Total PCBs). These calculations were also used when evaluating Tributary 5A sediment and surface water and groundwater in the sections below and were determined as follows:

- BTEX = sum of detected concentrations for benzene, toluene, ethylbenzene, and total xylenes (or xylene isomers).
- Total CBs = sum of detected concentrations for trichlorobenzene isomers, dichlorobenzene isomers, chlorobenzene, and hexachlorobenzene (as an SVOC).
- cPAHs = sum of detected concentrations for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene.
- Total PCBs = sum of detected concentrations for PCB Aroclors.
- The Total CBs are typically based on trichlorobenzene isomers and dichlorobenzene isomers from the SVOC analytical data. However, the trichlorobenzene and dichlorobenzene isomers in some of the samples were reported only for the VOC analysis; these data were used to calculate the Total CBs for these samples.
- As a guideline for interpretation of inorganic parameters in subsurface soils (and surface soils), a comparison of concentrations in naturally occurring North American soils (Dragun, 1988), reference materials provided by NYSDEC (McGovern, 1988), chemical characteristics of Solvay waste (Kulwahy, 1977), and NYSDEC Part375-6 Remedial Program Soil Cleanup Objectives (Restricted Use: Protection of Human Health – Industrial: NYSDEC, 2006) is presented in Table 4-1 below. The chemical characteristics of Solvay waste are also presented on Section 1.3.1.1, and the NYSDEC Part 375.6 Restricted Use – Industrial soil criteria or background values are included in all applicable data and statistics tables.

Table 4-1 Comparison of Background Values, Standards, and Typical Solvay Waste Concentrations

Analyte	Native Soil Concentrations (ppm) (a)	NYS Natural Background Level (ppm) (b)	Typical Concentrations in Solvay Waste (ppm) (c)	NYSDEC Part 375 Restricted Use – Industrial (ppm) (d)
Aluminum	10,000 - 300,000	1,000 - 25,000	*4,800*	--
Antimony	*0.6* - 10	--	--	--
Arsenic	1 - 40	3 - 12	16	16
Barium	100 - 3,500	15 - 600	--	10,000
Beryllium	0.1 - 40	0 - 1.75	--	2,700
Cadmium	0.01 - 7	0.01 - 0.88 (f)	2	60
Calcium	*100* - 400,000	130 -35,000	--	--
Chromium	5 - 3,000	1.5 - 40	*9*	--
Cobalt	*1* - 40	2.5 - 60	--	--
Copper	2 - 100	<1 - 15 (f)	10	10,000
Cyanide	--	--	0.04	10,000
Iron	7,000- 550,000	17,500 - 25,000 (f)	*4,520*	--
Lead	2 - 200	1 - 12.5 (f)	30	3,900
Magnesium	*600* - 6,000	2,500 - 6000 (f)	--	--
Manganese	100 - 4,000	50 - 5,000	--	10,000
Mercury	0.01 0.08	0.042 - 0.066 (f)	0.04	5.7

Table 4-1 Comparison of Background Values, Standards, and Typical Solvay Waste Concentrations

Nickel	5 - 1,000	0.5 - 25	13	10,000
Potassium	*400* - 30,000	8,500 - 43,000	--	--
Selenium	0.1 - 2	<0.1 - 0.125 (f)	--	6,800
Silver	0.1 - 5	--	--	6,800
Sodium	*750* - 7500	6,000 - 8,000 (f)	--	--
Thallium	*0.1* - 12	--	--	--
Vanadium	*20* - 500	--	--	--
Zinc	10 - 300	37 - 70 (f)	30	10,000

Notes:
-- = no value listed
Italicized values indicate the background value, standard, or typical Solvay waste concentration selected for comparison to the analytical results when a NYSDEC Part 375 Restricted Use – Industrial soil criterion is not listed.
(a) Dragun.1988. The Soil Chemistry of Hazardous Materials.
(b) McGovern.1988. Background Concentrations of 20 elements in soils with special regard for New York State.
(c) Kulwahy. 1977. Geotechnical Behavior of Solvay Waste.
(d) NYSDEC. 2006. Part 375-6 Remedial Program Soil Cleanup Objectives – Restricted Use – Industrial.
(e) Value for Massachusetts used.
(f) Value for Albany used.

4.3.1. Subsurface Soils

Subsurface soil sampling (soils from greater than 2 ft bgs) performed in the Plant Study Area, CHSA, and PSA consisted of the collection of soils from soil borings, test pit excavations, and subsurface utilities exploratory excavations during the RI, DGWI in 2007 and 2010, as well as berm excavation confirmation sampling in 2012. Analytical data for subsurface soils are presented in the following data tables as follows:

- Phase 1 soil borings in **Tables 8 to 11** and Phase 2 soil borings in **Table 12**.
- Phase 2 subsurface soils in **Tables 13 to 15a** and Phase 3 subsurface soils in **Tables 16 to 18**.
- Phase 2 subsurface utilities bedding materials in **Tables 19 to 21a**.
- Phase 3 AOS subsurface soils in **Tables 22 to 25**.
- Berm excavation confirmation soils in **Appendix B-5**.
- Deep Groundwater Phase 1 and 2 subsurface soils in **Appendix B-6**.
- The NYSDEC split sample data are presented in **Tables 13a to 15a** for Phase 2 subsurface soils and **Tables 19a to 21a** for Phase 2 subsurface utilities bedding materials. **Figures 33a and 33b** present the analytical results for mercury, Total CBs, Total PCBs, BTEX, Total cPAHs, and Total TEQ for each subsurface soil sample.

4.3.1.1 Plant Study Area

Summary statistics are provided in **Table 26** for the subsurface soil parameters detected in the Plant Study Area and include the NYSDEC Part 375.6 Restricted Use – Industrial soil criteria or background values (if available) and the number of exceedances of these soil criteria and background values.

The VOCs detected at the greatest frequencies included chlorinated benzenes (CBs), benzene, toluene, total xylenes, tetrachloroethene (PCE), trichloroethene (TCE), 1,2,4- and 1,3,5-trimethylbenzene, and carbon

disulfide. Most of these parameters were detected at the highest concentrations in the Plant Study Area subsurface soils; however, there were few exceedances of the NYSDEC Part 375.6 Restricted Use – Industrial soil criteria (**Table 26**). Additional VOCs were detected including methylene chloride and acetone, but their detection frequency was less than 20%, and no exceedances of soil criteria were observed. Elevated concentrations of chlorobenzene and benzene were detected in samples located near the production facilities (Para finishing and distillation buildings) including borings WA-B4 (24 to 26 ft, 30 to 32 ft), WA-B5 (10 to 12 ft, 18 to 20 ft), WA-B8 (6 to 8 ft), and WA-B10 (20 to 20 ft, 28 to 30 ft; **Table 8**). The sample from 006MATP2B (4 to 6 ft) had The highest BTEX concentration (12,488,000 µg/kg ; **Figure 33a**) was detected in sample 006MATP2B (4 to 6 ft) associated with Outfall 006, as well as elevated concentrations of trimethylbenzenes isomers, ethylbenzene, naphthalene, and sec- and tert-butylbenzene. Both NIMO1 (3 ft) and SS#3 (9 ft) associated with Outfall 004 contained elevated Total CB concentrations (776,700 µg/kg and 2,414,800 µg/kg, respectively; **Figure 33a**). On the lakeshore property, sample P.A.S. #1 (11 ft) had Total CB and Total BTEX concentrations of 114 µg/kg and 36 µg/kg, respectively, and WA-2D had a total petroleum hydrocarbon (TPH) of 2,000 mg/kg.

Chlorinated benzenes and assorted PAHs were the dominant SVOCs detected in the Plant Study Area subsurface soils, with the dichlorobenzene isomers and 1,2,4-trichlorobenzene detected at the highest concentrations. Multiple PAHs were detected at WA-B2 (24 to 26 ft) and WA-B5 (18 to 20 ft; **Table 9**) with the highest Total cPAHs concentration was at WA-B5 (18 to 20 ft; 38,100 µg/kg; **Figure 33a**). Each of the samples from WA-B3, WA-B4, WA-B5, WA-B6, WA-B8, and WA-B10 contained elevated Total CB concentrations (**Figure 33a**). These parameters were highest in WA-B6 (22 to 24 ft) with a Total CB concentration of 16,840,000 µg/kg. These sample locations are all located near the former para finishing and distillation buildings and mercury cell building (for WA-B2) and were likely associated with plant operations.

For pesticides and PCBs, hexachlorobenzene, Aroclor 1242, and Aroclor 1260 were detected in samples collected from near Outfall 006, Outfall 004, and the drainage ditch, and from SS#1, #2, and #3 (**Table 20 and Figure 33a**). Hexachlorobenzene and Aroclor 1260 were detected in most of the eleven and nine samples (respectively) collected with the maximum concentrations for all three parameters detected in SS#1 (6 ft; **Table 20**). The PCBs are likely related to on-site transformers on-site during operations. The hexachlorobenzene is most likely associated with former plant operations and manufacturing.

PCDD/Fs were present in all subsurface 29 samples collected from FCB2, FCB5A, FCB5B, FCB5C, and SB-08 through SB-12 (**Table 16**). The highest Total TEQs were associated with the samples collected within the footprint of the Former Chlorination Building (range = 9.44 ng/kg to 83,509 ng/kg; **Figure 33b**), while the range for samples outside the building footprint was 1.66 ng/kg to 89.4 ng/kg. Theses parameters are present due to the chlorination production process.

Inorganic parameters excluding mercury were detected all 20 samples collected from the WA-B1 through WA-B10 locations, and mercury was detected in 61 samples with 24 samples exceeding the 5.7 mg/kg NYSDEC Part 375.6 Restricted Use – Industrial soil criteria (**Table 26**). Arsenic was the only other inorganic parameter that exceeded its NYSDEC Part 375.6 Restricted Use – Industrial soil criteria in 2 of 20 samples. Mercury was detected at the highest concentrations in the footprint of the former Mercury Cell Building (max. concentration = 1,370 mg/kg at WA-B1 [14-16 ft]; **Figure 33b**). The Solvay waste-related metals (aluminum, calcium, magnesium, potassium, and sodium) typically exceeded their background values (**Table 26**). Iron also exceeded its background value with a maximum concentration of 16,600 mg/kg. The presence of these parameters throughout the Plant Study Area indicates the impact of production processes when the Willis Avenue and former Main Plant Site facilities were in operation.

Elemental mercury droplets were observed in subsurface soils in eight (MC-B4, MC-B4A, MC-B7 through MC-B9, MC-B12, and MC-B13) of the 15 borings advanced in footprint of the former Mercury Cell Building. These borings were advanced in the central portion of the former Mercury Cell Building, within the building foot print, and extend just to the north of the building foundation. The horizontal extent of the elemental mercury droplets was approximately 90 ft (north-south) by 30 ft (east-west) and was generally confined to the foot print of the former building. The maximum depth of elemental mercury droplets was 32 ft bgs in MC-B7. A summary of the

borings containing elemental mercury, the depth of boring, bottom depth of fill, and depth intervals at which elemental mercury was observed is presented in Table 4-2.

Table 4-2 Elemental Mercury in Soil Borings near the Former Mercury Cell Building

Soil Boring	Total Boring Depth (ft)	Bottom of Fill (ft)	Elemental Mercury Depth (ft)
MC-B4	10.6	-----	8 – 10.6
MC-B4A	68.0	27.8	8 – 22
MC-B7	48.0	29.5	6 – 22, 26 – 32
MC-B8	38.0	30.0	6 – 8, 12 – 14
MC-B9	38.0	31.9	5 – 6, 12 – 16
MC-B12	34.0	28.0	0 – 4, 12 – 16, 28 – 30
MC-B13	38.0	28.2	16 – 18

With the exception of boring MC-B7, elemental mercury was confined to the fill material. Elemental mercury in MC-B7 was observed extending through the peat layer and into the marl but had not extended into the silt/clay unit. The estimated horizontal extent of elemental mercury is presented on **Figure 34**. Based on the data collected, it is approximated that 3,000 cubic yards of soil could reasonably be expected to contain elemental mercury. It should be noted that elemental mercury is not present throughout the entire 3,000 cubic yard volume of soils; rather, it is interspersed as described above in Table 4-2.

Berm excavation soils

Mercury was the only parameter analyzed for in the berm excavation areas subsurface soil samples from the soil remaining after the excavation and clean fill placement. Mercury was detected in all eight samples with concentrations ranging from 0.41 mg/kg to 4.7 mg/kg with an average concentration of 2.3 mg/kg. The highest concentration was detected in SS-10 (2 to 3 ft). None of these samples exceeded the NYSDEC Part 375.6 Restricted Use – Industrial soil criteria (**Appendix B-5**).

4.3.1.2. Chlorobenzene Hot-Spots Area

Summary statistics are provided in **Table 27** for the subsurface soil parameters detected in the CHSA and include the NYSDEC Part 375.6 Restricted Use – Industrial soil criteria or background values (if available) and the number of exceedances of these soil criteria and background values.

Benzene, chlorobenzene, toluene, total xylenes, chlorinated benzenes, and 2-butanone, were the VOCs detected at the highest frequencies. 1,4-Dichlorobenzene exceeded NYSDEC Part 375.6 Restricted Use – Industrial soil criteria at DGWI location MPS-SB-29 with a concentration of 800,000 µg/kg. Acetone, PCE, and carbon disulfide were also detected in the CHSA subsurface soils. The maximum concentrations for benzene and chlorobenzene were detected in MPS-SB-29 (6 to 8 ft; 39,000 µg/kg and 290,000 µg/kg, respectively; **Appendix B-6**). The BTEX concentrations typically less than 100 µg/kg, with the maximum of 39,000 µg/kg at MPS-SB-29 (**Appendix B-6**). Chlorinated benzenes were reported as part of the VOC analyses during the DGWI, with the highest concentration of total CBs (1,541,120 µg/kg) detected at location MPS-SB-29.The elevated chlorobenzene, chlorinated benzenes and BTEX are likely related to the leakage from a former pipeline that transported cooling wastewater the Para building at the Willis Avenue Plant to the Main Plant. The elevated chlorobenzene concentration at CHSA-5 (4,600 µg/kg) is also likely related to this leakage.

The predominant SVOCs detected in the CHSA subsurface soil samples included assorted PAHs, bis(2-ethylhexyl)phthalate (BEHP), and chlorinated benzenes. The sample from CHSA-2 (2 to 10 ft) contained the highest concentrations of PAHs (Total cPAHs = 78,600 µg/kg) and Total CBs (6,532,000 µg/kg). The Total CBs are likely related to the leakage from a former pipeline that transported cooling wastewater from the Para building at the Willis Avenue Plant. The PAHs were detected in all samples indicating that historical operations in this area have likely impacted the CHSA.

Aroclor 1254 and six pesticides were detected in the CHSA subsurface soils, with pesticides being detected without any pattern of distribution or concentrations greater than 23 µg/kg (methyoxychlor; **Table 27**). Aroclor 1254 was detected in five of the six samples and exceeded it NYSDEC Part 375.6 Restricted Use – Industrial soil criteria (25,000 µg/kg) at CHSA-2 with a concentration of 92,000 µg/kg (**Table 24**), which is also the Total PCBs concentration (**Figure 33a**). The presence of the pesticides may be related to historical use of pesticides on-site. The PCBs are likely from former transformers associated with former industrial operations in the vicinity.

Multiple inorganic parameters were detected in the subsurface soils, including mercury and Solvay waste-related parameters (**Table 27**). Mercury exceeded its NYSDEC Part 375.6 Restricted Use – Industrial soil criteria once (5.8 mg/kg at CHSA-4**; Table 25**), but there were no other exceedances of the NYSDEC Part 375.6 Restricted Use – Industrial soil criteria. The Solvay waste-related metals and iron typically exceeded their background values presented in Dragun (1988), McGovern (1988), and Kulwahy (1977). The presence of these parameters throughout the CHSA indicates the area was historically impacted during production of soda ash at the former Main Plant.

4.3.1.3. Petroleum Storage Area

Summary statistics are provided in **Table 28** for the subsurface soil parameters detected in the PSA and include the NYSDEC Part 375.6 Restricted Use – Industrial soil criteria or background values (if available) and the number of exceedances of these soil criteria and background values.

VOCs detected in the PSA subsurface soils were predominantly BTEX compounds, 2-butanone, chlorobenzene, carbon disulfide, and styrene. There were no exceedances of the NYSDEC Part 375.6 Restricted Use – Industrial soil criteria, and the maximum concentration was total xylenes at location PSA-SB-05A (3,100 µg/kg [**Appendix B-6**]). Total BTEX concentrations ranged from 2.3 µg/kg to 4,080 µg/kg, with the maximum observed for PSA-SB-05A at 18 to 20 ft (**Appendix B-6**). Chlorinated benzenes were reported on as part of the VOC analyses during the DGWI, with the only detection being chlorinated benzene at location PSA-SB-01 (0.8 µg/kg [**Appendix B-6**]). The VOCs detected in the PSA subsurface soils are likely related to the use of this area for producing distilled coke light oil and storing petroleum while the production facilities were in operation.

The predominant SVOCs detected in the PSA subsurface soils were assorted PAHs and chlorinated benzenes. Most of these parameters were in three of the four samples collected, but only benzo(a)pyrene exceeded its NYSDEC Part 375.6 Restricted Use – Industrial soil criteria (once at PSA-2 [2 to 10 ft]). Total cPAHs ranged from not detected to 9,360 µg/kg, while Total CB concentrations in the SVOC analyses were between 87 µg/kg and 1,132 µg/kg (**Figure 33a**). These PAHs are likely related to the historical use of this area; the pathway for the chlorinated benzenes is not known.

Two PCB aroclors and seven pesticides were detected in these samples, but only Aroclor 1260 was detected more than once (**Table 28**). With the exception of methoxychlor, the pesticides were all detected in PSA-2 (2 to 10 ft; **Table 24**), and the maximum Total PCB concentration was also detected here (1,100 µg/kg; **Figure 33a**). The presence of these pesticides may be related to historical use of pesticides on-site and in surrounding area; however, there is no record of this. PCBS detected on-site are likely related to transformers associated with historic operations.

Inorganic parameters were detected in all four samples collected from the PSA subsurface soils, including mercury, arsenic, barium, and Solvay waste-related parameters (*i.e.* aluminum, calcium, iron, magnesium *etc.*). Arsenic in PSA-3 (6 to 8 ft) was the only exceedance of the NYSDEC Part 375.6 Restricted Use – Industrial soil

criteria, and the highest inorganic concentrations were associated with Solvay waste-related parameters (**Table 28**). Mercury was detected in all four samples, but the concentrations did not exceed 1 mg/kg (**Figure 33a**). The Solvay Process-related metals and iron exceeded their background values. The presence of the Solvay waste-related parameters throughout the PSA indicates the impact of former soda ash production processes on the area.

4.3.2. Surface Soils

Surface soil sampling (soils from 0 to 2 ft bgs) performed in the Plant Study Area, CHSA, and PSA consisted of the collection of soils from various locations on-site during Phases 2 and 3 of the RI. Surface soil samples were also collected in 1999 as part of the BERA and the 2012 berm excavation confirmation sampling. Analytical data for surface soils are presented in the following data tables as follows:

- Phase 2 surface soils in **Tables 29 to 34a** and Phase 3 surface soils in **Tables 35 to 41a**.
- Phase 3 AOS surface soils in **Tables 42 to 45**.
- BERA surface soils in **Tables 46 to 53**.
- Berm excavation confirmation soils in **Appendix B-5**.
- During Phase 1, surface soil samples were collected from the soil boring locations, and the analytical data is presented in **Tables 8 to 12**. The NYSDEC split sample data are presented in **Tables 30a to 32a and 34a** for Phase 2 surface soils and **Tables 39a to 41a** for Phase 3 surface soils.

4.3.2.1. Plant Study Area

Summary statistics are provided in **Table 54** for the surface soil parameters detected in the Plant Study Area and include the NYSDEC Part 375.6 Restricted Use – Industrial soil criteria or background values (if available) and the number of exceedances of these soil criteria and background values.

Among the predominant VOCs detected in the Plant Study Area surface soils were methylene chloride, chlorinated benzenes, chloroform, PCE, TCE, acetone, benzene, and toluene. There were no exceedances of the NYSDEC Part 375.6 Restricted Use – Industrial soil criteria (**Table 54**), and the maximum concentrations detected were for chlorobenzene and total xylenes from SB-12 (0 to 2 ft; 15,000 µg/kg and 1,700 µg/kg, respectively; **Table 35**). The other detected concentrations did not exceed 190 µg/kg for any of the samples, and no detected parameter was present in more than 44% of the samples. BTEX concentrations ranged from 1.4 µg/kg to 1,700 µg/kg (**Figure 35**). The VOCs detected across the Plant Study Area are likely related to the historical production processes. The highest concentrations (SB-12) were detected adjacent to the former Para distillation building.

The SVOCs detected in the Plant Study Area surface soils were predominantly PAHs, chlorinated benzenes, and phenolic compounds. Elevated concentrations were detected for PAHs, but the highest concentrations were observed for 1,4-dichlorobenzene and 1,2-dichlorobenzene (**Table 54**). The NYSDEC Part 375.6 Restricted Use – Industrial soil criteria were exceeded by concentrations of benzo(a)pyrene, dibenzo(a,h)anthracene, benzo(b)fluoranthene, benzo(a)anthracene, 1,4-dichlorobenzene, hexachlorobenzene, and indeno(1,2,3-cg)pyrene, and most parameters were detected in greater than 20% of the samples. Total cPAHs were present at their highest concentrations at SB-01 (74,800 µg/kg) and SB-07(105,400 µg/kg), with Total cPAHs concentrations typically higher than 1,000 µg/kg across the Plant Study Area (including the lakeshore property; **Figure 35**). The detected Total CB concentrations ranged from 8.8 µg/kg (004A [0 to 0.5 ft]) to 2,695,517 µg/kg (SB-11 [0 to 2 ft]), with the highest concentrations detected at SB-08, SB-11, and SB-12 (**Figure 35**). The chlorinated benzenes detected on-site are related to the historical production process, with the highest concentrations associated with samples collected in the vicinity of the Para distillation and finishing buildings driving the Total CB concentrations. The PAHs are likely related to the historic industrial use of the Site.

Multiple pesticides and Aroclors 1248, 1254,and 1260 were detected in the surface soils from the Plant Study Area (**Table 54**). From these parameters, only hexachlorobenzene, endosulfan II, 4,4'-DDE, Aroclor 1260, and Aroclor 1254 were detected in greater than 20% of the samples collected, and there was only one exceedance of the NYSDEC Part 375.6 Restricted Use – Industrial soil criteria (hexachlorobenzene at 17,000 µg/kg from 006A [1 to 1.5 ft]; **Table 30**). The highest concentrations were observed for hexachlorobenzene and Total PCBs from samples near Outfall 004 and Outfall 006 (**Figure 35**), with LS-2 on the lakeshore property also having an elevated Total PCB concentration (3,700 µg/kg). The hexachlorobenzene is likely related to former manufacturing processes at the Site, while the PCBs are likely related to transformers associated with the manufacturing facilities. The presence of pesticides other than hexchlorobenzene across the Site indicates some historic use of these compounds; however, there is no record of their use.

The PCDD/Fs were present in all 46 samples collected from the Plant Study Area, and 2,3,7,8-TCDD was detected in 42 of the 46 samples. The highest surface soil total TEQs were associated with the samples collected within the footprint of the Former Chlorination Building (range = 20.9 ng/kg to 222,967 ng/kg), while the range for samples outside the building footprint was 4.31 ng/kg to 7,492 ng/kg (**Table 39 and Figure 35**). These parameters are present across the Plant Study Area (including the lakeshore property) and are likely related to the former chlorination production process.

Inorganic parameters excluding mercury were detected all 26 samples collected from samples collected across the Plant Study Area (including Outfall 004 and Northwest Ditch, Outfall 006, lakeshore property, and Plant Area), and mercury was detected in 59 samples with 29 samples exceeding the 5.7-mg/kg NYSDEC Part 375.6 Restricted Use – Industrial soil criteria (**Table 54**). Arsenic was the only other inorganic parameter that exceeded its NYSDEC Part 375.6 Restricted Use – Industrial soil criteria. Mercury was detected at the highest concentrations in the Northwest Ditch (NW Ditch #1, #2, and #3 and NWDitch-S; SB-07), with elevated concentrations also detected in samples from Outfall 006 (006MASS#3, 006A, and 006B) and Outfall 004 (004B; **Figure 35**). The mercury is likely related to discharges when the Willis Ave plant was in operation. The source of the elevated arsenic is unknown. The Solvay waste-related parameters were present in all samples at concentrations that typically exceeded background values listed in Dragun (1988), McGovern (1988), and Kulwahy (1977). The presence of these parameters throughout the Plant Study Area indicates impacts from the Solvay waste.

The placement of Staged Soil Piles #1 and #2, Willis/Semet GWTP, and Site access roads on the Plant Area covered over some of the surface soil locations originally collected during the RI. These locations include SB-4, SB-5, SB-10, and MPS-SS (**Figure 5**). The analytical data from these locations were still used in the **Table 54** statistical analyses. It should be noted that these locations are considered temporarily covered, and the final determination of stage soil piles will be included in the FS.

Berm excavation soils

Surface soil samples from the berm excavation areas for soil left n place was mostly analyzed for mercury, with only SS-12 (0 to 1 ft) analyzed for VOCs. Methylene chloride was the only VOC detected in the sample at a concentration of 3.5 µg/kg (**Appendix B-3**). Mercury concentrations ranged from 0.7 mg/kg to 77.6 mg/kg and had a mean concentration of 9.1 mg/kg. The maximum concentration was detected at PCS-23 (0.5 to 1 ft), and this concentration exceeded the NYSDEC Part 375.6 Restricted Use – Industrial soil criteria of 5.7 mg/kg. Five other locations also exceeded 5.7 mg/kg (**Appendix B-3**).

4.3.2.2. Chlorobenzene Hot-Spots Area

Summary statistics are provided in **Table 55** for the surface soil parameters detected in the CHSA and include the NYSDEC Part 375.6 Restricted Use – Industrial soil criteria or background values (if available) and the number of exceedances of these soil criteria and background values.

Three VOCs were detected in the CHSA surface soils (chlorobenzene, benzene, and total xylenes), and the highest concentration was 46 µg/kg (CHSA-2 [0 to 2 ft]; **Table 40**). There were no exceedances of the NYSDEC Part 375.6 Restricted Use – Industrial soil criteria (**Table 55**). Total BTEX concentrations did not exceed 8 µg/kg (**Figure 35**). The parameters, in particular the chlorobenzene, may be present due to the leakage from a former pipeline that transported cooling wastewater from the Para building sump at the Willis Avenue Plant. However, it is more likely that the benzene and total xylenes are related to current area usage and vehicle traffic based on the low concentrations.

For SVOCs, PAHs, chlorinated benzenes, dibenzofuran, BEHP, and carbazole are the predominant parameters detected in the seven surface soil samples (**Table 55**). The highest Total CB concentration was detected in CHSA-2 (0 to 2 ft) at 35,196 µg/kg; the Total CB concentrations from CHSA-1 (0 to 2 ft; 1,420 µg/kg) and CHSA-SS (0 to 0.5 ft; 2,290 µg/kg) were also elevated (**Figure 35**). Total cPAHs were elevated for all seven samples (range = 1,760 µg/kg to 89,700 µg/kg) with the highest total concentration observed for CHSA-3 (**Figure 35)**. The chlorinated benzenes are likely related to leakage from a former pipeline that transported cooling wastewater from the Para building at the Willis Avenue Plant, while the PAHs are likely due to current usage of the area around the CHSA, including vehicle traffic adjacent to this area.

Aroclor 1254 and eight pesticides were detected in the CHSA surface soils (**Figure 35**). The pesticides were only detected in samples from CHSA-3, CHSA-4, CHSA-5, CHSA-6, and CHSA-SS at concentrations ranging from 9.2 µg/kg to 290 µg/kg (**Table 44 and 48**), with the highest concentrations detected in CHSA-SS (0 to 0.5 ft). The concentrations for Aroclor 1254 (and Total PCBs) ranged from 710 µg/kg to 120,000 µg/kg (**Figure 35**) and exceeded its NYSDEC Part 375.6 Restricted Use – Industrial soil criteria once (CHSA-2 [0 to 2 ft]). The higher PCB concentrations were observed on the eastern and western ends compared to the central portion of this area. The presence of these pesticides and PCB are likely related to historical use of pesticides on-site; however, there are no records of their use. The Aroclor 1254 is likely from transformers associated with former manufacturing processes in the vicinity.

Multiple inorganic parameters were detected in the CHSA surface soils, including mercury, arsenic, and soda ash production-related parameters. Mercury did not exceed the NYSDEC Part 375.6 Restricted Use – Industrial soil criteria (**Table 55**), but arsenic was over its NYSDEC Part 375.6 Restricted Use – Industrial soil criteria once at CHSA-4 (0 to 2 ft; **Table 45**). The Solvay Process-related calcium and magnesium, as well as iron, were present at concentrations that exceeded background values from Dragun (1988), McGovern (1988), and Kulwahy (1977). The presence of these parameters throughout the CHSA indicates the impact of current usage of the area around the CHSA and historical production processes when in operation, including the production of soda ash.

4.3.2.3. Petroleum Storage Area

Summary statistics are provided in **Table 56** for the surface soil parameters detected in the PSA and include the NYSDEC Part 375.6 Restricted Use – Industrial soil criteria or background values (if available) and the number of exceedances of these soil criteria and background values.

There were six VOCs detected in the four PSA surface soil samples and included benzene, toluene, total xylenes, chlorobenzene, methylene chloride, and carbon disulfide. The concentrations for these parameters ranged from 1 µg/kg to 86 µg/kg with no exceedances of the NYSDEC Part 375.6 Restricted Use – Industrial soil criteria (**Table 56**). Total detected BTEX concentrations ranged from 10 µg/kg to 193 µg/kg (**Figure 35**). The use of this area for producing distilled coke light oil and storing petroleum while the production facilities were in operation is the likely reason for these VOCs in the surface soils.

The SVOCs detected in the PSA surface soils included PAHs, assorted phenols, 1,4-dichlorobenzene, BEHP, dibenzofuran, carbazole, and di-n-butylphthalate. The PAHs were the majority of the detected parameters (**Table 56**). The Total cPAH concentrations ranged from 11,920 µg/kg to 43,000 µg/kg (**Figure 35**). Trace chlorinated benzenes were detected, and Total CB concentrations ranged from 36 µg/kg to 61 µg/kg. There

were no exceedances of the NYSDEC Part 375.6 Restricted Use – Industrial soil criteria. These SVOCs are likely related to the historical uses of this area.

Three PCBs (Aroclors 1248, 1254, and 1260) and seven pesticides were detected in the surface soil samples. The maximum concentration (720 μg/kg) was observed for Aroclor 1260 (**Table 56**). Total PCBs ranged from 140 μg/kg to 720 μg/kg (**Figure 35**). Endosulfan II (37 μg/kg) had the highest concentration of the seven pesticides. There were no PCB and pesticide exceedances of the NYSDEC Part 375.6 Restricted Use – Industrial soil criteria. The presence of these pesticides is likely related to historical use of pesticides on-site; however, there are no records of their use. The PCBs are likely related to historic manufacturing at the PSA and associated transformers.

Multiple inorganic parameters were detected in the PSA surface soils. These included arsenic mercury, barium, copper, lead, aluminum, calcium, iron, and magnesium (**Table 56**). Mercury was present in all four samples (**Figure 35**) and exceeded its NYSDEC Part 375.6 Restricted Use – Industrial soil criteria in PSA-01 (0 to 0.5 ft) and PSA-SS (0 to 2 ft) (**Tables 45 and 49**). The source of the mercury at the PSA is unknown. The Solvay Process-related aluminum, calcium, magnesium, and potassium, as well as iron, were present at concentrations that exceeded the background values from Dragun (1988), McGovern (1988), and Kulwahy (1977). The presence of these parameters throughout the PSA indicates the area was influenced by the historic production of soda ash at the Main Plant.

4.3.3. Staged Soil Piles

Sources of the soils placed in Soil Piles #1 and #2 were discussed in Section 1.5. The analytical data for the staged soil piles is presented in Tables 1 to 9 and Tables 10 to 19 in **Appendix B-3** for Soil Piles #1 and #2, respectively. Soil Pile #1 also includes Tributary 5A sediment. These data are presented in **Tables 59 to 72** and are included in the summary statistics for Pile #1. Summary statistics are provided in **Tables 57 and 58** for the Piles #1 and #2, respectively and present the statistics for all parameters detected. The data used to generate these two tables are the unleached (non-Toxicity Characteristics Leaching Procedure [TCLP]) analytical data for VOCs, SVOCs, pesticides, PCBs, and metals. The TCLP data are presented in **Tables 7 to 9 and Tables 14 to 19** in **Appendix B-3**. Summary statistics were not developed for the TCLP data.

4.3.3.1. Staged Soil Pile #1

Assorted VOCs were detected in the Pile #1 soil samples, and none of the detected concentrations exceeded the NYSDEC Part 375 Restricted Use – Industrial soil criteria. Among the detected parameters were BTEX compounds, chlorinated benzenes, 2-butanone, acetone, carbon disulfide, methlcyclohexane, cyclohexane, and isopropylbenzene, which are the parameters that were present in more than 20% of the samples. The maximum detected concentration was 25,000 μg/kg for benzene, which also had the highest mean concentration of the VOCs (4,940 μg/kg; **Table 57**). Toluene and total xylenes were also present at elevated mean concentrations of 4,104 μg/kg and 3,545 μg/kg, respectively. The remaining detected VOCs ranged from 1 μg/kg to 500 μg/kg (**Table 57**).

Like the VOCs, multiple SVOCs were detected in more than 20% of the soil samples, which included PAHs, chlorinated benzenes, phenolic compounds, and other assorted parameters. The PAHs were detected at the highest frequency and highest concentrations in the sediments removed from Tributary 5A and placed in Pile #1. The only exceedances of the NYSDEC Part 375.6 Restricted Use – Industrial soil criteria were observed for benzo(a)pyrene and benzo(a)anthracene (**Table 57**).

There were multiple pesticides detected in four of the Pile #1 soil samples, which included 4,4'DDE, endosulfan II, endrin, 4,4'-DDT, alpha-chlordane, delta-BHC, endosulfan sulfate, endrin ketone, and heptachlor epoxide. The detected concentrations ranged from 1.9 μg/kg to 69 μg/kg, and no concentration exceeded the NYSDEC Part 375.6 Restricted Use – Industrial soil criteria.

Aroclor 1248, Aroclor 1254, Aroclor 1260, and Aroclor 1268 were detected in concentrations ranging from 25 µg/kg to 11,000 µg/kg (**Table 57**). The detected PCB concentrations did not exceed their NYSDEC Part 375.6 Restricted Use – Industrial soil criteria.

The PCDD/Fs were present in all four RI samples for the Tributary 5A sediment, and 2,3,7,8-TCDD was detected in all four samples. The highest total TEQ was 26.5 ng/kg, with a mean TEQ of 13 ng/kg.

Multiple inorganic parameters were detected in the Pile #1 staged Tributary 5A sediments, including mercury, arsenic, lead, and soda ash production-related parameters (**Table 57**). Mercury was detected in 24 of the 26 samples, with ten concentrations exceeding its NYSDEC Part 375.6 Restricted Use – Industrial soil criterion of 5.7 mg/kg. Arsenic and lead also exceeded their NYSDEC Part 375.6 Restricted Use – Industrial soil criteria (5 exceedances and 1 exceedance, respectively). The Solvay Process-related aluminum, calcium, magnesium, and potassium, as well as iron, were present at concentrations that exceeded the background values from Dragun (1988), McGovern (1988), and Kulwahy (1977).

Based on the TCLP analytical data, none of the samples exceeded the TCLP regulatory limits. The soil placed in Pile #1 is considered non-hazardous.

4.3.3.2. Staged Soil Pile #2

The predominant VOCs detected in soil placed on Pile #2 were chlorinated benzenes and benzene. Assorted other VOCs were present in less than 20% of the samples. There were no exceedances of the NYSDEC Part 375.6 Restricted Use – Industrial soil criteria, and concentrations ranged from 0.64 µg/kg to 250,000 µg/kg, with the highest concentrations observed for 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, and 1,4-dichlorobenzene (**Table 58**).

There were no SVOCs or PCBs detected in the soils placed in Pile #2 (**Table 58**).

Only one sample was analyzed for the full list of metals, while twelve samples were analyzed for mercury. Mercury exceeded its NYSDEC Part 375.6 Restricted Use – Industrial soil criteria in nine of the 12 samples and ranged in concentration from 0.22 mg/kg to 27 mg/kg (mean = 11.3 mg/kg; **Table 58**). No other metals in the single sample exceeded the NYSDEC Part 375.6 Restricted Use – Industrial soil criteria (**Table 58**). The highest concentrations were observed for Solvay waste and Solvay Process-related parameters (*i.e.*, calcium, iron, magnesium, aluminum, and sodium).

Based on the TCLP analytical data, none of the samples exceeded the TCLP regulatory limits. The soil placed in Pile #2 is considered non-hazardous.

4.4. SEDIMENT CHARACTERIZATION

Tributary 5A sediment sampling included surface sediment collected during Phase 1 and Phase 4 of the RI and subsurface sediment samples from borings advanced as part of the Tributary 5A SDI. Phase 1 and 4 analytical data for the Tributary 5A sediment are presented on **Tables 59 to 63 and Tables 64 to 72**, respectively. Both RI sediment locations and the SDI sample locations are presented on **Figure 36**. These sediments have been removed and staged in Soil Pile #1 discussed above. As part of the remedial action in Tributary 5A, additional sediment samples were collected from the material that was left in place below the isolation layer. The additional data is provided in **Appendix B-4**. These data were used to develop the summary statistics presented in **Table 73**.

The VOCs detected in the Tributary 5A sediments included BTEX, acetone, methyl acetate, 2-butanone, carbon disulfide, and isopropylbenzene (**Table 73**). None of the detected concentrations exceeded the NYSDEC Part 375.6 Restricted Use – Industrial soil criteria. Benzene was detected at the highest mean concentration of the VOCs at 12,649 µg/kg, with a range of 370 µg/kg (T5A-SED-09 [7 to 9 ft]) to 71,000 µg/kg (T5A-SED-10 [5 to 7 ft]). The Total BTEX concentrations ranged from 6.8 µg/kg to 71,590 µg/kg (mean = 9,049 µg/kg). The remaining VOCs were detected at concentrations ranging from 2 µg/kg to 990 µg/kg.

SVOCs were detected in the Tributary 5A sediments that were left in place and included phenolic compounds, assorted PAHs, acetophenone, benzaldehyde, 1,1'-biphenyl, carbazole, and dibenzofuran. The highest detected concentrations were detected for 2-methylphenol, 4-methylphenol, naphthalene, and phenol, with the maximum concentration for phenol (7,800 µg/kg) at T5A-SED-07 (5 to 5.5 ft). There were no exceedances of the Part 375.6 Restricted Use – Industrial soil criteria, and the remaining SVOCs had detected concentrations ranging from 0.93 µg/kg to 940 µg/kg (**Table 73**).

Aroclor 1248 was the only PCB detected and was present in eight of the ten samples (**Table 73**). The detected concentrations did not exceed the Part 375.6 Restricted Use – Industrial soil criterion and ranged from 12 µg/kg (T5A-SED-10 [5 to 7 ft]) to 7,100 µg/kg (T5A-SED-10 [3 to 4 ft]).

Mercury was the only metal analyzed for in the in place sediment samples collected from Tributary 5a. It was present in all ten samples and had one exceedance of its Part 375.6 Restricted Use – Industrial soil criterion of 5.7 mg/kg (9.5 mg/kg at T5A-SED-10 [3 to 4 ft]). The detected concentrations ranged from 0.02 mg/kg to 9.5 mg/kg and had a mean concentration of 1.1 mg/kg.

The presence of organic parameters and mercury in the remaining sediment indicates that the Willis Ave and the Semet Ponds had impacted Tributary 5A. However, the Tributary 5A sediments were removed along its length at varying depths (up to 8 ft bgs) as part of the Semet Ponds Groundwater Remedial Action, and an isolation layer was installed prior to restoration of the waterbody. This removes most of the impacted sediments and prevents recontamination of the sediments by shallow groundwater.

4.5. SURFACE WATER CHARACTERIZATION

Surface water samples were collected from Tributary 5A during Phase 1 and 4 of the RI. Analytical data for the Tributary 5A surface waters are presented on **Tables 74 to 77 and Tables 78 to 83**, respectively; sample locations are presented on **Figure 37**. Summary statistics are provided in **Table 84** for the surface water parameters detected compared to NYSDEC Class C *Technical & Operational Guidance Series (TOGS) 1.1.1 Ambient Water Quality Standards and Guidance Values* (NYSDEC, 1998b).

There were only seven VOCs detected in the surface water samples collected from Tributary 5A, which included benzene, toluene, total xylenes, chlorobenzene, chloroform, bromodichloromethane, and carbon sulfide (**Table 84**). Chloroform was the only parameter detected in all of the samples with a maximum detected concentration of 16 µg/L. Benzene was detected in eight samples and exceeded its Class C standard in seven samples with a maximum detected concentration of 110 µg/L (5A-WA-M). Detected BTEX concentrations ranged from 6 µg/L to 126 µg/L (mean = 45 µg/L) with the total concentration being primarily benzene (**Figure 37**).

Miscellaneous SVOCs were detected in the surface water including 2,4,5-trichlorophenol, BEHP, pentachlorophenol, 1,4-dichlorobenzene, naphthalene, phenol, pyrene, diethyl phthalate, di-n-butyl phthalate, and n-nitrosodiphenylamine. The detected concentrations for 2,4,5-trichlorophenol and pentachlorophenol from 5A-WA-D and the BEHP concentration (870 µg/L) from 5A-WA-U (**Table 75**) exceeded Class C standards. The only Total CB concentration was 2.5 µg/L at 5A-WA-U (**Figure 37**).

There were no PCBs detected in the samples (**Table 80**), and delta-BHC and dieldrin were the only pesticides present in the surface water. Delta-BHC and dieldrin were detected once each and at concentrations less than 0.03 µg/L (**Table 84**).

Multiple metals were detected in the Tributary 5A Phase 1 and 4 RI samples including iron, cobalt, aluminum, vanadium, selenium, and cyanide. These parameters all had concentrations that exceeded their Class C standards (**Table 84**).

The presence of organic and inorganic parameters in the surface water indicates that Willis Avenue and the Semet Ponds have impacted Tributary 5A. However, few VOCs and SVOCs were detected in the RI samples, and only Solvay waste-related metals were present at concentrations greater than 100 mg/L. The source of these parameters is most likely shallow groundwater input from the Site and Semet Ponds Site. As part of the Semet

Ponds Groundwater Remedial Action, an isolation layer was installed after removing the sediment and prior to restoration of the waterbody, and a groundwater collection system was installed between the Semet Ponds Site and Tributary 5A. These remedial actions were implemented to prevent further impact from Site-related parameters.

4.6. GROUNDWATER CHARACTERIZATION

4.6.1. Previous and Subsequent Studies

Prior to initiation of the RI, previous studies of groundwater in the Plant Study Area, PSA, and CHSA were performed. As presented in Section 1.4, these studies included:

- Installation of 28 wells in the Willis Avenue Plant Study Area by Geraghty & Miller and Groundwater Technologies, Inc between 1979 and 1984;
- Installation of ten monitoring wells in the PSA by Groundwater Technologies, Inc. in 1984; and
- Installation of 28 borings, eight monitoring wells, and one piezometer in the CHSA by Blasland and Bouck in 1987.

Results of these studies provided the basis for the RI and are discussed in the Site History Report (**Appendix A**). The location of the historical wells is presented on **Figure 4**.

Subsequent to completion of the RI, the Deep Groundwater Investigation was performed in two phases between 2007 and 2010. As presented in Section 1.5, this investigation included:

- Installation of two monitoring wells in the Plant Study Area by O'Brien & Gere in 2007.
- Installation of one monitoring well and seven borings in the CHSA by O'Brien & Gere in 2007 and 2010.
- Installation of two monitoring wells (including PSA-MW-03S Replacement well) and six borings in the PSA by O'Brien & Gere in 2007.

These data are included in the groundwater discussion below and associated summary statistics tables. The location of the wells sampled during the DGWI are presented on **Figure 4A**.

4.6.2. Groundwater Characterization.

Groundwater samples were collected during Phase 1 (three rounds of samples) and Phase 2 of the Willis Avenue RI. Phase 1 Round 1 sampling was performed during March 1992 and April 1992, and Phase 1 Round 2 was performed in October 1992. Phase 1 Round 3 consisted of sampling of well nest WA-8 in January 1995 and monitoring well MW-111 in the CHSA in March 1995. Well nest WA-8 has subsequently become part of the Harbor Brook Site, and the sampling results were discussed in detail within the Harbor Brook RI/FS Report. Two rounds of groundwater sampling were also perfomed as part of the Deep groundwater investigation (O'Brien & Gere 2011), and results are discussed in detail with that report. Data from the DGWI is also included in summary tables and discussion within this RI report. Analytical data for groundwaters are presented in **Tables 85 to 89**, and concentration plots/isopleths are included as **Figures 38a to 43** for the Plant Study Area, **Figures 44 to 50** for the CHSA, and **Figures 51 to 53** for the PSA. Relevent data for the DGWI is presented in **Appendix B-6**.Due to the sample size, Site distribution of the detected parameters was evaluated but data trending was not performed.

4.6.2.1. Plant Study Area

Shallow Groundwater

Summary statistics are provided in **Table 90** for the groundwater parameters detected in the Plant Study Area shallow groundwater for the samples collected during Phase 1 and Phase 2. **Table 90** presents the statistics for all parameters detected and compares concentrations to the Class GA groundwater standards and guidance values.

The dominant VOCs detected in Plant Study Area shallow groundwater included benzene, chlorobenzene, toluene, and acetone (**Table 90**). These parameters were detected at the highest frequencies and/or concentrations, as well as highest number of exceedances above the Class GA standards and guidance values. Additional VOCs detected included ethylbenzene, total xylenes, chloroform, carbon disulfide, methylene chloride, and 2-butanone but at a lower detection frequency and/or lower concentrations. Concentration isopleths for benzene and Total BTEX were plotted on **Figure 38a** for Phase 1 Round 1 data and **Figure 39a** for Phase 1 Round 2 data. Benzene, chlorobenzene, and toluene were detected at their maximum concentrations (30,000 µg/L, 25,000 µg/L, and 27,000 µg/L, respectively) in WA-2S (**Tables 85 and 89**) with elevated concentrations also detected in WA-1S and WA-7S. Detected BTEX concentrations ranged from 1 µg/L to 57,000 µg/L. The elevated concentrations at WA-1S and WA-2S are due to their location on the lakeshore property and proximity to the DNAPL plume, while WA-7S is situated in the middle of the Plant Area adjacent to the Former Chlorination Building.

Chlorinated benzenes, assorted phenols, and naphthalene were the SVOCs detected at the highest frequencies and/or concentrations, as well as highest number of exceedances above the Class GA standards and guidance values. Assorted PAHs and phenols were among the SVOCs observed at a lower detection frequency and/or lower concentration (**Table 90**). Concentration isopleths for chlorinated benzenes (including chlorobenzene from the VOC analysis) were plotted on **Figure 40a** for Phase 1 Round 1 data and **Figure 41a** for Phase 1 Round 2 data. The chlorinated benzenes were mostly detected in SP-3A, WA-1S, WA-2S, and WA-7S, with the sources of the chlorinated benzenes for WA-1S, WA-2S, and WA-7S being the same as discussed above. Chlorobenzene was detected at low concentrations in WA-5S on the eastern extent of the Plant Study Area. SP-3A is situated on the eastern portion of the Semet Ponds Site and was likely influenced by the Semet Site, as well as former Plant Study Area operations.

Inorganics including sodium, mercury, iron, arsenic, and lead were detected at the highest frequencies and/or concentrations, as well as highest number of exceedances above the Class GA standards and guidance values (**Table 90**). These parameters and the other detected inorganics were detected throughout the Plant Study Area without any one monitoring well containing the only set of elevated concentrations. Concentration isopleths for mercury were plotted on **Figure 42a** for Phase 1 Round 1 data and **Figure 43** for Phase 2 data.

A comparison of the unfiltered and filtered metals data yielded a mixture of results with some metals decreasing due to filtration and others increasing post-filtration. The evaluation of the metals analytical data was performed without regard for concentrations. The mean concentrations for metals including aluminum, barium, cobalt, copper, iron, lead, magnesium, manganese, nickel, and selenium decreased at least 80% after filtering the sample. Conversely, arsenic, beryllium, calcium, chromium, silver, sodium, and vanadium mean concentrations increased following the sample filtration.

Intermediate Groundwater

Summary statistics are provided in **Table 91** for the groundwater parameters detected in the Plant Study Area intermediate groundwater for the samples collected during Phase 1 and Phase 2. **Table 91** presents the statistics for all parameters detected with their Class GA groundwater standards and guidance values, and detected parameters with no Class GA groundwater standards and guidance values.

The dominant VOCs detected in Plant Study Area intermediate groundwater included benzene, chlorobenzene, toluene, and acetone. These parameters were detected at the highest frequencies and/or concentrations, as well as highest number of exceedances above the Class GA standards and guidance values (**Table 91**). Additional VOCs detected included ethylbenzene, total xylenes, carbon disulfide, methylene chloride, and 2-butanone but at a lower detection frequency and/or lower concentrations. Concentration isopleths for benzene and total BTEX were plotted on **Figure 38b** for Phase 1 round 1 data and **Figure 39b** for Phase 1 Round 2 data. Benzene, chlorobenzene, and toluene were detected at their maximum concentrations (62,000 µg/L [WA-1I], 87,000 µg/L [WA-2I], and 80,000 µg/L [WA-2I], respectively), with elevated concentrations also detected in SP-3B and WA-7I (**Table 86**). Detected BTEX concentrations ranged from 3.6 µg/L to 134,000 µg/L. The elevated concentrations at WA-1S and WA-2S are due to their location on the lakeshore property and proximity to the DNAPL plume,

while WA-7I is situated in the middle of the Plant Study Area adjacent to the Former Chlorination Building. Well SP-3B is situated on the eastern portion of the Semet Ponds Site and was likely influenced by the Semet Site, as well as former Plant Area operations.

Chlorinated benzenes and assorted phenols were the SVOCs detected at the highest frequencies and/or concentrations, as well as highest number of exceedances above the Class GA standards and guidance values (**Table 91**). Assorted PAHs and phenols were among the SVOCs observed at a lower detection frequency and/or lower concentration. Concentration isopleths for chlorinated benzenes (including chlorobenzene from the VOC analysis) were plotted on **Figure 40b** for Phase 1 Round 1 data and **Figure 41b** for Phase 1 Round 2 data. The chlorinated benzenes were mostly detected in WA-1I, WA-2I, and WA-7I, with the sources of the chlorinated benzenes for WA-1I, WA-2I, and WA-7I being the same as discussed above. Chlorobenzene was detected as a VOC in all intermediate monitoring wells with its maximum concentrations in WA-1I and WA-2I.

Inorganics including sodium, arsenic, magnesium, mercury, and iron were detected at the highest frequencies and/or concentrations, as well as highest number of exceedances above the Class GA standards and guidance values. These parameters and the other detected inorganics were detected throughout the Plant Area without any one monitoring well containing the only set of elevated concentrations. Concentration isopleths for mercury were plotted on **Figure 42b** for Phase 1 data.

A comparison of the unfiltered and filtered metals data yielded a mixture of results with some metals decreasing due to filtration and others increasing post-filtration. The evaluation of the metals analytical data was performed without regard for concentrations. Mean metal concentrations that decreased by more than 40% due to filtration were observed for arsenic, copper, iron, lead, manganese, and potassium. The metals with mean concentrations that increased post-filtration included aluminum, barium, beryllium, calcium, mercury, selenium, sodium, vanadium, and zinc.

Deep Groundwater

Summary statistics are provided in **Table 92** for the groundwater parameters detected in the Plant Study Area deep groundwater for the samples collected during Phase 1 and Phase 2 of the RI, and Phase 1 and Phase 2 of the DGWI. **Table 92** presents the statistics for all parameters detected with their Class GA groundwater standards and guidance values, and detected parameters with no Class GA groundwater standards and guidance values.

The dominant VOCs detected in Plant Study Area deep groundwater included benzene, 1,2-dichloroethane, chlorobenzene, toluene, acetone, and total xylenes. These parameters were detected at the highest frequencies and/or concentrations, as well as highest number of exceedances above the Class GA standards and guidance values (**Table 92**). Additional VOCs detected included ethylbenzene, acetone, chloroform, carbon disulfide, 1,2-dichloropropane, 1,1-dichloroethane, and 2-butanone but at a lower detection frequency and/or lower concentrations. Concentration isopleths for benzene and Total BTEX were plotted on **Figure 38c** for Phase 1 Round 1 data and **Figure 39c** for Phase 1 Round 2 data. Benzene, chlorobenzene, and toluene were detected at their maximum concentrations (11,000 μg/L, 13,000 μg/L, and 15,000 μg/L, respectively) in WA-1D, with elevated concentrations for benzene also detected in WA-2D (**Tables 85 and 89**). Detected BTEX concentrations ranged from 1.3 μg/L to 26,000 μg/L. The elevated concentrations at WA-1D and WA-2D are due to their location on the lakeshore property and proximity to the DNAPL plume.

Chlorinated benzenes and naphthalene were the SVOCs detected at the highest frequencies and/or concentrations, as well as highest number of exceedances above the Class GA standards and guidance values. Assorted PAHs, phenols, and phthalates were among the SVOCs observed at a lower detection frequency and/or lower concentration (**Table 92**). Concentration isopleths for chlorinated benzenes (including chlorobenzene from the VOC analysis) were plotted on **Figure 40c** for Phase 1 Round 1 data and **Figure 41c** for Phase 1 Round 2 data. The chlorinated benzenes were only detected in WA-1D, WA-2D, and WA-7D, with the sources of the chlorinated benzenes being the same for WA-1D and WA-2D discussed above. Well WA-7D is situated in the middle of the Plant Area adjacent to the Former Chlorination Building.

Inorganics including manganese, sodium, magnesium, iron, and barium were detected at the highest frequencies and/or concentrations, as well as highest number of exceedances above the Class GA standards and guidance values (**Table 92**). These parameters and the other detected inorganics were detected throughout the Plant Area without any one monitoring well containing the only set of elevated concentrations. Mercury was only detected in three samples (WA-2D, WA-4D, and WA-6D) with low concentrations and one Class GA standard exceedance. Concentration isopleths for mercury were plotted on **Figure 42c** for Phase 1 data.

A comparison of the unfiltered and filtered metals data yielded a mixture of results with some metals decreasing due to filtration and others increasing post-filtration. The evaluation of the metals analytical data was performed without regard for concentrations. Most metals for the Plant Study Area deep groundwater had a mean concentration that decreased following sample filtration, with a minimum decrease of 18%. The only metals that did not have a decreasing mean concentration were arsenic, barium, and vanadium.

Bedrock Groundwater
One groundwater sample was collected from the bedrock zone during the DGWI from the Plant Study Area. One VOC (acetone) and one SVOC (bis[2-ethylhexyl]phthalate) were detected at low concentrations below Class GA groundwater standards and are both likely laboratory contaminants.

Inorganics analyzed for were calcium, magnesium, potassium and sodium. Magnesium and sodium exceeded Class GA groundwater with concentrations of 160 mg/L and 3500 mg/L respectively.

4.6.2.2. Chlorobenzene Hot-Spots Area

Summary statistics are provided in **Table 93** for the groundwater parameters detected in the CHSA shallow groundwater for the samples collected during Phase 1 and Phase 2 of the RI, and Phase 1 and Phase 2 of the DGWI. **Table 93** presents the statistics for all parameters detected with their Class GA groundwater standards and guidance values and parameters with no Class GA groundwater standards and guidance values.

The dominant VOCs detected in CHSA shallow groundwater included benzene and chlorinated benzenes. These parameters were detected at the highest frequencies and/or concentrations, as well as highest number of exceedances above the Class GA standards and guidance values (**Table 93**). Additional VOCs detected included ethylbenzene, toluene, total xylenes, naphthalene, and miscellaneous parameters but at a lower detection frequency and/or lower concentrations. Concentration isopleths for benzene and Total BTEX were plotted on **Figure 44** for Phase 1 Round 1 data, **Figure 45** for Phase 1 Round 2 data, and **Figure 46** for Phase 2. Benzene, chlorobenzene, 1,2-dichlorobenzene, and 1,4-dichlorobenzene were detected at their maximum concentrations (5,500 µg/L, 25,000 µg/L, 9,600 µg/L, and 3,800 µg/L, respectively) During the RI in C-13, with elevated concentrations for all four parameters also detected in MW-111 (**Tables 85 and 89**). The highest concentrations for benzene, chlorobenzene, 1,2-dichlorobenzene and 1,4-dichlorobenzene were detected during the DGWI at location (6,060 µg/L, 35,800 µg/L, 14,100 µg/L, and 26,500 µg/L, respectively), with elevated concentrations for all four parameters also detected in C-13 (**Appendix B-6)**. Detected BTEX concentrations ranged from 0.1 µg/L to 6,060 µg/L. The elevated concentrations at C-13 and MW-111 are due to their proximity to the former chlorobenzene residual waste pipeline that may have leaked during its operation.

Chlorinated benzenes were the SVOCs detected at the highest frequencies and/or concentrations, as well as highest number of exceedances above the Class GA standards and guidance values during the RI field programs. Chlorinated benzenes were only analyzed for on the VOC scan during the DGWI. Phenols are the SVOCs detected at the greatest frequency and have the greatest number of Class GA exceedances (four exceedances for both 2,4-dichlorophenol and 2-chlorophenol, and two exceedances for phenol), once the DGWI data are incorporated. Assorted PAHs were among the SVOCs observed at a lower detection frequency and/or lower concentration. Concentration isopleths for chlorinated benzenes (including chlorobenzene from the VOC analysis) were plotted on **Figure 47** for Phase 1 Round 1 data and **Figure 48** for Phase 1 Round 2 data. Concentration isopleths for chlorinated benzenes (chlorinated benzenes from the VOC analysis as no SVOCs were analyzed for) were plotted on **Figure 49** for Phase 2. The chlorinated benzenes were detected at elevated concentrations in C-13 and MW-111, with the sources of the chlorinated benzenes being the same as VOCs. They were also detected at low concentrations in C-13, C-14, and MW-PW.

Inorganics including sodium, iron, manganese, chromium, arsenic, mercury, and magnesium were detected at the highest frequencies and/or concentrations, as well as highest number of exceedances above the Class GA standards and guidance values (**Table 93**). These parameters and the other detected inorganics were detected throughout the CHSA without any one monitoring well containing the only set of elevated concentrations. Concentration isopleths for mercury were plotted on **Figure 50** for Phase 1 and 2 data.

A comparison of the unfiltered and filtered metals data yielded a mixture of results with some metals decreasing due to filtration and others increasing post-filtration. The evaluation of the metals analytical data was performed without regard for concentrations. The CHSA shallow groundwater also only had three metals with an increasing mean concentration after sample filtration (arsenic, beryllium, and selenium). The remaining metals all decreased at least 25% post-filtration, with most decreasing by 73% or more.

Bedrock Groundwater
One groundwater sample was collected from the bedrock groundwater zone during the DGWI from the CHSA. VOCs detected in this sample were BTEX parameters, 1,4-dichlorobenzene, chlorobenzene, and chloroethane. Benzene was the only parameter that exceeded Class GA standards and guidance values with a concentrations of 2.1 µg/L (**Appendix B-6).** SVOCs were not detected in the bedrock groundwater sample from the CHSA. Inorganics analyzed for were calcium, magnesium, potassium and sodium. Sodium exceeded Class GA groundwater with a concentration of 1,620 mg/L.

4.6.2.3. Petroleum Storage Area

Shallow Groundwater
Summary statistics are provided in **Table 94** for the groundwater parameters detected in the PSA shallow groundwater for the samples collected during Phase 1 and Phase 2 of the RI, and Phase 1 and Phase 2 of the DGWI. **Table 94** presents the statistics for all parameters detected with their Class GA groundwater standards and guidance values and parameters with no Class GA groundwater standards and guidance values.

The dominant VOC detected in PSA shallow groundwater was benzene, with toluene , totalxylenes,, and ethylbenzene making up the majority of VOC detections (**Tables 85, 89 and Appendix B-6**). Benzene was detected above Class GA standards (**Table 94)** in all eight samples, and had a maximum concentration of 4,400 µg/L (PS-1). Concentration isopleths for BTEX were plotted on **Figure 51** for Phase 1 Round 1 data and **Figure 52** for Phase 1 Round 2 data. Detected BTEX concentrations ranged from 4 µg/L to 4,400 µg/L. The elevated concentrations of benzene are likely due to the use of this area to formerly store No. 2 fuel oil.

Assorted PAHs and phenols were the SVOCs detected in the shallow groundwater. Naphthalene was detected at the highest concentration (1,600 µg/L) in PS-3SR (**Appendix B-6**).

Inorganics including sodium, magnesium, manganese, iron, chromium, and lead were detected at the highest frequencies and/or concentrations, as well as highest number of exceedances above the Class GA standards and guidance values (**Table 94**). These parameters and the other detected inorganics were detected throughout the PSA without any one monitoring well containing the only set of elevated concentrations. Concentration isopleths for mercury were plotted on **Figure 53** for Phase 1 data.

A comparison of the unfiltered and filtered metals data yielded a mixture of results with some metals decreasing due to filtration and others increasing post-filtration. The evaluation of the metals analytical data was performed without regard for concentrations. The mean concentration decreased for all metals except sodium after filtering the samples in the PSA shallow groundwater. Most of these metals (*i.e.*, aluminum, chromium, cobalt copper, iron, lead, magnesium, and nickel) decreased at least 58% due to the sample filtering.

Deep Groundwater
Summary statistics are provided in **Table 95** for the groundwater parameters detected in the PSA Deep groundwater for the samples collected during Phase 1 and Phase 2 of the RI, and Phase 1 and Phase 2 of the

DGWI. **Table 94** presents the statistics for all parameters detected with their Class GA groundwater standards and guidance values and parameters with no Class GA groundwater standards and guidance values.

The dominant VOCs detected in PSA deep groundwater were benzene and total xylenes. Benzene was detected in two of the three samples, had a maximum concentration of 42 µg/L, and had two exceedances of its Class GA standard (**Table 95**). Xylenes were only detected in the Phase 1 round 1 sample (43 µg/L; **Table 85**). Other VOCs detected included 1,1,2,2-tetrachloroethane, carbon disulfide, ethylbenzene, tetrachloroethene, and toluene. Concentration isopleths for BTEX were plotted on **Figure 51** for Phase 1 Round 1 data and **Figure 52** for Phase 1 Round 2 data.

Naphthalene, phenol, and 2-methylnaphthalene were the only SVOCS detected in PS-3D. The maximum detected concentration was naphthalene at 3 µg/L (**Table 95)**.

Inorganics including magnesium, sodium, beryllium, iron, and manganese were detected at the highest frequencies and/or concentrations, as well as highest number of exceedances above the Class GA standards and guidance values (**Table 95**). Mercury was only detected in the filtered Phase 1 Round 1 sample. Concentration isopleths for mercury were plotted on **Figure 53** for Phase 1 data.

A comparison of the unfiltered and filtered metals data yielded a mixture of results with some metals decreasing due to filtration and others increasing post-filtration. The evaluation of the metals analytical data was performed without regard for concentrations. Similar to the PSA shallow groundwater, most deep groundwater sample metals decreased at least 65%. The only metals that increased with post-filtration were mercury and sodium.

Bedrock Groundwater
One groundwater sample was collected from the bedrock groundwater zone during the DGWI from the PSA. VOCs and SVOCs were not detected in this sample (**Appendix B-6).** Inorganics analyzed for were calcium, magnesium, potassium and sodium. Magnesium and sodium exceeded Class GA groundwater with concentrations of 100 mg/L and 270 mg/L respectively.

4.7. P.A. SEWER AND MILL WATER INTAKE CHARACTERIZATION

Water samples were collected from the P.A. Sewer and the Mill Water Intake during Phase 2 of the RI to evaluate the potential for these subsurface utilities to act as residual migration pathways. Samples were collected from one upgradient manhole and one downgradient manhole of the P.A. Sewer. Two samples were also collected from access points of the Mill Water Intake, including an access point at the Mill Water Intake pipe along the lakeshore property (LSWI) and an access point on the Semet Residue Ponds Site (SPWI). Analytical data for these samples are presented on **Tables 96 to 99**, with the NYSDEC split sample data presented in **Tables 96a to 99a**. Sample locations are presented on **Figures 4 and 5**.

4.7.1. P.A. Sewer

The VOCs detected in the P.A. Sewer samples were higher in the downstream sample (P.A.S Down) than the downstream sample (P.A.S Up). These parameters included chlorinated benzenes, benzene, chloroform, and naphthalene in P.A.S. Down, and those 1,2,4- and 1,3,5-trimethylbenzene, 1,2- and 1,4-dichlorobenzene, benzene, bromobenzene, chlorobenzene, chloroform, cis-1,2-dichloroethene, dibromochloromethane, ethylbenzene, naphthalene, toluene, and total xylenes. Benzene exceeded its Class GA standard on both samples, while 1,2-, 1,3-, and 1,4-dichlorobenzene and chlorobenzene exceeded their Class GA standards in P.A.S. Down (**Table 96**). Chloroform also exceeded its Class GA standard in P.A.S. Up. The maximum concentration detected was for chlorobenzene in P.A.S. Down at 150 µg/L (**Table 96**). The remaining VOCs were detected at concentrations of 2.1 µg/L or lower. The detected VOCs in P.A.S. Up indicate some input from Site shallow groundwater on the P.A. Sewer, and the increase in chlorinated benzenes at P.A.S. Down demonstrates shallow groundwater from the Site is entering the P.A. Sewer.

For the PCB and pesticide analyses, only hexachlorobenzene was detected in WA-P.A.S. Down at a concentration of 0.57 µg/L (**Table 98**). This concentration does exceed its Class GA standard of 0.04 µg/L.

Mercury was the only inorganic analyzed for in P.A.S Up and P.A.S Down. Similar to the chlorinated benzenes, mercury concentration increased between the upstream and downstream samples slightly (0.0005 mg/L to 0.013 mg/L; **Table 99**). The concentration from WA-P.A.S. Down exceeded its Class GA standard. This indicates some input from the Site shallow groundwater to the P.A. Sewer.

4.7.2. Mill Water Intake

Only four VOCs were detected in the two samples collected from the Mill Water Intake (L.S.W.I. and S.P.W.I) and included 1,1,1-trichloroethane, acetone, and chlorobenzene in L.S.W.I and chloroform in S.P.W.I. The concentrations did not exceed 6 μg/L or their Class GA standards (**Table 96**).

Similar to the VOCs, BEHP was the only SVOC detected in the samples (**Table 97**). The maximum concentration was 1.4 μg/L, which did not exceed its Class GA standard.

There were no PCBs or pesticides detected in L.S.W.I. and S.P.W.I (**Table 98**).

Among the metals detected in these two samples were aluminum, arsenic, calcium, copper, iron, magnesium, mercury, potassium, sodium, and zinc. Only calcium, magnesium, potassium, and sodium were present in lakeshore property sample, with sodium exceeding its Class GA standard (**Table 99**). Mercury (0.0023 mg/L) and sodium (240 mg/L) exceeded their Class GA standards in the Semet Ponds Site sample. The remaining metals were generally detected at concentrations less than 23 mg/L, with a maximum concentration 140 mg/L (**Table 99**).

Based on these analytical results, the Site is not impacting the Mill Water Intake pipe. This seems to be the case for groundwater from Plant Area (due to connected piping), Semet Ponds Site, and the lakeshore property.

4.8. DNAPL TARGOST® PROBING

TarGOST® probing was shown to be effective in detecting the presence of DNAPL within each of the investigation areas on the lakeshore property and generally correlated with the DNAPL observed in previous soil borings discussed in Section 1.5.1. These borings are presented on Figure 2 in **Appendix B-1**.TarGOST® probing was used to further characterize the horizontal and vertical distribution of DNAPL in the two lakeshore areas. A full report of this investigation was provided to the NYSDEC on March 31, 2011.

The previous soil borings and more recent TarGOST® probes indicate that DNAPL is present within Investigation Areas 1 and 2 (Figure 2 in **Appendix B-1**). Solvay waste material is not present in Investigation Area 1. Therefore, the DNAPL is only present in the marl/trans-marl in this area. Within Investigation Area 2, DNAPL is present within the Solvay waste material, at the Solvay waste/marl interface, and the marl.

Based on the TarGOST® results and previous boring information, three DNAPL recovery wells were installed to evaluate the recoverability of DNAPL from the Solvay waste (RW-14), the Solvay waste/marl interface (RW-13), and the marl/trans-marl (RW-12). Two weeks subsequent to recovery well installation, approximately 0.4 ft, 1.2 ft, and 7.8 ft of DNAPL had accumulated in the Solvay waste/marl interface, marl/trans-marl, and Solvay waste recovery wells, respectively. Following the investigation, RW-14 was incorporated into the DNAPL recovery system, and RW-12 and RW-13 were kept as monitoring wells.

5. RESIDUALS FATE, PERSISTENCE, AND TRANSPORT

The nature and extent of residuals in various media was described in Section 4. Compounds detected in soils, groundwater and sediment at the greatest frequency included benzene and other BTEX parameters, chlorinated benzenes, naphthalene, phenolic compounds, PCBs, PCDD/Fs, and mercury. This section provides a discussion of possible migration mechanisms for these compounds. Additional compounds detected in the Site media included pesticides and Solvay Process-related metals, but these compounds are not discussed in this section. These were not considered for this discussion due to irregular detection frequency (pesticides) or nutrient-based nature of the parameters (metals).

Based on data generated during completion of the RI and the physical characteristics of the Site, the following potential transport mechanisms were evaluated:

- Transport of residuals from soils to surface water bodies via surface water runoff.
- Groundwater transport of residuals.
  - Transport of elemental mercury and chlorinated benzene DNAPL.
- Transport of residuals to surface water bodies via underground utilities.
- Transport of residuals to Onondaga Lake via surface water.
- Vapor migration of volatile residuals.

The fate and transport mechanisms presented in this section should be viewed within the framework of the ongoing IRMs and remedial actions. These efforts are discussed in Section 1.5.

5.1. TRANSPORT OF RESIDUALS FROM SOILS TO SURFACE WATER BODIES VIA SURFACE WATER RUNOFF

Transport of residuals from soils to surface water bodies via surface water runoff is not considered to be significant due to the fact that the majority of the Plant Study Area is covered with the Willis/Semet GWTP, soil piles, concrete, asphalt, and fill materials. Isolated areas where residuals were detected in surface soils include the Northwest Ditch, Semet Ponds ditch, the drainage ditch near Outfall 004, the drainage ditch near Outfall 006, and the Former Chlorination Building. These areas would not be expected to significantly impact surface water bodies, such as Tributary 5A or Onondaga Lake via overland flow since they are porous, very rarely receive surface water flow, and are located a considerable distance from nearby surface water bodies. For example, flow has not been observed at Outfalls 004 and 006 since the inception of the SPDES discharge permit. Flow would also not be expected in the northwest ditch due to the high permeability of the fill materials which cover the Plant Area. However, these areas may contribute to groundwater contamination via the infiltration of rainwater, and shallow groundwater ultimately discharges to Tributary 5A and Onondaga Lake.

5.2. GROUNDWATER TRANSPORT OF RESIDUALS

5.2.1. Organic Compound Transport in Groundwater

5.2.1.1. Willis Avenue Plant Study Area

Organic parameters most frequently detected in groundwater were benzene, chlorinated benzenes, phenols, and naphthalene. Onondaga Lake is the area of groundwater discharge from the shallow, intermediate, and deep groundwater from the Plant Study Area and, therefore, defines the northern extent of groundwater migration from the Plant Study Area. Based on regional groundwater flow, Onondaga Lake is also the most likely recipient of the dissolved organic parameters and DNAPL observed in the Site groundwater and subsurface soils. The impacts of Site groundwater on Onondaga Lake are being addressed in the Onondaga Lake RI/FS and the Willis/Semet Barrier Wall IRM. Based on data collected during the Substance Distribution Investigation (PTI, 1993), sediments in Onondaga Lake adjacent to the lakeshore property have been impacted by Site-related VOCs (*i.e.*, chlorinated benzenes). DNAPL was observed in lake sediment samples collected from downgradient of the

Site in sediment cores during the Onondaga Lake 2000 Phase 2A investigation and 2002 piezometer installation (NYSDEC/TAMS, 2002).

Dissolved Organic Parameters
Per Site groundwater flow maps (**Figures 16 through 23**), shallow and intermediate groundwater flows towards the north and northeast of the Plant Area, which is towards Onondaga Lake. This is also the general flow pattern for the deep groundwater. The detected VOCs and SVOCs in the monitoring wells from the Plant Study Area, especially the lakeshore property, indicate that some of the dissolved parameters have migrated towards Onondaga Lake. It is also likely that these dissolved parameters are related to the DNAPL that has migrated to the lakeshore property and Onondaga Lake (discussed below).

DNAPL
Along with the organic parameters dissolved in groundwater, DNAPL has migrated to Onondaga Lake in the intermediate groundwater aquifer moving along and within the marl unit. In the past, some DNAPL migrated beneath the lake in the immediate vicinity of the shore. Based on DNAPL found beneath the lake, the barrier wall alignment was adjusted and extended into the lake to contain these compounds and facilitate the installation of the groundwater and DNAPL collection systems.

The DNAPL was detected in monitoring wells MW-1I and MW-2I during RI groundwater sampling. DNAPL has also been detected in several recovery and monitoring wells in the lakeshore property associated with the DNAPL IRM. The western extent of the DNAPL is defined by the Mill Water Intake. The eastern extent of DNAPL is defined by soil boring SB-1, which was installed by Groundwater Technology in 1993 (**Figure 4**). The extent of the DNAPL present along the lakeshore was further refined in the pre-design investigation work associated with the DNAPL Recovery System Design (Honeywell, 2011). Figure 2 in **Appendix B-1** presents the extent of DNAPL found in the additional borings advanced in 2010. DNAPL may also be present in the northern portion of the Plant Area. DNAPL has been observed during completion of soil borings in this area. The quantity of DNAPL in the Plant Area is likely to be minimal compared to that in the lakeshore property.

Based on the available information, the vertical extent of residuals in groundwater is the top of weathered bedrock (till). Groundwater flows from the bedrock into the overburden in this area since Onondaga Lake is a regional discharge area. Although residuals have reached the deep groundwater zone, the concentrations are significantly lower than those in the intermediate zone and are focused at the WA-1 well nest. The highest concentrations of process-related compounds in the groundwater occur in the intermediate zone. DNAPLs also occur in the intermediate zone. The presence of silts and clays below the screened interval of the intermediate wells is likely limiting the vertical migration of chlorinated benzenes DNAPL to the deeper groundwater zone. This has been validated by the DNAPL IRM. Groundwater recharge by precipitation and the permeable nature of the fill in the shallow groundwater zone is likely affecting the quality of groundwater in the shallow zone by reducing the concentration of Site-related compounds; however, we do not have the temporal data to support this.

5.2.1.2. Chlorobenzene Hot-Spot Area

Dissolved VOCs in shallow groundwater in the CHSA likely migrate north towards the CSX Railroad tracks. However, data collected during Phase 2 sampling suggest that VOCs are migrating to some extent to the north. Based on the very low hydraulic conductivities ($3x10^{-2}$ cm/sec to $5x10^{-5}$ cm/sec) observed in this area, migration of VOCs from this area would be minimal. Migration of contaminants in groundwater may be greater in areas where fill materials (*e.g.*, Solvay waste, coal, ash, and cinders) are present. If VOCs were to migrate, they would have historically discharged to Tributary 5A. Due to the liner and collection system installed as part of the Semet Ponds Site Shallow Groundwater Remedial Action, this shallow groundwater and associated constituents are collected and treated at the Willis/Semet GWTP. There is also no silt/clay confining unit below the fill in this area. It is possible that groundwater constituents migrate vertically downward in this area into till and bedrock; however, the flow is likely to be minimal due to the low permeability of the fill and materials discussed in Section 3.3.2.4.

5.2.1.3. Petroleum Storage Area

Tributary 5A provides horizontal control of the shallow groundwater from the PSA by acting as a groundwater discharge boundary. Benzene was the primary VOC detected at the PSA and is relatively mobile in groundwater based on its K_{ow} and is likely being transported downgradient from the PSA towards Tributary 5A. This shallow groundwater is now collected by the groundwater collection trench installed as part of the Semet Ponds Shallow Groundwater Remedial Action and treated at the Willis/Semet GWTP. There is the potential for groundwater to discharge to drainage swales adjacent to the property (**Figures 4 and 6**) if shallow groundwater elevations are high enough. However, this is unlikely due to the shallow nature of these drainage swales.

5.2.2. Transport of PCBs and PCDD/Fs in Groundwater

Transport of PCBs and PCDD/Fs via groundwater is not a viable transport mechanism due to the strong affinity of these compounds to sorb to particulate matter and their very low water solubilities (ATSDR, 1998). However, the presence of organic co-solvents enhances the mobility of PCBs and PCDD/Fs. This facilitated transport mechanism can be significant at co-solvent concentrations greater than a few percent (USEPA, 1989c). The presence of benzene and chlorobenzene in Site groundwater may be increasing mobility of these constituents at the Site. Due to the high affinity of these constituents to sorb to subsurface particles, it may also alter and facilitate their mobility in groundwater (USEPA, 1989c). However, there are no groundwater data to support this.

5.2.3. Transport of Mercury in Groundwater

Elemental mercury encountered near the former Mercury Cell Building in the Plant Area could be transported by two mechanisms: 1) by acting as a source of dissolved mercury to groundwater and 2) transport as elemental mercury.

5.2.3.1. Transport of Dissolved Mercury in Groundwater

Elemental mercury droplets were encountered in the shallow groundwater zone within fill materials in the Plant Area, in the footprint of the former Mercury Cell Building. At one location (MC-B7), elemental mercury extended into the marl unit and the intermediate groundwater zone. The dissolved mercury detected at downgradient locations (WA-7S and WA-7I) in the shallow and intermediate groundwater zones may be attributed to the area containing elemental mercury droplets. Based on data collected during the Substance Distribution Investigation (PTI, 1993), sediments in Onondaga Lake adjacent to the Site have been impacted by Site-related metals, including mercury.

5.2.3.2. Transport of Elemental Mercury in Groundwater

For the most part, the migration of elemental mercury in the subsurface is expected to occur in zones of continuous mercury. In such zones, the elemental mercury in different pore openings forms a continuum. Once the release of mercury to the subsurface ceases, the forces driving its movement dissipate and the elemental mercury in the pore spaces becomes disconnected. These disconnected droplets and globules form a zone of residual elemental mercury. These residual droplets and globules will remain immobilized unless environmental conditions change sufficiently that they are remobilized. Experiments and case studies of chlorinated DNAPLs behavior in the subsurface have demonstrated that these denser than water materials typically reach residual conditions relatively rapidly once the source is discontinued (Cohen and Mercer, 1993 and Pankow and Cherry, 1996). Since the source of elemental mercury was discontinued over 20 years ago, it is expected that the elemental mercury droplets and globules have been at residual conditions for approximately 20 years. This suggests that the elemental mercury droplets are immobile and would not be expected to become mobile in the future. This hypothesis is supported by the fact that the horizontal extent of elemental mercury was confined to the foot print of the former Mercury Cell Building, where it was originally introduced and the vertical extent of elemental mercury was confined to the upper unconsolidated geologic units (fill, peat and marl) and did not extend to till.

Should elemental mercury droplets eventually reach the top of the silt layer, an extremely high horizontal gradient would be required to transport droplets along the silt lens. The critical horizontal gradient (ic) that must exist across an elemental mercury "pool" of length L beneath the water table to overcome capillary resistance and mobilize the elemental mercury is calculated by (USEPA, 1993):

$$ic = 2\sigma * \cos(\varphi) / r\rho_w gL$$

where σ = interfacial tension between mercury and water (N/m), φ = contact angle (°), r = pore radius (m), ρ_w = density of water (kg/m^3), L = length of pool (m), and g = acceleration due to gravity (m/sec^2).

Using a pore size of 8 x 10^{-6} m that corresponds to the silty sand unit (USEPA, 1993) and an interfacial tension of 0.375 N/m for mercury, the critical hydraulic gradients for mobilization of pools of different lengths were calculated to be, 94.2, 18.8, and 9.4 for pool lengths of 0.1 m, 0.5 m, and 1 m, respectively (Gradient, 1997). Since the maximum theoretical hydraulic gradient in the environment is 1.0 ft/ft, the calculated gradients are infeasible. For reference, the calculated gradient for the intermediate groundwater aquifer was 0.015 ft/ft. As a result, it can be concluded that even if elemental mercury droplets or globules were to reach the top of the silt layer that they would not be expected to be mobile.

5.3. TRANSPORT OF RESIDUALS TO ONONDAGA LAKE VIA UNDERGROUND UTILITIES

Transport of residuals from the Site via underground utilities is not considered to be significant due to the fact that few Site-related residuals were detected in the Mill Water Intake and P.A. Sewer. Few residuals were detected in either pipe, with a slight increase in chlorinated benzene concentrations between the upstream and downstream samples from the P.A. Sewer. Additionally, the P.A. Sewer is scheduled to be abandoned after bypass system is installed that redirects the stormwater to the Main Sewer as discussed in Section 1.5.6.

5.4. TRANSPORT OF RESIDUALS TO ONONDAGA LAKE VIA SURFACE WATER

Transport of residuals via surface water bodies to Onondaga Lake is not considered possible due to the East Flume IRM and Semet Ponds Shallow Groundwater Remedial Action. The East Flume was removed as part of the East Flume IRM. As part of the Semet Ponds Shallow Groundwater Remedial Action, Tributary 5A sediment that contained Site-related residuals was removed up to a depth of 8 ft bgs along the length of the water body, and a groundwater collection system was installed along its length to collect shallow groundwater and the Site-related (and Semet Ponds Site-related) parameters.

5.5. VAPOR MIGRATION OF VOLATILE RESIDUALS

Volatile constituents in Site soils and groundwaters can vaporize, migrate through soil as soil vapor, and enter the atmosphere or the buildings on-site. The Willis/Semet GWTP is constructed on-site and consideration was given to potential vapor intrusion, and the design included a vapor barrier and the installation of a venting system. Similar preventative measures may be included in the design and construction of any future buildings at the Site to mitigate the risk of exposure to on-Site soil gas.

5.6. RESIDUE FATE AND PERSISTENCE

Analytical results obtained during the RI and subsequent IRM investigations suggest that certain process residues are being leached from the soil. Compounds detected in soils and groundwater at the greatest frequency included benzene, toluene, chlorinated benzenes, phenolic compounds, PAHs, and mercury. Other compounds detected included PCBs and PCDD/Fs. A chlorinated benzene DNAPL was encountered on the lakeshore property, in the vicinity of the former Mercury Cell Building, and in the CHSA, and elemental mercury was encountered within the footprint of the former Mercury Cell Building.

Table 100 shows the relevant environmental fate data for the potentially site-related compounds detected during the investigation. This table gives the water solubility, organic carbon partition coefficient (K_{oc}), octanol-water partition coefficient (K_{ow}), and aquatic degradation rates for these compounds. The K_{oc} values for these compounds are a rough estimate of their mobility in soil. Table 5.1 shows the relationship between K_{oc} and mobility:

Table 5-1 Relationship Between K_{oc} and Mobility

K_{oc}	Mobility Class
0 - 50	Very High (acetone, chloroform, phenol)
50 - 150	High (carbon disulfide)
150 - 500	Medium (chlorobenzene, toluene, xylene)
500 - 2,000	Low (dichlorobenzene, naphthalene, ethylbenzene)
2,000 - 5,000	Slight
greater than 5,000	Immobile (fluoranthene, pyrene, PCBs)

Notes:
Site-related example parameters are listed each mobility class listed above.
Source: Swann, RL *et al*., 1985.

Once in groundwater, benzene and chlorinated benzene compounds are subject to chemical and microbial degradation. Metabolites of benzene include phenol and methylated phenols (Howard, 1989). A large number of bacteria and fungi found in the environment are capable of degrading chlorobenzene and mineralizing it. The products of this biodegradation are 2-chlorophenol and 4-chlorophenol (Howard, 1989). It should be noted that degradation of chlorobenzene is generally slow. Dichlorobenzenes are slowly degraded in aerobic conditions and are not expected to be degraded in anaerobic conditions. 1,2,4-trichlorobenzene degrades slowly in both aerobic and anaerobic conditions (Howard, 1989). Ethylbenzene also degrades slowly in anaerobic conditions but degrades quickly in aerobic conditions. The chlorinated benzene compounds comprising the DNAPL are not expected to biodegrade due to the fact that microorganisms are not likely to become acclimated to the DNAPL.

PCBs are hydrophobic compounds that have a strong affinity to bind to soils and sediments. PCBs degrade naturally in the environment via anaerobic dechlorination and aerobic degradation (Abramowicz *et al.*, 1992), however, the amount of PCB loss is minimal. Anaerobic bacteria typically attack the higher chlorinated PCB congeners through reductive dechlorination resulting in lower chlorinated, ortho-substituted PCB congeners. The less chlorinated PCB congeners are suitable substrates for oxidative degradation by a wide range of aerobic organisms. Anaerobic processes, in subsurface strata, account for a majority of PCBs degradation. Half-lives of approximately 3 years have been documented (Abramowicz et al., 1992).

PCDD/Fs are stable hydrophobic and lipophilic compounds which are highly persistent in the environment. Leaching of PCDD/Fs to groundwater is not likely due to their very low water solubilities and high affinity to become sorbed to soils (Agency for Toxic Substances and Disease Registry [ATSDR], 1998). However, the mobility of PCDD/Fs can be enhanced in the presence of organic solvents. Degradation of PCDD/Fs occurs rapidly via photolysis in aqueous solution within surficial materials (1 to 3 cm in depth). However, decomposition occurs slowly in soils as photolysis in this medium is limited by light penetration. Half-lives of 9 to 15 years for surface soils and 25 to 100 years for subsurface soils have been estimated (Paustenbach *et al.*, 1992).

Mercury is present in the environment in inorganic and organic forms. Inorganic mercury exists in three valence states: mercuric (Hg^{2+}), mercurous (Hg^{2+}), and elemental (Hg^0) mercury (Nriagu, 1979). Inorganic mercuric compounds are strongly retained in soils containing an organic component; whereas, soils (particularly subsoils) lacking organic matter may allow the translocation and leaching of the Hg, with groundwater transport as the dominant mechanism. However, the mobility of mercury may be enhanced by the conversion to Hg^0, which results in the vaporization of mercury and potential evasion into the atmosphere. The abiotic and biotic transformation of inorganic mercury within the soil can form the organic mercuric compounds (*e.g.*, methylmercury (MeHg), dimethylmercury). Organic mercurials have a higher mobility subsequent to methylation as they are only partially inactivated by strong adsorption to the soil material, with

dimethylmercury evading to the atmosphere more rapidly than MeHg and leaching occurring in permeable soils. Additionally, other soil mechanisms have been observed that prevent the accumulation of organic mercurials (*i.e.*, demethylation, *etc.*). Organic mercuric compounds generally make up less than one percent of the total Hg present in the soil.

6. COMPARISON OF ANALYTICAL RESULTS TO APPLICABLE STANDARDS AND/OR GUIDANCE VALUES

6.1. COMPARISON OF GROUNDWATER AND SURFACE WATER CONCENTRATIONS TO STANDARDS AND GUIDANCE VALUES IN 6NYCRR PART 702 AND NYSDEC TOGS 1.1.1. AMBIENT WATER QUALITY STANDARDS AND GUIDANCE VALUES

At the request of NYSDEC, groundwater and surface water analytical results were compared to applicable standards and guidance values.

6.1.1. Groundwater

Groundwater results were compared to class GA standards obtained from 6 New York Code of Rule and Regulations (NYCRR) Part 703 and NYSDEC *TOGS 1.1.1 Ambient Water Quality Standards and Guidance Values* (NYSDEC, 1998b). The principal organic contaminant (POC) standard was used for compounds meeting the POC description found in TOGS 1.1.1 and for which a specific standard was not available. Guidance values, if available, were used for compounds for which standards have not been assigned. The standards or guidance values are included in the groundwater analytical results tables (**Tables 85 through 89**). Plant Area groundwater summary statistics for detected constituents are presented in **Tables 90, 91, and 92** for shallow, intermediate, and deep groundwater, respectively. Shallow groundwater summary statistics for detected constituents are presented in **Tables 93 and 94** for the CHSA and PSA, respectively.

6.1.2. Surface Water

Tributary 5A surface water results were compared to class C surface water standards obtained from 6 NYCRR Part 703 and NYSDEC *TOGS 1.1.1 Ambient Water Quality Standards and Guidance Values* (NYSDEC, 1998b). For compounds which contain multiple Class C standards for various water uses, the lowest (most conservative) value was used for the comparison. Guidance values, if available, were used for compounds for which standards have not been assigned. The standards or guidance are included in the surface water analytical results tables (**Tables 74 through 77 and Tables 78 through 83**). Tributary 5A surface water summary statistics for detected constituents are presented in **Table 84**.

6.2. COMPARISON OF SOIL AND SEDIMENT CONCENTRATIONS TO SCREENING GUIDANCE

At the request of NYSDEC, soil and sediment analytical results were compared to soil and sediment screening guidance.

6.2.1. Soil

Soil analytical results were compared to NYSDEC Part 375-6 Remedial Program Soil Cleanup Objectives – Restricted Use – Industrial (NYSDEC, 2006). NYSDEC criteria were taken directly except for inorganic compounds for which the cleanup objective was listed as a site background value. In the absence of Site-specific background data, the lowest of three available background values was used. Background values were obtained from Soil Chemistry of Hazardous Materials (Dragun, 1988), Background Concentrations of 20 Elements in Soils with Special Regard for NYS (McGovern, 1988), and Geotechnical Behavior of Solvay Waste (Kulwahy, 1977). The PCDD/F TEFs were taken from Van den Berg *et* al. (2006). The guidance are included in the analytical results tables for surface soils (**Tables 29 to 25**), and subsurface soils (**Tables 8 to 12, 13 to 15, 16 to 18, 19 to 21a, and 22 to 39**). Surface soil summary statistics for detected constituents are presented on **Tables 54, 54, and 55** for the Plant Study Area, CHSA, and PSA, respectively. Subsurface soil summary statistics for detected constituents are presented on **Tables 26, 27, and 28** for the Plant Study Area, CHSA, and PSA, respectively.

6.2.2. Sediment

Sediment results were compared to screening values obtained from Technical Guidance for Screening Contaminated Sediments (NYSDEC, 1999). Consistent with the procedure utilized for the ERA, a total organic carbon value of 2.14% was used to calculate criteria for organic compounds. This value was derived from the minimum value observed in Tributary 5A. The organic analytical results were compared to the human health bioaccumulation and benthic chronic screening values to account for a wide range of potential receptors. Inorganic analytical results were compared to the lowest effect levels and severe effect levels. The criteria are

included in the sediment analytical results tables (**Tables 59 to 63 and 64 to 72**). Tributary 5A sediment summary statistics for detected constituents are presented in **Table 73**.

6.3. PRELIMINARY CHEMICAL PARAMETERS OF INTEREST

The Site preliminary CPOIs for the Plant Study Area, CHSA, PSA, and Tributary 5A were selected from the detected constituents if one of the following criteria was met.

- The constituent was detected in 20% or more of the samples
- The constituent exceeded screening or guidance values in at least one sample
- The constituent was a known bioaccumulator.

These full lists of CPOIs are included in **Table 101**. Based on this investigation, the key CPOIs for each study area are identified below.

Plant Study Area Soils and Groundwater

- Organic CPOIs: BTEX compounds, chlorinated benzenes (mono-, di-, and tri- isomers), PAHs (primarily naphthalene), phenolic compounds, Aroclors 1254 and 1260, and PCDD/Fs.
- Inorganic CPOIs: Mercury and Solvay Process-related parameters (aluminum, calcium, iron, magnesium, potassium, and sodium).

CHSA Soils and Groundwater

- Organic CPOIs: Benzene, BEHP, chlorinated benzenes (mono-, di-, tri-, and hexa- isomers), PAHs, and Aroclor 1254.
- Inorganic CPOIs: Mercury and Solvay Process-related parameters (aluminum, calcium, iron, magnesium, potassium, and sodium).

PSA Soils and Groundwater

- Organic CPOIs: BTEX compounds, chlorinated benzenes (mono-, di-, and tri- isomers), naphthalene, and phenolic compounds.
- Inorganic CPOIs: Mercury and Solvay Process-related parameters (aluminum, calcium, iron, magnesium, potassium, and sodium).

Tributary 5A Sediment and Surface Water

- Organic CPOIs: BTEX compounds, chlorinated benzenes (mono- and di- isomers), PAHs, phenolic compounds, BEHP, and Aroclors 1248, 1254, and 1260.
- Inorganic CPOIs: Metals, including mercury and Solvay Process-related parameters (aluminum, calcium, iron, magnesium, potassium, and sodium).

7. HUMAN HEALTH RISK ASSESSMENT

An HHRA is performed to provide the necessary risk information needed to assist in the decision making process at remedial sites. The risk assessment is used to provide the following items (USEPA, 1989b):

- An analysis of baseline risks
- Evaluation of the need for remedial action at sites
- A basis for evaluating levels of constituents that can remain onsite and be adequately protective of public health, and
- A basis for comparing potential impacts of various remedial alternatives.

The Willis Avenue Chlorobenzene Site HHRA was performed to assess potential impacts to public health related to the presence of chemical substances at the Site in Geddes, New York. Health risks were evaluated for potential trespassers, workers, and residents under current and future exposure scenarios. Estimated current and future cancer risks (CRs) are largely within the acceptable regulatory range (1×10^{-4} to 1×10^{-6}), except in the Former Chlorination Building exposure area, which was historically involved in the production of chlorinated benzene products. Estimated current and future non-cancer hazards are also highest in the Former Chlorination Building exposure area, with lesser regulatory exceedances found in other Site exposure areas. Across exposure areas, the construction worker, and to a lesser extent the industrial and utility workers, had higher hazard indices relative to other receptors, as a result of greater time spent in the area and greater potential exposure to contaminated media. Although Site groundwater is not used for potable water and municipal water is supplied from the Onondaga County Water Authority (OCWA), potential future residential exposure to groundwater as potable water was evaluated and found to pose unacceptable cancer risks and non-cancer hazards. Overall primary Site risk drivers include potential exposure to dioxins, mercury, PCBs, and benzene.

Risk drivers were evaluated on the basis of reasonable maximum exposure (RME) scenarios and are subject to uncertainty including but not limited to:

- Exposure point concentrations are based on the upper confidence limit of mean chemical concentrations.
- Exposure factors include conservative estimates of frequency and duration of exposure.
- Toxicity factors typically account for sensitive sub-populations.

In addition, risks are estimated separately for each exposure area. However, it is unlikely that a given receptor would spend all of their time in one exposure area. Thus, the risks and hazards shown for a given exposure area are likely an overestimate, and the true risk to a receptor would likely be a weighted average of the risks from several exposure areas.

7.1. SITE BACKGROUND

This HHRA was performed to assess potential impacts to public health related to the presence of chemical substances at the Site and related AOS (CHSA, PSA, and Tributary 5A). The objective of the HHRA was to assess potential risks to human health associated with Site-related chemical substances under current and reasonably foreseeable future land uses and to facilitate the consideration and evaluation of possible future remedial actions. The HHRA was performed as part of the RI/FS being conducted for the Site. The final HHRA was approved by the NYSDEC on August 10, 2010.

7.2. EXPOSURE AREAS, RECEPTORS, AND EXPOSURE MEDIA

Currently, the Site is not in active use, and there are no routine activities conducted on-site. The General Plant Area, which consists of the Plant Area, the Former Chlorination Building, and On-Site Ditches, is surrounded by an 8-foot high fence and is monitored by Honeywell surveillance personnel during working hours. The Plant Study Area also includes the State Fair Blvd./Northwest Off-Site/Outfall 004 and Southwest Off-Site/Outfall 006

Exposure Areas, as well as the Lakeshore Area. Three additional AOS (Tributary 5A, PSA, and CHSA) are included in the HHRA as well. Off-site areas accessible by the public include Southwest Off-Site/Outfall 006 Exposure Area, State Fair Blvd./Off-Site/Outfall 004 Exposure Area, the Lakeshore Area, Tributary 5A, PSA, and portions of the CHSA. The State Fair Blvd./Off-Site/Outfall 004 is the most easily accessible as many of the other areas have fences or railroad tracks on several sides. Based on historical observations, exposures at these areas are expected to be infrequent and of short duration. Based on current conditions at the Site and surrounding areas, the following current receptor populations were identified:

- Adolescent trespasser (Plant Area, On-Site Ditches, Former Chlorination Building, Tributary 5A, Southwest Off-Site/Outfall 006 Exposure Area, State Fair Blvd./Off-Site/Outfall 004 Exposure Area, Lakeshore Area, PSA, CHSA)
- Adult trespasser (Plant Area, Former Chlorination Building, On-Site Ditches, Tributary 5A, Southwest Off-Site/Outfall 006 Exposure Area, State Fair Blvd./Off-Site/Outfall 004 Exposure Area, Lakeshore Area, PSA, CHSA)
- Utility worker (State Fair Blvd./Off-Site/Outfall 004 Exposure Area, Lakeshore Area, Tributary 5A)
- State Fair Boulevard transient (State Fair Blvd./Off-Site/Outfall 004 Exposure Area)
- Surveillance worker (Plant Area, Former Chlorination Building, On-Site Ditches)

The Site and AOS are not expected to be developed as residential areas since the exposure areas are located in a heavily industrialized setting and are zoned industrial. Based on this consideration, the following receptors were identified under reasonably foreseeable future conditions.

- Adolescent trespasser (Plant Area, On-Site Ditches, Former Chlorination Building, Tributary 5A, Southwest Off-Site/Outfall 006 Exposure Area, State Fair Blvd./Off-Site/Outfall 004 Exposure Area, Lakeshore Area, PSA, CHSA)
- Adult trespasser (Plant Area, On-Site Ditches, Former Chlorination Building, Tributary 5A, Southwest Off-Site/Outfall 006 Exposure Area, State Fair Blvd./Off-Site/Outfall 004 Exposure Area, Lakeshore Area, PSA, CHSA)
- Adult transient (State Fair Blvd./Off-Site/Outfall 004 Exposure Area)
- Surveillance worker (Plant Area, On-Site Ditches, Former Chlorination Building)
- Industrial worker (Plant Area, On-Site Ditches, Former Chlorination Building, Southwest Off-Site/Outfall 006 Exposure Area, PSA)
- Construction worker (Plant Area, On-Site Ditches, Former Chlorination Building, Southwest Off-Site/Outfall 006 Exposure Area, PSA, CHSA)
- Utility worker (Plant Area, On-Site Ditches, Former Chlorination Building, Tributary 5A, State Fair Blvd./ Off-Site/Outfall 004 Exposure Area, Lakeshore Area, PSA, CHSA)
- Child (< 6 years) resident (Potable water)
- Adult resident (Potable water)

Exposure media considered in both current and future scenarios include soil, sediment, surface water, groundwater, and indoor air. Receptors that may be exposed to surface soils (0 to 2 ft) include trespassers, surveillance workers, industrial workers, and State Fair Boulevard transients. Construction workers and utility workers may contact upper soils (0 to 10 ft) and intermediate soils (0 to 20 ft), respectively. Trespassers and utility workers in the Tributary 5A area may be exposed to sediment and surface water. On-site groundwater occurs at a depth of approximately 15 to 20 ft bgs, while off-Site, it occurs at approximately 4 to 5 ft at the CHSA, PSA, and Lakeshore Area.

Groundwater at the Plant Study Area and at other AOS is not used as a drinking or industrial water supply and is highly unlikely to be used as a drinking or industrial supply in the future, since the area is supplied by municipal water from OCWA. However, the New York State groundwater classification for the Site and surrounding area is GA (*i.e.,* suitable for drinking use). In accordance with the NYSDEC's request, the hypothetical residential drinking water scenario was evaluated for future receptors in the risk assessment.

Hazard indices (HI) and cancer risks were derived based on the RME and central tendency (CT) concentrations for the identified receptor scenarios.

7.3. RISK DISCUSSION

In general, under current conditions, cancer risks for receptors in all exposure areas are within the acceptable regulatory range of 10^{-4} to 10^{-6}, except for the Former Chlorination Building, and hazard indices for receptors in the Plant Area, State Fair Blvd/ Northwest Off-Site/Outfall 004 Exposure Area, and the PSA are within the threshold of 1.

Under future conditions, cancer risks for receptors in all exposure areas are within the acceptable regulatory range of 10^{-4} to 10^{-6}, except for the Southwest Off-Site/Outfall 006 Exposure Area and the Former Chlorination Building. Under future conditions, hazard indices for receptors in the State Fair Blvd/Northwest Off-Site/ Outfall 004 Exposure Area are within the threshold of 1.

It should be noted that it is unlikely that a given receptor would spend all of their time in one exposure area. Thus, the potential risks and hazards shown for a given exposure area are likely an overestimate, and the true risk to a receptor would likely be a weighted average of the risks from several exposure areas.

All receptors at the Former Chlorination Building Exposure Area had estimated cancer risk values in excess of 1×10^{-4}, driven primarily by high concentrations of 2,3,7,8-TCDD equivalent in soils; this was responsible for the high HI values as well. In contrast, receptors associated with the State Fair Blvd./Northwest Off-Site/Outfall 006 Exposure Area, as well as trespassers associated with the Lakeshore Area, had HI and cancer risks below the acceptable regulatory thresholds.

Across all applicable Exposure Areas, the construction worker, and to a lesser extent the industrial and utility workers, had higher HI values relative to the other receptors. This is a function of the assumptions of greater time spent in the area and greater exposure to contaminated media for these receptors relative to others.

The calculated RME HI for the future adult resident and child resident at the hypothetical drinking water source area were 2×10^{2} and 4×10^{2}, while the RME cancer risks were 1×10^{-2} and 7×10^{-3}, respectively. These values were attributable primarily to exposure to the maximum detected concentration of benzene in groundwater. Groundwater at the Site is not suitable for use as a drinking water supply irrespective of any contributions related to waste at the Site. The drinking water pathway was included in this section at the request of NYSDEC; however, this is considered to be an incomplete pathway under reasonably foreseeable land use scenarios.

8. BASELINE ECOLOGICAL RISK ASSESSMENT

The BERA is a component of the RI/FS being conducted at the Site. The objectives of the BERA, as outlined in ERAGS (USEPA, 1997b), are as follows:

- document whether actual or potential ecological risks exist at a site
- identify which contaminants present at a site pose an ecological risk
- generate data to be used in evaluating cleanup options.

Historically, the principal activity of the plant was the production of chlorinated benzene products. Additional operations that reportedly occurred included production of caustic potash, caustic soda, and chlorine gas. As a result of these past operations, Site-related constituents including benzene, chlorinated benzenes, mercury, PAHs, PCBs, and PCDD/Fs have been detected in Site soils and groundwater and within the surface water and sediment of Tributary 5A.

The BERA was performed in accordance with ERAGS (USEPA, 1997b) and the guidance co-developed by the NYSDEC and USEPA for Onondaga Lake Sites (NYSDEC, 1998a). Additionally, the BERA was performed in accordance with the NYSDEC's *Fish and Wildlife Impact Analysis* (NYSDEC, 1994). The final BERA Report was approved by the NYSDEC on May 21, 2013.

8.1. SITE ECOLOGICAL CHARACTERISTICS

The majority of the upland ecological communities in the vicinity of the Site are considered *terrestrial cultural* covertypes as defined in Edinger (*et. al.* 2002). The Plant Area, PSA, and CHSA properties contain ecological communities that can be classified as *urban vacant lot*. Additional covertypes within the Site vicinity include *urban structure exterior, successional old field, successional shrubland, and successional northern hardwoods.* There were seven state and 26 National Wetland Inventory (NWI) wetlands within two miles of the Site perimeter. The Onondaga Lake shoreline, which is within two miles of the Site, is classified as NWI wetland habitat. The Semet Ponds are also listed as wetlands on the NWI map, but these ponds do not have federally defined wetland characteristics based on Site reconnaissance observations.

8.2. EVALUATED MEDIA, EXPOSURE PATHWAYS, AND IDENTIFICATION OF CONSTITUENTS OF CONCERN

For the purposes of the Revised BERA, analytical data representing the most likely areas for ecological exposures were assessed. The following media and exposure pathways were evaluated:

Plant Study Area: The surface soil (0 to 2 ft bgs) exposure pathway consists of the terrestrial Plant Area surface soil samples. The Plant Study Area surface soil database is utilized in the BERA for comparison to standards, criteria and guidance (SCGs) for the protection of terrestrial plants, soil invertebrates and wildlife as model inputs for estimating risk to the short-tailed shrew, American robin, eastern cottontail rabbit, red-tailed hawk, and the red fox.

Petroleum Storage Area: The surface soil (0 to 2 ft bgs) exposure pathway consists of the terrestrial PSA surface soil samples. The PSA surface soil database is utilized in the BERA for comparison to SCGs for the protection of terrestrial plants, soil invertebrates and wildlife as model inputs for estimating risk to the short-tailed shrew, American robin, red-tailed hawk, and the red fox.

Chlorobenzene Hot-Spot Area: The surface soil (0 to 2 ft bgs) exposure pathway consists of the terrestrial CHSA surface soil samples. The CHSA surface soil database is utilized in the BERA for comparison to SCGs for the protection of terrestrial plants, soil invertebrates and wildlife as model inputs for estimating risk to the short-tailed shrew, American robin, red-tailed hawk, and the red fox.

The selected assessment endpoints for the Revised BERA are listed below. The BERA risk characterization is based on an integrated evaluation of the various endpoints along multiple lines of evidence.

The assessment endpoints selected for this Revised BERA include the viability and function (*i.e.,* survival, growth, and reproduction) of:

- The terrestrial plant community of the Site as a source of forage and cover for wildlife
- The terrestrial soil invertebrate community of the Site as a source of forage for wildlife
- The insectivorous mammal populations inhabiting the terrestrial portions of the Site
- The omnivorous bird populations likely to forage on prey available from terrestrial portions of the Site
- The herbivorous mammal populations likely to forage on prey available from terrestrial portions of the Site
- The carnivorous mammal populations likely to forage on prey available from the terrestrial portions of the Site
- The predatory bird populations likely to forage on prey available from terrestrial portions of the Site.

The identification of constituents of concern for the Site is based on several considerations, including comparisons of maximum detected concentrations to conservative ecologically-based SCGs. For the purposes of the BERA, the available data were further evaluated according to the Site AOS identified. Due to the revision of the study area and dataset a supplemental screening of the available Site data was performed for the Revised BERA to refine the list of constituents of concern (COCs) that are further evaluated in the BERA. The final list of COCs for each Site area is discussed below.

8.2.1. Plant Study Area

Of the 88 constituents detected in Plant Study Area surface soil, sixty-nine constituents were retained including 33 constituents that exceeded selected SCGs and 26 retained due to a lack of SCGs. Forty-six constituents were retained as COCs due to their bioaccumulative nature (not including the bioaccumulative constituents that also exceeded SCGs (20) or constituents that lacked appropriate SCGs (12)). Constituents retained as COCs included 19 metals, total PCBs, 14 pesticides, 24 SVOCs, nine VOCs, and the mammalian and avian dioxin equivalents.

8.2.2. Petroleum Storage Area

Sixty-two constituents were detected at least once in PSA surface soil. Forty-eight constituents were retained for this exposure pathway including 22 retained due to their exceedance of selected SCGs and 14 retained due to a lack of SCGs. Thirty-one constituents were retained as COCs due to their bioaccumulative nature (not including the bioaccumulative constituents that also exceeded SCGs (13) or constituents that lacked appropriate SCGs [three]). Constituents retained as COCs included 17 metals, total PCBs, seven pesticides, 21 SVOCs, and two VOCs.

8.2.3. Chlorobenzene Hot-Spots Area

Sixty constituents were detected at least once in CHSA surface soil. Forty-eight constituents were retained for this exposure pathway including 26 retained due to their exceedance of selected SCGs and 16 retained due to a lack of SCGs. Thirty-three constituents were retained as COCs due to their bioaccumulative nature (not including the bioaccumulative constituents that also exceeded SCGs (18) or constituents that lacked appropriate SCGs (six)). Constituents retained as COCs included 15 metals, total PCBs, eight pesticides, 20 SVOCs, and four VOCs.

8.3. RISK SUMMARY AND CONCLUSIONS

Ecological risk at the Plant Study Area, PSA, and CHSA was assessed based on terrestrial exposure pathways. Lines of evidence were developed for this Revised BERA based on toxicological effects, receptor exposures, and field observations at the Plant Study Area, PSA, and CHSA. Average and maximum detected constituent concentrations in surface soil (0 to 2 ft bgs) were screened against applicable SCGs for the protection of terrestrial plants, soil invertebrates, and wildlife. Potential risk to terrestrial upper trophic level receptors, including the short-tailed shrew, American robin, eastern cottontail rabbit, red fox, and red-tailed hawk, was modeled as an additional line of evidence in the revised BERA. These lines of evidence indicated the potential for

adverse ecological effects at multiple trophic levels. A summary of the BERA results for each receptor group, and the uncertainty associated with this assessment is discussed below.

8.3.1. Terrestrial Plant Summary

While field observations indicate that a variety of stresses may be responsible for the lack of vegetative cover in all three AOSs (*e.g.*, soil infertility, low nutrients), the quantitative line of evidence used in this assessment was a comparison to various SCGs. The Plant Study Area had the most exposure point concentration (EPC)/screening criteria ratios that exceeded 10 (eight COCs), the CHSA was next (five COCs), and the PSA had the least (three COCs). The primary risk drivers for terrestrial plant exposure at each Site are as follows: Plant Study Area (mercury, lead, methyl mercury, 4,4'-DDE, 1,4-dichlorobenzene, zinc), PSA (mercury), and CHSA (mercury).

8.3.2. Soil Invertebrate Summary

The quantitative line of evidence used in this assessment to examine risk to soil invertebrates was comparison of Site EPC to various SCGs. The Plant Area had the most EPC/Screening criteria ratios that exceeded 10 (10 COCs), the CHSA was next (six COCs) and the PSA had the least (four COCs). The primary risk drivers for terrestrial invertebrate exposure at each Site are as follows: Plant Study Area (mercury, 4,4'-DDE, 1,4-dichlorobenzene, total PCBs, chromium, and iron), PSA (mercury and iron), and CHSA (mercury and iron).

8.3.3. Insectivorous Mammal Summary

The viability and function of the insectivorous mammal community in the Plant Study Area, PSA, and CHSA was assessed using the two lines of evidence. The Plant Study Area had the most EPC/ecological soil screening levels and guidance (Eco-SSLs) ratios that exceeded 1 (17 COCs), the CHSA was next (16 COCs) and the PSA had the least (14 COCs). A Site-specific food chain model (short-tailed shrew) provided a less conservative evaluation of risk compared to the Eco-SSLs. The four highest lowest observed adverse effect level (LOAEL)-based HQ from the Plant Area were dioxins (1110), methyl mercury (984), chlorobenzene (398), and mercury (118). The four highest LOAEL-based HQ from the PSA were BEHP (22.1), endrin ketone (15.4), aldrin (13.7), and endrin (9.3). The four highest LOAEL-based HQ from the CHSA were hexachlorobenzene (1060), total PCBs (144), endrin aldehyde (97.3), and aldrin (70.1).

8.3.4. Omnivorous Birds Summary

The viability and function of the omnivorous bird community in the AOSs was assessed using the two lines of evidence. The Plant Study Area had the most EPC/Eco-SSL ratios that exceeded 1 (eight COCs), the PSA was next (seven COCs) and the CHSA had the least (six COCs). A Site-specific food chain model (American robin) provided a less conservative evaluation of risk compared to the Eco-SSLs. The four highest LOAEL-based HQ from the Plant Study Area were mercury (740), methyl mercury (38.6), chromium (30.4), and dioxin (27.9). The four highest LOAEL-based HQ from the PSA were BEHP (369), endrin ketone (142), endrin (85.7), and mercury (41.8). The four highest LOAEL-based HQ from the CHSA were hexachlorobenzene (1510), endrin aldehyde (900), endrin ketone (391), and total PCBs (193).

8.3.5. Herbivorous Mammals Summary

The viability and function of the herbivorous mammal community in the Plant Area was assessed using the two lines of evidence. The Plant Study Area had 17 EPC/Eco-SSL ratios that exceeded 1. The four highest ratios were pyrene (4.5), dieldrin (4.1), benzo(b)fluoranthene (3.8), and lead (3.4). A Site-specific food chain model (eastern cottontail) provided a less conservative evaluation of risk compared to the Eco-SSLs. The four highest LOAEL-based HQ from the Plant Area were mercury (295), chromium (52.7), dioxins (22.0), and manganese (7.0).

8.3.6. Carnivorous Mammal Summary

Ecological risk to carnivorous mammals from media in the Plant Study Area, PSA, and CHSA was typically characterized by several surface soil EPC/Eco-SSL ratios that exceed one (metals, pesticides, and PAHs). However, the use of less conservative, Site-specific food chain models yielded very few LOAEL-based HQs that were greater than one [Plant Study Area (chromium, mercury, methyl mercury, and selenium), PSA (methyl mercury and selenium), and CHSA (total PCBs)].

8.3.7. Predatory Birds Summary

Similar to the carnivorous mammal summary described above, ecological risk to predatory birds from exposure to media in all three AOSs was demonstrated by several surface soil EPC/Eco-SSL ratios that exceed one (metals and pesticides). However, the use of less conservative, Site-specific, food chain models yielded very few LOAEL-based HQs that were greater than one [Plant Study Area (mercury, methyl mercury, and dioxins), PSA (4-methylphenol), and CHSA (total PCBs)].

8.4. SUMMARY OF UNCERTAINTIES

The level of uncertainty associated with this BERA is moderate. The sources of uncertainty evaluated as part of the BERA were:

1. Comparison of soil concentrations to regional background and reference conditions,
2. Comparison of tissue concentrations to reference conditions,
3. Habitat suitability and area use factors,
4. Bioavailability of the chemical present in the environment, and
5. Small sample sizes, low frequencies of detection, and the use of maximum concentrations.

Considered together, these issues represent a moderate source of uncertainty for the risk estimate reported in this assessment.

9. CONCLUSIONS AND PRELIMINARY REMEDIAL ACTION OBJECTIVES

9.1. CONCLUSIONS

The evaluation of the analytical data and field observations from the RI and subsequent IRM investigations indicates that the sources of impacted Site media are related to historic production processes on the Plant Study Area and former Main Plant Site. These included the mercury cell process, chlorinated benzene products production, and the Solvay Process. During the RI, it became evident that portions of the Site had been impacted by previous operations. A series of IRMs have been implemented that have mitigated impacts from the Site.

The following conclusions were developed based on the investigations.

- Site geology varied between the Plant Area, CHSA, and PSA.
  - Plant Study Area geology consists of fill material, marl/peat layer, silt and clay, fine sand and silt, sand and gravel, till, and bedrock.
  - The overburden geology in the CHSA consists of fill, lacustrine sediments, and till underlain by bedrock
  - The PSA geology was a thin layer of fill (up 10 ft thick) overlying the bedrock or glacial till.
- The unconsolidated hydrogeologic units identified for the Plant Study Area, CHSA, and PSA varied significantly.
  - Plant Study Area: fill unit, Solvay waste, a low permeability silt and clay unit, and the deep unit consisting of the fine grained sand and silt and basal sand and gravel layers.
  - CHSA: fill unit and lacustrine sediments.
  - PSA: shallow fill unit.
- Shallow groundwater flow is generally towards Onondaga with some component discharging to Tributary 5A and drainage ditches.
- Intermediate and deep groundwater flows north towards the lake from the Plant Study Area (no intermediate or deep units present for the CHSA or PSA).
- The intermediate unit is separated from the deep unit throughout the Plant Study Area by a low permeability silt and clay layer, which acts as a confining layer for the deep hydrogeologic unit.
- The vertical hydraulic potential is downward from the fill to the native sediments across the majority of the Plant Study Area, CHSA, and PSA.
- On the lakeshore property of the Plant Study Area, there is an upward vertical hydraulic head between the intermediate and deep monitoring wells and Onondaga Lake.
- Hydraulic conductivities for the hydrogeologic units are:
  - Plant Study Area
    - Shallow groundwater: 2.3×10^{-2} cm/sec to 8.6×10^{-5} cm/sec, with $.9 \times 10^{-2}$ cm/sec to 2.1×10^{-3} cm/sec for the lakeshore property.
    - Intermediate groundwater: 3.9×10^{-4} cm/sec to 2.8×10^{-5} cm/sec, with 7.2×10^{-5} cm/sec to 5.0×10^{-5} cm/sec for the lakeshore property.
    - Deep silt and sand unit: 1.1×10^{-4} cm/sec to 2.0×10^{-3} cm/sec.
    - Deep sand and gravel unit: 4.8×10^{-2} cm/sec to 3.8×10^{-1} cm/sec.
  - CHSA: 3.5×10^{-6} cm/sec to 2.8×10^{-2} cm/sec for the fill and lacustrine sediments.

  - PSA: 2 x 10^{-5} cm/sec to 3.8 x 10^{-3} cm/sec.
- Source areas for the Plant Study Area are:
  - On-site areas associated with the production of chlorinated benzene products or storm water conveyance for chlorinated benzenes,
  - The footprint of the former Mercury Cell Building for elemental and other forms of mercury,
  - Transformers that supported production facilities for PCBs, and
  - Free product that migrated from the Plant Area to the lakeshore property.
- The main source area for the CHSA was the former pipe that transported cooling water from the Para building to the former Main Plant site pump house.
- The key source areas for the PSA were the former distillation facility on-site that produced benzene, toluene, xylenes, and naphthalene, benzene pipeline to the Plant Area, and former storage tanks for No. 2 fuel oil.
- Plant Study Area CPOIs include BTEX compounds, chlorinated benzenes (mono-, di-, and tri- isomers), PAHs (primarily naphthalene), phenolic compounds, Aroclors 1254 and 1260, PCDD/Fs, mercury, iron, and Solvay Process-related parameters (calcium, magnesium, potassium, and sodium).
- The CHSA CPOIs include Benzene, BEHP, chlorinated benzenes (mono-, di-, tri-, and hexa- isomers), PAHs, Aroclor 1254, mercury, iron, and Solvay Process-related parameters (calcium, magnesium, potassium, and sodium).
- The PSA CPOIs include BTEX compounds, chlorinated benzenes (mono-, di-, and tri- isomers), naphthalene, phenolic compounds, mercury, iron, and Solvay Process-related parameters (calcium, magnesium, potassium, and sodium).
- The Tributary 5A CPOIs include BTEX compounds, chlorinated benzenes (mono- and di- isomers), PAHs, phenolic compounds, BEHP, Aroclors 1248,1254, and 1260, and metals, including mercury Solvay Process-related parameters (calcium, magnesium, potassium, and sodium).
- The Willis/Semet Barrier Wall IRM and DNAPL IRM address the groundwater migration of dissolved organic parameters and DNAPL towards Onondaga Lake.
- The extent of the lakeshore property DNAPL was further delineated by the TarGOST® probing investigation, and this information was used to design the DNAPL collection system footprint.
- The Semet Residue Ponds Shallow Groundwater Remedial Action addressed shallow groundwater contamination through the construction and operation of a groundwater collection system and treatment of the collected groundwater at the Willis Avenue Wastewater Treatment Facility. This remedial action also addressed impacted sediment within Tributary 5A through removal. However, as Tributary 5A is part of the Willis Avenue Chlorobenzene Site, the need for any further remedial action with respect Tributary 5A sediment will be evaluated as part of the Willis Avenue Chlorobenzene Site Feasibility Study.
- The HHRA and BERA, performed using the conservative regulatory methodologies prescribed within CERCLA and ARAR guidance, identified unacceptable risk in site soils and groundwater for both human health and ecological receptors at the Willis Avenue Site.

The nature and extent of the CPOIs has been well defined, and the ecological and human health risk assessments have been formally approved by the NYSDEC. No further Site characterization is warranted.

9.2. PRELIMINARY REMEDIAL ACTION OBJECTIVES

A list of preliminary RAOs was developed based on the April 14, 1999 meeting between Honeywell, NYSDEC and O'Brien & Gere and the July 5, 2002 comment letter from the NYSDEC to Honeywell. These preliminary RAOs

are presented below; however, the IRMs discussed in Section 1.5 were performed to address these preliminary RAOs and will be further evaluated within the Feasibility Study (FS).

Soil/Fill/Sediment/Surface Water RAOs for Public Health Protection

- Prevent, or reduce to the extent practicable, ingestion/direct contact with contaminated soil/fill, sediment, and surface water.
- Prevent, or reduce to the extent practicable, inhalation of or exposure from contaminants volatilizing from contaminants in soil/fill.

Soil/Fill/Sediment/Surface Water RAOs for Environmental Protection

- Prevent, or reduce to the extent practicable, migration of contaminants that would result in groundwater, sediment, or surface water contamination.
- Prevent, or reduce to the extent practicable, impacts to biota from ingestion/direct contact with contaminated soil/fill or sediment causing toxicity or impacts from bioaccumulation through the terrestrial food chain.

Groundwater RAOs for Public Health Protection

- Prevent ingestion of groundwater with contaminant levels exceeding drinking water standards.
- Prevent contact with, or inhalation of volatiles from, contaminated groundwater.

Groundwater RAOs for Environmental Protection

- Restore groundwater aquifer to pre-disposal/pre-release conditions, to the extent practicable.
- Prevent, or reduce to the extent practicable, the discharge of contaminants to sediment and surface water.
- Remove, or reduce to the extent practicable, the source of groundwater, surface water, or sediment contamination.

Soil Vapor RAO

- Mitigate impacts to public health resulting from existing, or potential for, soil vapor intrusion into buildings at site.

9.3. FUTURE ACTIVITIES

The RAOs will be evaluated within the context of alternatives within the FS. Also, the Federal Emergency Management Agency (FEMA) floodplain mapping for the Site area will be utilized to evaluate if the Site is within the FEMA defined 100-year and 500-year floodplains. If it is determined that the remedial measures proposed for the Site may impact identified floodplain areas, a Floodplain Assessment Report will be prepared and submitted as part of the FS Report.

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Volume 4 – Appendix L (Human Health Risk Assessment)

Willis Avenue Chlorobenzene Site
Remedial Investigation
Geddes, New York

Honeywell

Christopher C. Calkins
Vice President

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O'BRIEN & GERE

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Attachment A

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2.16d Derivation of total chlordanes – Lakeshore Area, Surface Soil (Current/Future)
2.17a Occurrence, distribution, and selection of COPC – Lakeshore Area, Upper Soil (Current/Future)
2.17b Derivation of toxicity equivalents for dioxins – Lakeshore Area, Upper Soil (Current/Future)
2.17c Derivation of PCB equivalents for chlorinated chemicals – Lakeshore Area, Upper Soil (Current/Future)
2.17d Derivation of total chlordanes – Lakeshore Area, Upper Soil (Current/Future)
2.18 Occurrence, distribution, and selection of COPC – Lakeshore Area, Shallow Groundwater (Current/Future)
2.19a Occurrence, distribution, and selection of COPC – Tributary 5A, Sediment (Current/Future)
2.19b Derivation of toxicity equivalents for dioxins – Tributary 5A, Sediment (Current/Future)
2.19c Derivation of PCB equivalents for chlorinated chemicals – Tributary 5A, Sediment (Current/Future)
2.19d Derivation of total chlordanes – Tributary 5A, Sediment (Current/Future)
2.20 Occurrence, distribution, and selection of COPC – Tributary 5A, Surface Water (Current/Future)
2.21a Occurrence, distribution, and selection of COPC – Petroleum Storage Area, Surface Soil (Current/Future)
2.21b Derivation of PCB equivalents for chlorinated chemicals – Petroleum Storage Area, Surface Soil (Current/Future)
2.22a Occurrence, distribution, and selection of COPC – Petroleum Storage Area, Upper Soil (Current/Future)
2.22b Derivation of PCB equivalents for chlorinated chemicals – Petroleum Storage Area, Upper Soil (Current/Future)
2.22c Derivation of total chlordanes – Petroleum Storage Area, Upper Soil (Current/Future)
2.23 Occurrence, distribution, and selection of COPC – Petroleum Storage Area, Shallow Groundwater (Current/Future)

2.24 Occurrence, distribution, and selection of COPC – Petroleum Storage Area, Shallow Groundwater: Vapor Intrusion (Current/Future)
2.25a Occurrence, distribution, and selection of COPC – Chlorobenzene Hot-Spot Area, Surface Soil (Current/Future)
2.25b Derivation of PCB equivalents for chlorinated chemicals – Chlorobenzene Hot-Spot Area, Surface Soil (Current/Future)
2.26a Occurrence, distribution, and selection of COPC – Chlorobenzene Hot-Spot Area, Upper Soil (Current/Future)
2.26b Derivation of PCB equivalents for chlorinated chemicals – Chlorobenzene Hot-Spot Area, Upper Soil (Current/Future)
2.27 Occurrence, distribution, and selection of COPC – Chlorobenzene Hot-Spot Area, Shallow Groundwater (Current/Future)
2.28 Occurrence, distribution, and selection of COPC – Chlorobenzene Hot-Spot Area, Shallow Groundwater: Vapor Intrusion (Current/Future)
2.29 Occurrence, distribution, and selection of COPC – Site Wide, Groundwater (Current/Future)

Table 3 Series: Occurrence, distribution, and selection of COPC
3.1 Exposure Point Concentration Summary – Plant Area, Surface Soil (Current/Future)
3.2 Exposure Point Concentration Summary – Plant Area, Upper Soil (Current/Future)
3.3 Exposure Point Concentration Summary – Plant Area, Intermediate Soil (Current/Future)
3.4 Exposure Point Concentration Summary – Plant Area, Intermediate Groundwater (Current/Future)
3.5 Exposure Point Concentration Summary – Former Chlorination Building, Surface Soil (Current/Future)
3.6 Exposure Point Concentration Summary – Former Chlorination Building, Upper Soil (Current/Future)
3.7 Exposure Point Concentration Summary – Former Chlorination Building, Intermediate Soil (Current/Future)
3.8 Exposure Point Concentration Summary – On-Site Ditches, Surface Soil (Current/Future)
3.9 Exposure Point Concentration Summary – On-Site Ditches, Upper Soil (Current/Future)
3.10 Exposure Point Concentration Summary – On-Site Ditches, Intermediate Soil (Current/Future)
3.11 Exposure Point Concentration Summary – Southwest Off-Site Area/Outfall 006 Exposure Area, Surface Soil (Current/Future)
3.11 Exposure Point Concentration Summary – Southwest Off-Site Area/Outfall 006 Exposure Area, Upper Soil (Current/Future)
3.13 Exposure Point Concentration Summary – State Fair Blvd/Northwest Off-Site/Outfall 004 Exposure Area, Surface Soil (Current/Future)
3.14 Exposure Point Concentration Summary – State Fair Blvd/Northwest Off-Site/Outfall 004 Exposure Area, Upper Soil (Current/Future)
3.15 Exposure Point Concentration Summary – Lakeshore Area, Surface Soil (Current/Future)
3.16 Exposure Point Concentration Summary – Lakeshore Area, Upper Soil (Current/Future)
3.17 Exposure Point Concentration Summary – Lakeshore Area, Shallow Groundwater (Current/Future)
3.18 Exposure Point Concentration Summary – Tributary 5A, Sediment (Current/Future)
3.19 Exposure Point Concentration Summary – Tributary 5A, Surface Water (Current/Future)
3.20 Exposure Point Concentration Summary – Petroleum Storage Area, Surface Soil (Current/Future)

3.21 Exposure Point Concentration Summary – Petroleum Storage Area, Upper Soil (Current/Future)
3.22 Exposure Point Concentration Summary – Petroleum Storage Area, Shallow Groundwater (Current/Future)
3.23 Exposure Point Concentration Summary – Chlorobenzene Hot-Spot Area, Surface Soil (Current/Future)
3.24 Exposure Point Concentration Summary – Chlorobenzene Hot-Spot Area, Upper Soil (Current/Future)
3.25 Exposure Point Concentration Summary – Chlorobenzene Hot-Spot Area, Shallow Groundwater (Current/Future)
3.26 Exposure Point Concentration Summary – Site Wide, Groundwater (Current/Future)

Table 4 Series: Values used for daily intake calculations
4.1 RME Values used for daily intake calculations – Plant Area, Surface Soils (Current/Future Receptors)
4.2a RME Values used for daily intake calculations – Plant Area, Surface Soils (Future Receptors)
4.2b RME Values used for daily intake calculations – Plant Area, Upper Soils (Future Receptors)
4.2c RME Values used for daily intake calculations – Plant Area, Intermediate Soils (Future Receptors)
4.2d RME Values used for daily intake calculations – Plant Area, Groundwater (Future Receptors)
4.3 RME Values used for daily intake calculations – On-Site Ditches, Surface Soils (Current/Future Receptors)
4.4a RME Values used for daily intake calculations – On-Site Ditches, Surface Soils (Future Receptors)
4.4b RME Values used for daily intake calculations – On-Site Ditches, Upper Soils (Future Receptors)
4.4c RME Values used for daily intake calculations – On-Site Ditches, Intermediate Soils (Future Receptors)
4.4d RME Values used for daily intake calculations – On-Site Ditches, Groundwater (Future Receptors)
4.5 RME Values used for daily intake calculations – Former Chlorination Building, Surface Soils (Current/Future Receptors)
4.6a RME Values used for daily intake calculations – Former Chlorination Building, Surface Soils (Future Receptors)
4.6b RME Values used for daily intake calculations – Former Chlorination Building, Upper Soils (Future Receptors)
4.6c RME Values used for daily intake calculations – Former Chlorination Building, Intermediate Soils (Future Receptors)
4.6d RME Values used for daily intake calculations – Former Chlorination Building, Groundwater (Future Receptors)
4.7 RME Values used for daily intake calculations – Southwest Off-Site/Outfall 006 Exposure Area, Surface Soils (Current/Future Receptors)
4.8a RME Values used for daily intake calculations – Southwest Off-Site/Outfall 006 Exposure Area, Surface Soils (Future Receptors)
4.8b RME Values used for daily intake calculations – Southwest Off-Site/Outfall 006 Exposure Area, Upper Soils (Future Receptors)
4.9a RME Values used for daily intake calculations – State Fair Blvd./Northwest Off-Site/Outfall 004 Exposure Area, Surface Soils (Current/Future Receptors)

4.9b RME Values used for daily intake calculations – State Fair Blvd./Northwest Off-Site/Outfall 004 Exposure Area, Upper Soils (Future Receptors)
4.10a RME Values used for daily intake calculations – Lakeshore Area, Surface Soils (Current/Future Receptors)
4.10b RME Values used for daily intake calculations – Lakeshore Area, Upper Soils (Future Receptors)
4.10c RME Values used for daily intake calculations – Lakeshore Area, Shallow Groundwater, (Current/Future Receptors)
4.11a RME Values used for daily intake calculations – Tributary 5A, Surface Water, (Current/Future Receptors)
4.11b RME Values used for daily intake calculations – Tributary 5A, Surface Sediment, (Current/Future Receptors)
4.11c RME Values used for daily intake calculations – Tributary 5A, Upper Sediment, (Current/Future Receptors)
4.12 RME Values used for daily intake calculations – Petroleum Storage Area, Surface Soils (Current/Future Receptors)
4.13a RME Values used for daily intake calculations – Petroleum Storage Area, Surface Soils (Future Receptors)
4.13b RME Values used for daily intake calculations – Petroleum Storage Area, Upper Soils (Future Receptors)
4.13c RME Values used for daily intake calculations – Petroleum Storage Area, Shallow Groundwater, (Current/Future Receptors)
4.14 RME Values used for daily intake calculations – Chlorobenzene Hot-Spot Area, Surface Soils (Current/Future Receptors)
4.15a RME Values used for daily intake calculations – Chlorobenzene Hot-Spot Area, Surface Soils (Future Receptors)
4.15b RME Values used for daily intake calculations – Chlorobenzene Hot-Spot Area, Upper Soils (Future Receptors)
4.15c RME Values used for daily intake calculations – Chlorobenzene Hot-Spot Area, Shallow Groundwater, (Current/Future Receptors)
4.16 RME Values used for daily intake calculations – Hypothetical Drinking Water Source Area, Groundwater (Future Receptors)
4.16 RME Supplement A – Values used for daily intake calculations – Hypothetical Drinking Water Source Area, Groundwater (Future Receptors)
4.16 RME Supplement B – Age-Dependent Adjustment Factor – Exposure Parameters

4.1 CT Values used for daily intake calculations – Plant Area, Surface Soils (Current/Future Receptors)
4.2a CT Values used for daily intake calculations – Plant Area, Surface Soils (Future Receptors)
4.2b CT Values used for daily intake calculations – Plant Area, Upper Soils (Future Receptors)
4.2c CT Values used for daily intake calculations – Plant Area, Intermediate Soils (Future Receptors)
4.2d CT Values used for daily intake calculations – Plant Area, Groundwater (Future Receptors)
4.3 CT Values used for daily intake calculations – On-Site Ditches, Surface Soils (Current/Future Receptors)
4.4a CT Values used for daily intake calculations – On-Site Ditches, Surface Soils (Future Receptors)

4.4b CT Values used for daily intake calculations – On-Site Ditches, Upper Soils (Future Receptors)
4.4c CT Values used for daily intake calculations – On-Site Ditches, Intermediate Soils (Future Receptors)
4.4d CT Values used for daily intake calculations – On-Site Ditches, Groundwater (Future Receptors)
4.5 CT Values used for daily intake calculations – Former Chlorination Building, Surface Soils (Current/Future Receptors)
4.6a CT Values used for daily intake calculations – Former Chlorination Building, Surface Soils (Future Receptors)
4.6b CT Values used for daily intake calculations – Former Chlorination Building, Upper Soils (Future Receptors)
4.6c CT Values used for daily intake calculations – Former Chlorination Building, Intermediate Soils (Future Receptors)
4.6d CT Values used for daily intake calculations – Former Chlorination Building, Groundwater (Future Receptors)
4.7 CT Values used for daily intake calculations – Southwest Off-Site/Outfall 006 Exposure Area, Surface Soils (Current/Future Receptors)
4.8a CT Values used for daily intake calculations – Southwest Off-Site/Outfall 006 Exposure Area, Surface Soils (Future Receptors)
4.8b CT Values used for daily intake calculations – Southwest Off-Site/Outfall 006 Exposure Area, Upper Soils (Future Receptors)
4.9a CT Values used for daily intake calculations – State Fair Blvd./Northwest Off-Site/Outfall 004 Exposure Area, Surface Soils (Current/Future Receptors)
4.9b CT Values used for daily intake calculations – State Fair Blvd./Northwest Off-Site/Outfall 004 Exposure Area, Upper Soils (Future Receptors)
4.10a CT Values used for daily intake calculations – Lakeshore Area, Surface Soils (Current/Future Receptors)
4.10b CT Values used for daily intake calculations – Lakeshore Area, Upper Soils (Future Receptors)
4.10c CT Values used for daily intake calculations – Lakeshore Area, Shallow Groundwater, (Current/Future Receptors)
4.11a CT Values used for daily intake calculations – Tributary 5A, Surface Water, (Current/Future Receptors)
4.11b CT Values used for daily intake calculations – Tributary 5A, Surface Sediment, (Current/Future Receptors)
4.11c CT Values used for daily intake calculations – Tributary 5A, Upper Sediment, (Current/Future Receptors)
4.12 CT Values used for daily intake calculations – Petroleum Storage Area, Surface Soils (Current/Future Receptors)
4.13a CT Values used for daily intake calculations – Petroleum Storage Area, Surface Soils (Future Receptors)
4.13b CT Values used for daily intake calculations – Petroleum Storage Area, Upper Soils (Future Receptors)
4.13c CT Values used for daily intake calculations – Petroleum Storage Area, Shallow Groundwater, (Current/Future Receptors)
4.14 CT Values used for daily intake calculations – Chlorobenzene Hot-Spot Area, Surface Soils (Current/Future Receptors)

4.15a CT Values used for daily intake calculations – Chlorobenzene Hot-Spot Area, Surface Soils (Future Receptors)
4.15b CT Values used for daily intake calculations – Chlorobenzene Hot-Spot Area, Upper Soils (Future Receptors)
4.15c CT Values used for daily intake calculations – Chlorobenzene Hot-Spot Area, Shallow Groundwater, (Current/Future Receptors)
4.16 CT Values used for daily intake calculations – Hypothetical Drinking Water Source Area, Groundwater (Future Receptors)
4.16 CT Supplement A – Values used for daily intake calculations – Hypothetical Drinking Water Source Area, Groundwater (Future Receptors)
4.16 CT Supplement B – Age-Dependent Adjustment Factor – Exposure Parameters

Table 5 Series: Non-cancer toxicity data
5.1 Non-cancer toxicity data – oral/dermal
5.2 Non-cancer toxicity data – inhalation

Table 6 Series: Cancer toxicity data
6.1 Cancer toxicity data – oral/dermal
6.2 Cancer toxicity data – inhalation

Table 7 Series: Calculation of cancer risks and non-cancer hazards
7.1a RME: Calculation of chemical cancer risks and non-cancer hazards – Adolescent Trespasser, Plant Area (Current/Future)
7.1b RME: Calculation of chemical cancer risks and non-cancer hazards – Adolescent Trespasser, On-Site Ditches (Current/Future)
7.1c RME: Calculation of chemical cancer risks and non-cancer hazards – Adolescent Trespasser, Former Chlorination Building (Current/Future)
7.1d RME: Calculation of chemical cancer risks and non-cancer hazards – Adolescent Trespasser, Southwest Off-Site/Outfall 006 Exposure Area (Current/Future)
7.1e RME: Calculation of chemical cancer risks and non-cancer hazards – Adolescent Trespasser, State Fair Blvd/Northwest Off-Site/Outfall 004 Exposure Area (Current/Future)
7.1f RME: Calculation of chemical cancer risks and non-cancer hazards – Adolescent Trespasser, Lakeshore Area (Current/Future)
7.1g RME: Calculation of chemical cancer risks and non-cancer hazards – Adolescent Trespasser, Petroleum Storage Area (Current/Future)
7.1h RME: Calculation of chemical cancer risks and non-cancer hazards – Adolescent Trespasser, Chlorobenzene Hot-Spot Area (Current/Future)
7.1i RME: Calculation of chemical cancer risks and non-cancer hazards – Adolescent Trespasser, Tributary 5A (Current/Future)
7.1 RME Supplement A: Calculation of Chemical Cancer Risks for COPC with a Mutagenic Mode of Action
7.2a RME: Calculation of chemical cancer risks and non-cancer hazards – Adult Trespasser, Plant Area (Current/Future)
7.2b RME: Calculation of chemical cancer risks and non-cancer hazards – Adult Trespasser, On-Site Ditches (Current/Future)
7.2c RME: Calculation of chemical cancer risks and non-cancer hazards – Adult Trespasser, Former Chlorination Building (Current/Future)

7.2d RME: Calculation of chemical cancer risks and non-cancer hazards – Adult Trespasser, Southwest Off-Site/Outfall 006 Exposure Area (Current/Future)
7.2e RME: Calculation of chemical cancer risks and non-cancer hazards – Adult Trespasser, State Fair Blvd/Northwest Off-Site/Outfall 004 Exposure Area (Current/Future)
7.2f RME: Calculation of chemical cancer risks and non-cancer hazards – Adult Trespasser, Lakeshore Area (Current/Future)
7.2g RME: Calculation of chemical cancer risks and non-cancer hazards – Adult Trespasser, Petroleum Storage Area (Current/Future)
7.2h RME: Calculation of chemical cancer risks and non-cancer hazards – Adult Trespasser, Chlorobenzene Hot-Spot Area (Current/Future)
7.2i RME: Calculation of chemical cancer risks and non-cancer hazards – Adult Trespasser, Tributary 5A (Current/Future)
7.3a RME: Calculation of chemical cancer risks and non-cancer hazards – Surveillance Worker, Plant Area (Current/Future)
7.3b RME: Calculation of chemical cancer risks and non-cancer hazards – Surveillance Worker, On-Site Ditches (Current/Future)
7.3c RME: Calculation of chemical cancer risks and non-cancer hazards – Surveillance Worker, Former Chlorination Building (Current/Future)
7.4a RME: Calculation of chemical cancer risks and non-cancer hazards – Industrial Worker, Plant Area (Future)
7.4b RME: Calculation of chemical cancer risks and non-cancer hazards – Industrial Worker, On-Site Ditches (Future)
7.4c RME: Calculation of chemical cancer risks and non-cancer hazards – Industrial Worker, Former Chlorination Building (Future)
7.4d RME: Calculation of chemical cancer risks and non-cancer hazards – Industrial Worker, Southwest Off-Site/Outfall 006 Exposure Area (Future)
7.4e RME: Calculation of chemical cancer risks and non-cancer hazards – Industrial Worker, Petroleum Storage Area (Future)
7.4f RME: Calculation of chemical cancer risks and non-cancer hazards – Industrial Worker, Chlorobenzene Hot-Spot Area (Future)
7.5a RME: Calculation of chemical cancer risks and non-cancer hazards – Construction Worker, Plant Area (Future)
7.5b RME: Calculation of chemical cancer risks and non-cancer hazards – Construction Worker, On-Site Ditches (Future)
7.5c RME: Calculation of chemical cancer risks and non-cancer hazards – Construction Worker, Former Chlorination Building (Future)
7.5d RME: Calculation of chemical cancer risks and non-cancer hazards – Construction Worker, Southwest Off-Site/Outfall 006 Exposure Area (Future)
7.5e RME: Calculation of chemical cancer risks and non-cancer hazards – Construction Worker, Petroleum Storage Area (Future)
7.5f RME: Calculation of chemical cancer risks and non-cancer hazards – Construction Worker, Chlorobenzene Hot-Spot Area (Future)
7.6 RME: Calculation of chemical cancer risks and non-cancer hazards – Transient Trespasser, State Fair Blvd/Northwest Off-Site/Off-Site Outfall 004 Exposure Area (Current/Future)
7.7a RME: Calculation of chemical cancer risks and non-cancer hazards – Utility Worker, Plant Area (Future)
7.7b RME: Calculation of chemical cancer risks and non-cancer hazards – Utility Worker, On-Site Ditches (Future)

7.7c RME: Calculation of chemical cancer risks and non-cancer hazards – Utility Worker, Former Chlorination Building (Future)
7.7d RME: Calculation of chemical cancer risks and non-cancer hazards – Utility Worker, State Fair Blvd/Northwest Off-Site/Off-Site Outfall 004 Exposure Area (Current/Future)
7.7e RME: Calculation of chemical cancer risks and non-cancer hazards – Utility Worker, Lakeshore Area (Current/Future)
7.7f RME: Calculation of chemical cancer risks and non-cancer hazards – Utility Worker, Petroleum Storage Area (Future)
7.7g RME: Calculation of chemical cancer risks and non-cancer hazards – Utility Worker, Chlorobenzene Hot-Spot Area (Future)
7.7h RME: Calculation of chemical cancer risks and non-cancer hazards – Utility Worker, Tributary 5A (Current/Future)
7.8 RME: Calculation of chemical cancer risks and non-cancer hazards – Adult Resident, Hypothetical Potable Water (Future)
7.9 RME: Calculation of chemical cancer risks and non-cancer hazards – Child Resident, Hypothetical Potable Water (Future)
7.9 RME Supplement A: Calculation of Chemical Cancer Risks for COPC with a Mutagenic Mode of Action

7.1a CT: Calculation of chemical cancer risks and non-cancer hazards – Adolescent Trespasser, Plant Area (Current/Future)
7.1b CT: Calculation of chemical cancer risks and non-cancer hazards – Adolescent Trespasser, On-Site Ditches (Current/Future)
7.1c CT: Calculation of chemical cancer risks and non-cancer hazards – Adolescent Trespasser, Former Chlorination Building (Current/Future)
7.1d CT: Calculation of chemical cancer risks and non-cancer hazards – Adolescent Trespasser, Southwest Off-Site/Outfall 006 Exposure Area (Current/Future)
7.1e CT: Calculation of chemical cancer risks and non-cancer hazards – Adolescent Trespasser, State Fair Blvd/Northwest Off-Site/Outfall 004 Exposure Area (Current/Future)
7.1f CT: Calculation of chemical cancer risks and non-cancer hazards – Adolescent Trespasser, Lakeshore Area (Current/Future)
7.1g CT: Calculation of chemical cancer risks and non-cancer hazards – Adolescent Trespasser, Petroleum Storage Area (Current/Future)
7.1h CT: Calculation of chemical cancer risks and non-cancer hazards – Adolescent Trespasser, Chlorobenzene Hot-Spot Area (Current/Future)
7.1i CT: Calculation of chemical cancer risks and non-cancer hazards – Adolescent Trespasser, Tributary 5A (Current/Future)
7.1 CT Supplement A: Calculation of Chemical Cancer Risks for COPC with a Mutagenic Mode of Action
7.2a CT: Calculation of chemical cancer risks and non-cancer hazards – Adult Trespasser, Plant Area (Current/Future)
7.2b CT: Calculation of chemical cancer risks and non-cancer hazards – Adult Trespasser, On-Site Ditches (Current/Future)
7.2c CT: Calculation of chemical cancer risks and non-cancer hazards – Adult Trespasser, Former Chlorination Building (Current/Future)
7.2d CT: Calculation of chemical cancer risks and non-cancer hazards – Adult Trespasser, Southwest Off-Site/Outfall 006 Exposure Area (Current/Future)

7.2e CT: Calculation of chemical cancer risks and non-cancer hazards – Adult Trespasser, State Fair Blvd/Northwest Off-Site/Outfall 004 Exposure Area (Current/Future)
7.2f CT: Calculation of chemical cancer risks and non-cancer hazards – Adult Trespasser, Lakeshore Area (Current/Future)
7.2g CT: Calculation of chemical cancer risks and non-cancer hazards – Adult Trespasser, Petroleum Storage Area (Current/Future)
7.2h CT: Calculation of chemical cancer risks and non-cancer hazards – Adult Trespasser, Chlorobenzene Hot-Spot Area (Current/Future)
7.2i CT: Calculation of chemical cancer risks and non-cancer hazards – Adult Trespasser, Tributary 5A (Current/Future)
7.3a CT: Calculation of chemical cancer risks and non-cancer hazards – Surveillance Worker, Plant Area (Current/Future)
7.3b CT: Calculation of chemical cancer risks and non-cancer hazards – Surveillance Worker, On-Site Ditches (Current/Future)
7.3c CT: Calculation of chemical cancer risks and non-cancer hazards – Surveillance Worker, Former Chlorination Building (Current/Future)
7.4a CT: Calculation of chemical cancer risks and non-cancer hazards – Industrial Worker, Plant Area (Future)
7.4b CT: Calculation of chemical cancer risks and non-cancer hazards – Industrial Worker, On-Site Ditches (Future)
7.4c CT: Calculation of chemical cancer risks and non-cancer hazards – Industrial Worker, Former Chlorination Building (Future)
7.4d CT: Calculation of chemical cancer risks and non-cancer hazards – Industrial Worker, Southwest Off-Site/Outfall 006 Exposure Area (Future)
7.4e CT: Calculation of chemical cancer risks and non-cancer hazards – Industrial Worker, Petroleum Storage Area (Future)
7.4f CT: Calculation of chemical cancer risks and non-cancer hazards – Industrial Worker, Chlorobenzene Hot-Spot Area (Future)
7.5a CT: Calculation of chemical cancer risks and non-cancer hazards – Construction Worker, Plant Area (Future)
7.5b CT: Calculation of chemical cancer risks and non-cancer hazards – Construction Worker, On-Site Ditches (Future)
7.5c CT: Calculation of chemical cancer risks and non-cancer hazards – Construction Worker, Former Chlorination Building (Future)
7.5d CT: Calculation of chemical cancer risks and non-cancer hazards – Construction Worker, Southwest Off-Site/Outfall 006 Exposure Area (Future)
7.5e CT: Calculation of chemical cancer risks and non-cancer hazards – Construction Worker, Petroleum Storage Area (Future)
7.5f CT: Calculation of chemical cancer risks and non-cancer hazards – Construction Worker, Chlorobenzene Hot-Spot Area (Future)
7.6 CT: Calculation of chemical cancer risks and non-cancer hazards – Transient Trespasser, State Fair Blvd/Northwest Off-Site/Off-Site Outfall 004 Exposure Area (Current/Future)
7.7a CT: Calculation of chemical cancer risks and non-cancer hazards – Utility Worker, Plant Area (Future)
7.7b CT: Calculation of chemical cancer risks and non-cancer hazards – Utility Worker, On-Site Ditches (Future)
7.7c CT: Calculation of chemical cancer risks and non-cancer hazards – Utility Worker, Former Chlorination Building (Future)

7.7d CT: Calculation of chemical cancer risks and non-cancer hazards – Utility Worker, State Fair Blvd/Off-Site Outfall 004 Exposure Area (Current/Future)
7.7e CT: Calculation of chemical cancer risks and non-cancer hazards – Utility Worker, Lakeshore Area (Current/Future)
7.7f CT: Calculation of chemical cancer risks and non-cancer hazards – Utility Worker, Petroleum Storage Area (Future)
7.7g CT: Calculation of chemical cancer risks and non-cancer hazards – Utility Worker, Chlorobenzene Hot-Spot Area (Future)
7.7h CT: Calculation of chemical cancer risks and non-cancer hazards – Utility Worker, Tributary 5A (Current/Future)
7.8 CT: Calculation of chemical cancer risks and non-cancer hazards – Adult Resident, Potable Hypotethical Water (Future)
7.9 CT: Calculation of chemical cancer risks and non-cancer hazards – Child Resident, Potable Hypothetical Water (Future)
7.9 CT Supplement A: Calculation of Chemical Cancer Risks for COPC with a Mutagenic Mode of Action

Table 9 series: Summary of receptor risks and hazards for COPCs
9.1a RME: Summary of receptor risks and hazards for COPCs – Adolescent Trespasser, Plant Area (Current/Future)
9.1b RME: Summary of receptor risks and hazards for COPCs – Adolescent Trespasser, On-Site Ditches (Current/Future)
9.1c RME: Summary of receptor risks and hazards for COPCs – Adolescent Trespasser, Former Chlorination Building (Current/Future)
9.1d RME: Summary of receptor risks and hazards for COPCs – Adolescent Trespasser, Southwest Off-Site/Outfall 006 Exposure Area (Current/Future)
9.1e RME: Summary of receptor risks and hazards for COPCs – Adolescent Trespasser, State Fair Blvd/Outfall 004 Exposure Area (Current/Future)
9.1f RME: Summary of receptor risks and hazards for COPCs – Adolescent Trespasser, Lakeshore Area (Current/Future)
9.1g RME: Summary of receptor risks and hazards for COPCs – Adolescent Trespasser, Petroleum Storage Area (Current/Future)
9.1h RME: Summary of receptor risks and hazards for COPCs – Adolescent Trespasser, Chlorobenzene Hot-Spot Area (Current/Future)
9.1i RME: Summary of receptor risks and hazards for COPCs – Adolescent Trespasser, Tributary 5A (Current/Future)
9.2a RME: Summary of receptor risks and hazards for COPCs – Adult Trespasser, Plant Area (Current/Future)
9.2b RME: Summary of receptor risks and hazards for COPCs – Adult Trespasser, On-Site Ditches (Current/Future)
9.2c RME: Summary of receptor risks and hazards for COPCs – Adult Trespasser, Former Chlorination Building (Current/Future)
9.2d RME: Summary of receptor risks and hazards for COPCs – Adult Trespasser, Southwest Off-Site/Outfall 006 Exposure Area (Current/Future)
9.2e RME: Summary of receptor risks and hazards for COPCs – Adult Trespasser, State Fair Blvd/Northwest Off-Site/Outfall 004 Exposure Area (Current/Future)
9.2f RME: Summary of receptor risks and hazards for COPCs – Adult Trespasser, Lakeshore Area (Current/Future)

9.2g RME: Summary of receptor risks and hazards for COPCs – Adult Trespasser, Petroleum Storage Area (Current/Future)
9.2h RME: Summary of receptor risks and hazards for COPCs – Adult Trespasser, Chlorobenzene Hot-Spot Area (Current/Future)
9.2i RME: Summary of receptor risks and hazards for COPCs – Adult Trespasser, Tributary 5A (Current/Future)
9.3a RME: Summary of receptor risks and hazards for COPCs – Surveillance Worker, Plant Area (Current/Future)
9.3b RME: Summary of receptor risks and hazards for COPCs – Surveillance Worker, On-Site Ditches (Current/Future)
9.3c RME: Summary of receptor risks and hazards for COPCs – Surveillance Worker, Former Chlorination Building (Current/Future)
9.4a RME: Summary of receptor risks and hazards for COPCs – Industrial Worker, Plant Area (Future)
9.4b RME: Summary of receptor risks and hazards for COPCs – Industrial Worker, On-Site Ditches (Future)
9.4c RME: Summary of receptor risks and hazards for COPCs – Industrial Worker, Former Chlorination Building (Future)
9.4d RME: Summary of receptor risks and hazards for COPCs – Industrial Worker, Southwest Off-Site/Outfall 006 Exposure Area (Future)
9.4e RME: Summary of receptor risks and hazards for COPCs – Industrial Worker, Petroleum Storage Area (Future)
9.4f RME: Summary of receptor risks and hazards for COPCs – Industrial Worker, Chlorobenzene Hot-Spot Area (Future)
9.5a RME: Summary of receptor risks and hazards for COPCs – Construction Worker, Plant Area (Future)
9.5b RME: Summary of receptor risks and hazards for COPCs – Construction Worker, On-Site Ditches (Future)
9.5c RME: Summary of receptor risks and hazards for COPCs – Construction Worker, Former Chlorination Building (Future)
9.5d RME: Summary of receptor risks and hazards for COPCs – Construction Worker, Southwest Off-Site/Outfall 006 Exposure Area (Future)
9.5e RME: Summary of receptor risks and hazards for COPCs – Construction Worker, Petroleum Storage Area (Future)
9.5f RME: Summary of receptor risks and hazards for COPCs – Construction Worker, Chlorobenzene Hot-Spot Area (Future)
9.6 RME: Summary of receptor risks and hazards for COPCs – Transient Trespasser, State Fair Blvd/Northwest Off-Site/Outfall 004 Exposure Area (Current/Future)
9.7a RME: Summary of receptor risks and hazards for COPCs – Utility Worker, Plant Area (Future)
9.7b RME: Summary of receptor risks and hazards for COPCs – Utility Worker, On-Site Ditches (Future)
9.7c RME: Summary of receptor risks and hazards for COPCs – Utility Worker, Former Chlorination Building (Future)
9.7d RME: Summary of receptor risks and hazards for COPCs – Utility Worker, State Fair Blvd/Off-Site Outfall 004 Exposure Area (Current/Future)
9.7e RME: Summary of receptor risks and hazards for COPCs – Utility Worker, Lakeshore Area (Current/Future)

9.7f RME: Summary of receptor risks and hazards for COPCs – Utility Worker, Petroleum Storage Area (Future)
9.7g RME: Summary of receptor risks and hazards for COPCs – Utility Worker, Chlorobenzene Hot-Spot Area (Future)
9.7h RME: Summary of receptor risks and hazards for COPCs – Utility Worker, Tributary 5A (Current/Future)
9.8 RME: Summary of receptor risks and hazards for COPCs – Adult Resident, Hypothetical Potable Water (Future)
9.9 RME: Summary of receptor risks and hazards for COPCs – Child Resident, Hypothetical Potable Water (Future)

9.1a CT: Summary of receptor risks and hazards for COPCs – Adolescent Trespasser, Plant Area (Current/Future)
9.1b CT: Summary of receptor risks and hazards for COPCs – Adolescent Trespasser, On-Site Ditches (Current/Future)
9.1c CT: Summary of receptor risks and hazards for COPCs – Adolescent Trespasser, Former Chlorination Building (Current/Future)
9.1d CT: Summary of receptor risks and hazards for COPCs – Adolescent Trespasser, Southwest Off-Site/Outfall 006 Exposure Area (Current/Future)
9.1e CT: Summary of receptor risks and hazards for COPCs – Adolescent Trespasser, State Fair Blvd/Northwest Off-Site/Outfall 004 Exposure Area (Current/Future)
9.1f CT: Summary of receptor risks and hazards for COPCs – Adolescent Trespasser, Lakeshore Area (Current/Future)
9.1g CT: Summary of receptor risks and hazards for COPCs – Adolescent Trespasser, Petroleum Storage Area (Current/Future)
9.1h CT: Summary of receptor risks and hazards for COPCs – Adolescent Trespasser, Chlorobenzene Hot-Spot Area (Current/Future)
9.1i CT: Summary of receptor risks and hazards for COPCs – Adolescent Trespasser, Tributary 5A (Current/Future)
9.2a CT: Summary of receptor risks and hazards for COPCs – Adult Trespasser, Plant Area (Current/Future)
9.2b CT: Summary of receptor risks and hazards for COPCs – Adult Trespasser, On-Site Ditches (Current/Future)
9.2c CT: Summary of receptor risks and hazards for COPCs – Adult Trespasser, Former Chlorination Building (Current/Future)
9.2d CT: Summary of receptor risks and hazards for COPCs – Adult Trespasser, Southwest Off-Site/Outfall 006 Exposure Area (Current/Future)
9.2e CT: Summary of receptor risks and hazards for COPCs – Adult Trespasser, State Fair Blvd/Northwest Off-Site/Outfall 004 Exposure Area (Current/Future)
9.2f CT: Summary of receptor risks and hazards for COPCs – Adult Trespasser, Lakeshore Area (Current/Future)
9.2g CT: Summary of receptor risks and hazards for COPCs – Adult Trespasser, Petroleum Storage Area (Current/Future)
9.2h CT: Summary of receptor risks and hazards for COPCs – Adult Trespasser, Chlorobenzene Hot-Spot Area (Current/Future)
9.2i CT: Summary of receptor risks and hazards for COPCs – Adult Trespasser, Tributary 5A (Current/Future)

9.3a CT: Summary of receptor risks and hazards for COPCs – Surveillance Worker, Plant Area (Current/Future)
9.3b CT: Summary of receptor risks and hazards for COPCs – Surveillance Worker, On-Site Ditches (Current/Future)
9.3c CT: Summary of receptor risks and hazards for COPCs – Surveillance Worker, Former Chlorination Building (Current/Future)
9.4a CT: Summary of receptor risks and hazards for COPCs – Industrial Worker, Plant Area (Future)
9.4b CT: Summary of receptor risks and hazards for COPCs – Industrial Worker, On-Site Ditches (Future)
9.4c CT: Summary of receptor risks and hazards for COPCs – Industrial Worker, Former Chlorination Building (Future)
9.4d CT: Summary of receptor risks and hazards for COPCs – Industrial Worker, Southwest Off-Site/Outfall 006 Exposure Area (Future)
9.4e CT: Summary of receptor risks and hazards for COPCs – Industrial Worker, Petroleum Storage Area (Future)
9.4f CT: Summary of receptor risks and hazards for COPCs – Industrial Worker, Chlorobenzene Hot-Spot Area (Future)
9.5a CT: Summary of receptor risks and hazards for COPCs – Construction Worker, Plant Area (Future)
9.5b CT: Summary of receptor risks and hazards for COPCs – Construction Worker, On-Site Ditches (Future)
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9.5f CT: Summary of receptor risks and hazards for COPCs – Construction Worker, Chlorobenzene Hot-Spot Area (Future)
9.6 CT: Summary of receptor risks and hazards for COPCs – Transient Trespasser, State Fair Blvd/Northwest Off-Site/Outfall 004 Exposure Area (Current/Future)
9.9a CT: Summary of receptor risks and hazards for COPCs – Utility Worker, Plant Area (Future)
9.7b CT: Summary of receptor risks and hazards for COPCs – Utility Worker, On-Site Ditches (Future)
9.7c CT: Summary of receptor risks and hazards for COPCs – Utility Worker, Former Chlorination Building (Future)
9.7d CT: Summary of receptor risks and hazards for COPCs – Utility Worker, State Fair Blvd/Northwest Off-Site/Outfall 004 Exposure Area (Current/Future)
9.7e CT: Summary of receptor risks and hazards for COPCs – Utility Worker, Lakeshore Area (Current/Future)
9.7f CT: Summary of receptor risks and hazards for COPCs – Utility Worker, Petroleum Storage Area (Future)
9.7g CT: Summary of receptor risks and hazards for COPCs – Utility Worker, Chlorobenzene Hot-Spot Area (Future)
9.7h CT: Summary of receptor risks and hazards for COPCs – Utility Worker, Tributary 5A (Current/Future)

9.8 CT: Summary of receptor risks and hazards for COPCs – Adult Resident, Hypothetical Potable Water (Future)
9.9 CT: Summary of receptor risks and hazards for COPCs – Child Resident, Hypothetical Potable Water (Future)

Table 10 series: Risk Summary
10.1a RME: Risk Summary – Adolescent Trespasser, Plant Area (Current/Future)
10.1b RME: Risk Summary – Adolescent Trespasser, On-Site Ditches (Current/Future)
10.1c RME: Risk Summary – Adolescent Trespasser, Former Chlorination Building (Current/Future)
10.1d RME: Risk Summary – Adolescent Trespasser, Southwest Off-Site/Outfall 006 Exposure Area (Current/Future)
10.1e RME: Risk Summary – Adolescent Trespasser, State Fair Blvd/Northwest Off-Site/Outfall 004 Exposure Area (Current/Future)
10.1f RME: Risk Summary – Adolescent Trespasser, Lakeshore Area (Current/Future)
10.1g RME: Risk Summary – Adolescent Trespasser, Petroleum Storage Area (Current/Future)
10.1h RME: Risk Summary – Adolescent Trespasser, Chlorobenzene Hot-Spot Area (Current/Future)
10.1i RME: Risk Summary – Adolescent Trespasser, Tributary 5A (Current/Future)
10.2a RME: Risk Summary – Adult Trespasser, Plant Area (Current/Future)
10.2b RME: Risk Summary – Adult Trespasser, On-Site Ditches (Current/Future)
10.2c RME: Risk Summary – Adult Trespasser, Former Chlorination Building (Current/Future)
10.2d RME: Risk Summary – Adult Trespasser, Southwest Off-Site/Outfall 006 Exposure Area (Current/Future)
10.2e RME: Risk Summary – Adult Trespasser, State Fair Blvd/Northwest Off-Site/Outfall 004 Exposure Area (Current/Future)
10.2f RME: Risk Summary – Adult Trespasser, Lakeshore Area (Current/Future)
10.2g RME: Risk Summary – Adult Trespasser, Petroleum Storage Area (Current/Future)
10.2h RME: Risk Summary – Adult Trespasser, Chlorobenzene Hot-Spot Area (Current/Future)
10.2i RME: Risk Summary – Adult Trespasser, Tributary 5A (Current/Future)
10.3a RME: Risk Summary – Surveillance Worker, Plant Area (Current/Future)
10.3b RME: Risk Summary – Surveillance Worker, On-Site Ditches (Current/Future)
10.3c RME: Risk Summary – Surveillance Worker, Former Chlorination Building (Current/Future)
10.4a RME: Risk Summary – Industrial Worker, Plant Area (Future)
10.4b RME: Risk Summary – Industrial Worker, On-Site Ditches (Future)
10.4c RME: Risk Summary – Industrial Worker, Former Chlorination Building (Future)
10.4d RME: Risk Summary – Industrial Worker, Southwest Off-Site/Outfall 006 Exposure Area (Future)
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10.5e RME: Risk Summary – Construction Worker, Petroleum Storage Area (Future)
10.5f RME: Risk Summary – Construction Worker, Chlorobenzene Hot-Spot Area (Future)

10.6 RME: Risk Summary – Transient Trespasser, State Fair Blvd/Northwest Off-Site/Outfall 004 Exposure Area (Current/Future)
10.7a RME: Risk Summary – Utility Worker, Plant Area (Future)
10.7b RME: Risk Summary – Utility Worker, On-Site Ditches (Future)
10.7c RME: Risk Summary – Utility Worker, Former Chlorination Building (Future)
10.7d RME: Risk Summary – Utility Worker, State Fair Blvd/Northwest Off-Site/Outfall 004 Exposure Area (Current/Future)
10.7e RME: Risk Summary – Utility Worker, Lakeshore Area (Current/Future)
10.7f RME: Risk Summary – Utility Worker, Petroleum Storage Area (Future)
10.7g RME: Risk Summary – Utility Worker, Chlorobenzene Hot-Spot Area (Future)
10.7h RME: Risk Summary – Utility Worker, Tributary 5A (Current/Future)
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10.6 CT: Risk Summary – Transient Trespasser, State Fair Blvd/Northwest Off-Site/Outfall 004 Exposure Area (Current/Future)
10.7a CT: Risk Summary – Utility Worker, Plant Area (Future)
10.7b CT: Risk Summary – Utility Worker, On-Site Ditches (Future)
10.7c CT: Risk Summary – Utility Worker, Former Chlorination Building (Future)
10.7d CT: Risk Summary – Utility Worker, State Fair Blvd/Northwest Off-Site/Outfall 004 Exposure Area (Current/Future)
10.7e CT: Risk Summary – Utility Worker, Lakeshore Area (Current/Future)
10.7f CT: Risk Summary – Utility Worker, Petroleum Storage Area (Future)
10.7g CT: Risk Summary – Utility Worker, Chlorobenzene Hot-Spot Area (Future)
10.7h CT: Risk Summary – Utility Worker, Tributary 5A (Current/Future)
10.8 CT: Risk Summary – Adult Resident, Hypothetical Potable Water (Future)
10.10 CT: Risk Summary – Child Resident, Hypothetical Potable Water (Future)

Acronyms

ABS – Dermal absorption factor
ADAF – Age-dependent adjustment factors
AF – Soil to skin adherence factor
AOS – Area of study
AT – Averaging time
ATSDR – Agency for Toxic Substances and Disease Register
AVG – Average
BGS – Below ground surface
Blvd – Boulevard
BTEX – benzene, ethylbenzene, toluene, xylene
BTX – benzene, toluene, and xylene
BW – Body weight
C_{air} – COPC concentration in air
CalEPA – California Environmental Protection Agency
CDI – Chronic daily intake
CF - Conversion factor
CFR – Code of Federal Regulations
CHSA – Chlorobenzene Hot-Spot Area
COPC – Compound of potential concern
$C_{sediment}$ – Sediment exposure point concentration
CSF – Cancer slope factor
CSM – Conceptual Site Model
C_{sw} – Concentration of each constituent in surface water
CSX – CSX Corporation
CT – Central tendency
C_{water} - Concentration of each constituent in drinking water
DAD - Dermal absorbed dose
DNAPL – Dense non-aqueous phase liquid
DQO – Data quality objectives
ED - Exposure duration
EF - Exposure frequency
EMPC – Estimated Maximum Possible Concentration
EPC – Exposure point concentration
ET – Exposure time
FCB – Former chlorination building
FI – Fraction ingested from contaminated source
Ft – Feet
GA – Groundwater suitable for drinking
GC – Gas chromatograph
HASP – Health and Safety Plan
HEAST – Health Effects Summary Tables
HHRA – Human Health Risk Assessment
HI – Hazard index/indicies
HQ – Hazard quotient
InR – Inhalation rate

IR – Ingestion rate for soil or water
IRIS – Integrated Risk Information System
IRM – Interim Remedial Measure
IEUBK – Integrated Exposure Uptake Biokinetic Model for Lead in Children
Kg – kilograms
L – Liters
L/hr – Liters/hour
LOAEL – Lowest-observed-adverse-effects-level
µg/l – Micrograms per liter
MM – millimeters
MMOA – Mutagenic mode of action
MRL – Minimal Response Level
MW – Monitoring well
NA – Not applicable
NAPL – Non-aqueous phase liquid
NATO/CSS – North Atlantic Treaty Organization/Committee on Challenges of Modern Society
NCEA – National Center for Environmental Assessment
NCP – National Contingency Plan
NIMO – Niagara Mohawk Company
NOAEL – No-observed-adverse-effects-level
NYSDEC – New York State Department of Environmental Conservation
OCWA – Onondaga County Water Authority
ORNL – Oak Ridge National Laboratory
OSWER – Office of Solid Waste and emergency response
PA – Plant area
PAH – Polycyclic aromatic hydrocarbons
PbS – Lead exposure point concentration term
PC - Permeability Coefficient (cm/hour)
PCB – Polychlorinated biphenyls
PCDD/Fs - polychlorinated dibenzo-p-dioxins and dibenzofurans
PEF – Particle emission factor
PPRTV – Provisional Peer-reviewed Toxicity Values
PRGs – Preliminary remediation goals
PSA – Petroleum storage area
QAPP – Quality Assurance Project Plan
RAGS – Risk Assessment Guidance for Superfund
RAIS – Risk Assessment Information System
RBCs – Risk-based concentrations
RfC – Reference concentration
RfD – Reference dose
RI – Remedial Investigation
RI/FS – Remedial Investigation/Feasibility Study
RME – Reasonable maximum exposure
ROS – Regression on Order Statistics
SA - Skin surface area for dermal absorption
SCS – Soil classification and standards
SPDES – State Pollutant Discharge Elimination System
STSC – Superfund Technical Support Center

SVOC – Semi-volatile organic compound
TCDD - Tetrachlorodibenzo-p-dioxin
TEFs- Toxic Equivalency Factors
TEQ – Toxicity equivalent concentration
TPH – Total petroleum hydrocarbons
UCL – Upper confidence limit
USDA – United States Department of Agriculture
USEPA – United States Environmental Protection Agency
VF – Volatilization factor
VOCs – Volatile organic compounds
WHO – World Health Organization

Executive Summary

A human health risk assessment (HHRA) is performed to provide the necessary risk information needed to assist in the decision making process at remedial sites. The risk assessment is used to provide the following items (USEPA 1989):

- An analysis of baseline risks
- Evaluation of the need for remedial action at sites
- A basis for evaluating levels of constituents that can remain onsite and be adequately protective of public health, and
- A basis for comparing potential impacts of various remedial alternatives.

The Willis Avenue Chlorobenzene Site HHRA was performed to assess potential impacts to public health related to the presence of chemical substances at the Site in Geddes, New York. Health risks were evaluated for potential trespassers, workers, and residents under current and future exposure scenarios. Estimated current and future cancer risks are largely within the acceptable regulatory range (1×10^{-4} to 1×10^{-6}), except in the Former Chlorination Building exposure area, which was historically involved in the production of chlorinated benzene products. Estimated current and future non-cancer hazards are also highest in the Former Chlorination Building exposure area, with lesser regulatory exceedances found in other Site exposure areas. Across exposure areas, the construction worker, and to a lesser extent the industrial and utility workers, had higher hazard indices relative to other receptors, as a result of greater time spent in the area and greater potential exposure to contaminated media. Although Site ground water is not used for potable water and municipal water is supplied from the Onondaga County Water Authority (OCWA), potential future residential exposure to ground water as potable water was evaluated and found to pose unacceptable cancer risks and non-cancer hazards. Overall primary Site risk drivers include potential exposure to dioxins, mercury, PCBs, and benzene.

Risk drivers were evaluated on the basis of reasonable maximum exposure (RME) scenarios and are subject to uncertainty including but not limited to:

- Exposure point concentrations are based on the upper confidence limit of mean chemical concentrations.
- Exposure factors include conservative estimates of frequency and duration of exposure.
- Toxicity factors typically account for sensitive sub-populations.

In addition, risks are estimated separately for each exposure area. However, it is unlikely that a given receptor would spend all of their time in one exposure area. Thus the risks and hazards shown for a given exposure area are likely an overestimate, and the true risk to a receptor would likely be a weighted average of the risks from several exposure areas.

Site Background

This human health risk assessment (HHRA) was performed to assess potential impacts to public health related to the presence of chemical substances at the Willis Avenue Chlorobenzene Site (the

Site) in Geddes, New York, and related areas of study (AOS)[1]. The objective of the HHRA was to assess potential risks to human health associated with Site-related chemical substances under current and reasonably foreseeable future land uses and to facilitate the consideration and evaluation of possible future remedial actions. The HHRA was performed as part of the Remedial Investigation (RI) performed by O'Brien & Gere Engineers, Inc. (O'Brien & Gere) on behalf of Honeywell International Inc. (Honeywell) pursuant to Consent Order R7-0201-87-08 (Order) between AlliedSignal and the New York State Department of Environmental Conservation (NYSDEC) dated August 12, 1990.

An HHRA Report was originally submitted to the NYSDEC in June 1999 (Appendix L of the RI report; O'Brien & Gere 1999). The NYSDEC issued comments on that report on January 25, 2002 and the HHRA report was resubmitted in June 2002 (O'Brien & Gere 2002). Comments on the 2002 report were issued by the NYSDEC on July 19, 2004. The HHRA report was resubmitted in October 2004 (O'Brien & Gere 2004) and a summary of the revisions was provided to the NYSDEC in a letter from Honeywell dated December 2, 2004. The NYSDEC provided comments on the October 2004 HHRA in a letter to Honeywell dated March 13, 2007. This document presents the revised HHRA report that addresses the March 13, 2007 comments of the NYSDEC.

Site History

The principal activity of the plant was the production of chlorinated benzene products (monochlorobenzene and dichlorobenzene) from 1918 until production operations were discontinued in 1977; the Site has been inactive since 1977 except as a warehouse for various products produced at the Main Plant Site (1977-1986). Additional operations that reportedly took place at the plant included the production of caustic potash (potassium hydroxide), caustic soda (sodium hydroxide), and chlorine gas. Caustic potash and chlorine were produced by the electrolysis of potassium chloride brine solution. Initially, this was done in diaphragm cells, but in 1947, mercury cells were installed to manufacture these products. The process operations that took place at this facility have been described in detail in the History of the Willis Avenue Plant, Petroleum Storage Facility, and Associated "Hot-Spots" Report (O'Brien & Gere 1990).

Constituents related to former processes, primarily chlorinated benzene products and mercury, have been detected in surface soils (0-2 ft below ground surface (bgs)), subsurface soils (upper soils at 0-10 ft bgs and deep soils at > 10 ft bgs), and groundwater at the Site and related AOS. In addition, elevated mercury and chlorinated benzene concentrations have been detected in drainage ditches, outfalls, utility conduits, dredge spoils areas, and other migration pathways at and in the immediate vicinity of the General Plant Area. The objective of this HHRA was to evaluate current and reasonably foreseeable potential human exposures associated with these media and exposure pathways.

[1]Potential exposures in Onondaga Lake were not evaluated as part of the HHRA. These exposures will be assessed as part of the Onondaga Lake Study. The related areas of study included the Petroleum Storage Area (PSA), Chlorobenzene Hot-Spot Area (CHSA), and Tributary 5A.

Exposure Areas, Receptors, and Exposure Media

Currently, the Site is not in active use and there are no routine activities conducted On-Site. The General Plant Area, which consists of the Plant Area, the Former Chlorination Building, and On-Site Ditches, is surrounded by an eight-foot high fence and is monitored by Honeywell surveillance personnel during working hours. The Willis Avenue Plant Study Area also includes the State Fair Blvd./Northwest Off-Site/Outfall 004 and Southwest Off-Site/Outfall 006 Exposure Areas, as well as the Lakeshore Area. Three additional AOS (Tributary 5A, the Petroleum Storage Area, and the Chlorobenzene Hot-Spot Area) are included in the HHRA as well. Off-Site areas accessible by the public include Southwest Off-Site/Outfall 006 Exposure Area, State Fair Blvd./ Off-Site/Outfall 004 Exposure Area, the Lakeshore Area, Tributary 5A, PSA, and portions of the CHSA. The State Fair Blvd./ Off-Site/Outfall 004 is the most easily accessible, as many of the other areas have fences or railroad tracks on several sides. Based on historical observations, exposures at these areas are expected to be infrequent and of short duration. Based on current conditions at the Site and surrounding areas, the following current receptor populations were identified:

- Adolescent trespasser (Plant Area, On-Site Ditches, Former Chlorination Building, Tributary 5A, Southwest Off-Site/Outfall 006 Exposure Area, State Fair Blvd./ Off-Site/Outfall 004 Exposure Area, Lakeshore Area, Petroleum Storage Area, Chlorobenzene Hot-Spot Area)

- Adult trespasser (Plant Area, Former Chlorination Building, On-Site Ditches, Tributary 5A, Southwest Off-Site/Outfall 006 Exposure Area, State Fair Blvd./ Off-Site/Outfall 004 Exposure Area, Lakeshore Area, Petroleum Storage Area, Chlorobenzene Hot-Spot Area)

- Utility worker (State Fair Blvd./ Off-Site/Outfall 004 Exposure Area, Lakeshore Area, Tributary 5A)

- State Fair Boulevard transient (State Fair Blvd./ Off-Site/Outfall 004 Exposure Area)

- Surveillance worker (Plant Area, Former Chlorination Building, On-Site Ditches)

The Site and AOS are not expected to be developed as residential areas since the exposure areas are located in a heavily industrialized setting and are zoned industrial. Based on this consideration, the following receptors were identified under reasonably foreseeable future conditions.

- Adolescent trespasser (Plant Area, On-Site Ditches, Former Chlorination Building, Tributary 5A, Southwest Off-Site/Outfall 006 Exposure Area, State Fair Blvd./ Off-Site/Outfall 004 Exposure Area, Lakeshore Area, Petroleum Storage Area, Chlorobenzene Hot-Spot Area)
- Adult trespasser (Plant Area, On-Site Ditches, Former Chlorination Building, Tributary 5A, Southwest Off-Site/Outfall 006 Exposure Area, State Fair Blvd./ Off-Site/Outfall 004 Exposure Area, Lakeshore Area, Petroleum Storage Area, Chlorobenzene Hot-Spot Area)
- Adult transient (State Fair Blvd./ Off-Site/Outfall 004 Exposure Area)
- Surveillance worker (Plant Area, On-Site Ditches, Former Chlorination Building)
- Industrial worker (Plant Area, On-Site Ditches, Former Chlorination Building, Southwest Off-Site/Outfall 006 Exposure Area, Petroleum Storage Area)
- Construction worker (Plant Area, On-Site Ditches, Former Chlorination Building, Southwest Off-Site/Outfall 006 Exposure Area, Petroleum Storage Area, Chlorobenzene Hot-Spot Area)

- Utility worker (Plant Area, On-Site Ditches, Former Chlorination Building, Tributary 5A, State Fair Blvd./ Off-Site/Outfall 004 Exposure Area, Lakeshore Area, Petroleum Storage Area, Chlorobenzene Hot-Spot Area)
- Child (< 6 years) resident (Potable water)
- Adult resident (Potable water)

Exposure media considered in both current and future scenarios include soil, sediment, surface water, groundwater, and indoor air. Receptors that may be exposed to surface soils (0-2 ft) include trespassers, surveillance workers, industrial workers, and State Fair Boulevard transients. Construction workers and utility workers may contact upper soils (0-10 ft) and intermediate soils (0-20 ft), respectively. Trespassers and utility workers in the Tributary 5A area may be exposed to sediment and surface water. On-Site groundwater occurs at a depth of approximately 15-20 ft bgs while Off-Site it occurs at approximately 4-5 ft at the Chlorobenzene Hot-Spot Area, Petroleum Storage Area, and Lakeshore Area.

Groundwater at the Plant Study Area and at other AOS is not used as a drinking or industrial water supply and is highly unlikely to be used as a drinking or industrial supply in the future, since the area is supplied by municipal water from OCWA. However, the New York State groundwater classification for the Site and surrounding area is GA (*i.e.*, suitable for drinking use). In accordance with the NYSDEC's request, the hypothetical residential drinking water scenario was evaluated for future receptors in the risk assessment.

Hazard indices (HI) and cancer risks were derived based on the reasonable maximum exposure (RME) and central tendency (CT) concentrations for the identified receptor scenarios. Summaries of current and future receptors HI's and CT's are presented in Tables 7.1 and 7.2, respectively.

Risk Discussion

In general, under current conditions, cancer risks for receptors in all exposure areas are within the acceptable regulatory range of 10^{-4} to 10^{-6}, except for the Former Chlorination Building, and hazard indices for receptors in the Plant Area, State Fair Blvd/ Northwest Off-Site/ Outfall 004 Exposure Area, and the Petroleum Storage Area are within the threshold of 1.

Under future conditions, cancer risks for receptors in all exposure areas are within the acceptable regulatory range of 10^{-4} to 10^{-6}, except for the Southwest Off-Site/Outfall 006 Exposure Area and the Former Chlorination Building. Under future conditions, hazard indices for receptors in the State Fair Blvd/ Northwest Off-Site/ Outfall 004 Exposure Area are within the threshold of 1.

It should be noted that it is unlikely that a given receptor would spend all of their time in one exposure area. Thus the risks and hazards shown for a given exposure area are likely an overestimate, and the true risk to a receptor would likely be a weighted average of the risks from several exposure areas.

All receptors at the Former Chlorination Building (FCB) Exposure Area had estimated cancer risk values in excess of 1×10^{-4}, driven primarily by high concentrations of 2,3,7,8-TCDD equivalent in soils; this was responsible for the high HI values as well. In contrast, receptors associated with the

State Fair Blvd./Northwest Off-Site/Outfall 006 Exposure Area, as well as trespassers associated with the Lakeshore Area, had HI and cancer risks below the acceptable regulatory thresholds.

Across all applicable Exposure Areas, the construction worker, and to a lesser extent the industrial and utility workers, had higher HI values relative to the other receptors. This is a function of the assumptions of greater time spent in the area and greater exposure to contaminated media for these receptors relative to others.

The calculated RME HI for the future adult resident and child resident at the hypothetical drinking water source area were 2×10^{2} and 4×10^{2}, while the RME cancer risks were 1×10^{-2} and 7×10^{-3}, respectively. These values were attributable primarily to exposure to the maximum detected concentration of benzene in groundwater. Groundwater at the Site is not suitable for use as a drinking water supply irrespective of any contributions related to waste at the Site. The drinking water pathway was included in this section at the request of NYSDEC; however, this is considered to be an incomplete pathway under reasonably foreseeable land use scenarios.

Risk Drivers

A summary of risk drivers is presented in the RAGS Table 10 series and below.

Plant Area

Current/Future Receptors

There are no unacceptable cancer risks or non-cancer hazards for current/future Site-receptors (adolescent trespasser, adult trespasser, and surveillance worker).

Future Receptors

Under the future exposure scenarios, there are no unacceptable cancer risks associated with any receptor in this exposure area. Non-cancer hazard exceeding the threshold for the future construction worker is driven primarily by exposure to:

- Nickel (HQ = 20)

Non-cancer hazards for the future utility worker is driven primarily by exposure to:

- Mercury (HQ = 3).

On-Site Ditches

Current/Future Receptors

There are no unacceptable cancer risks for current/future Site-receptors. Likewise, there are no unacceptable chemical-specific hazards for the current/future adult trespasser or surveillance worker. The non-cancer hazards for the adolescent trespasser are driven primarily by exposure to:

- 2,3,7,8-TCDD Equivalents (HQ = 3)
- Mercury (HQ = 3).

Future Receptors

There are no unacceptable cancer risks for future Site-receptors. Non-cancer hazards for the future construction worker are driven by exposure to:

- 2,3,7,8-TCDD Equivalents (HQ = 10)
- Mercury (HQ = 30).

Non-cancer hazards for future utility workers is also driven primarily by exposure to:

- 2,3,7,8-TCDD Equivalents (HQ = 9)
- Mercury (HQ = 5).

To a lesser extent, non-cancer hazards for future industrial workers is also driven primarily by these constituents.

Former Chlorination Building

Current/Future Receptors

Cancer risk to the adolescent trespasser, adult trespasser, and surveillance worker was estimated at the higher end of the regulatory threshold range of 10^{-4} to 10^{-6}. This risk was driven primarily by potential exposure to:

- 2,3,7,8-TCDD Equivalents (CR = 4×10^{-4})

Non-cancer hazards for these receptors also exceeded the regulatory threshold and are also driven by potential exposure to:

- 2,3,7,8-TCDD Equivalents (HQ = 20).

Future Receptors

Cancer risks to the future industrial worker, construction worker, and utility worker exceeded the regulatory threshold range of 10^{-4} to 10^{-6}. These risks are driven primarily by potential exposure to:

- 2,3,7,8-TCDD Equivalents (CR range = 1.7×10^{-3} to7.6×10^{-4})

Non-cancer hazards for these receptors also exceeded the regulatory threshold and are also driven by potential exposure to:

- 2,3,7,8-TCDD Equivalents (HQ ranges from 30 to 400).

Southwest Off-Site/Outfall 006 Exposure Area

Current/Future Receptors

There are no unacceptable cancer risks or non-cancer hazards for current/future Site-receptors in the Southwest Off-Site/Outfall 006 Exposure Area.

Future Receptors

There are no unacceptable cancer risks or non-cancer hazards for future industrial worker. Cancer risk to the future construction worker exceeded the regulatory threshold range of 10^{-4} to 10^{-6}. Cancer risk was driven primarily by exposure to:

- Benzene (CR = 1.5×10^{-4})

Non-cancer hazards for the future construction worker exceeded the regulatory threshold of 1 and was driven primarily by exposure to:

- Benzene (HQ = 40)
- Mercury (HQ = 10)
- Xylenes (HQ = 9)

State Fair Blvd/Northwest Off-Site/Outfall 004 Exposure Area

Current/Future Receptors

There are no unacceptable cancer risks or non-cancer hazards for the current/future receptor in this exposure area.

Future Receptors

There are no unacceptable cancer risks or non-cancer hazards for anticipated future receptors in this exposure area.

Lakeshore Property Area

Current/Future Receptors

There are no unacceptable cancer risks or non-cancer hazards for the adolescent trespasser or adult trespasser. There are also no unacceptable cancer risks for the utility worker in this exposure area;

however non-cancer hazards for this receptor exceeded the regulatory threshold. The non-cancer hazard was driven primarily by potential exposure to:

- Benzene (HQ = 9)
- Chlorobenzene (HQ = 3)

Petroleum Storage Area

Current/Future Receptors

There are no unacceptable cancer risks or non-cancer hazards for the adolescent trespasser or adult trespasser in this exposure area.

Future Receptors

There are no unacceptable cancer risks or non-cancer hazards for future industrial or utility worker. There are also no unacceptable cancer risks to the future construction worker; however, non-cancer hazards for the future construction worker exceeded the regulatory threshold of 1 and was driven primarily by exposure to:

- Manganese (HQ = 5)

Chlorobenzene Hot-Spot Area

Current/Future Receptors

There are no unacceptable cancer risks for the adolescent trespasser or the adult trespasser in the CHSA. Non-cancer hazard, however, did exceed the regulatory threshold and was driven by exposure to:

- PCBs (HQ = 4 and 3, respectively)

Future Receptors

There are no unacceptable cancer risks for future industrial worker in the CHSA. Non-cancer hazard, however, did exceed the regulatory threshold and was driven by exposure to:

- PCBs (HQ = 6)

There are no unacceptable cancer risks for future construction worker in the CHSA. Non-cancer hazards, however, did exceed the regulatory threshold and were driven primarily by exposure to:

- Manganese (HQ = 4)
- PCBs (HQ = 6)

There are no unacceptable cancer risks for future utility worker in the CHSA. Non-cancer hazard, however, did exceed the regulatory threshold and was driven primarily by exposure to:

- PCBs (HQ = 7)

Tributary 5A

Current/Future Receptors

There are no unacceptable cancer risks or non-cancer hazards for the adolescent trespasser or the adult trespasser in this exposure area.

Hypothetical Drinking Water Source Area

Groundwater at the Site is not suitable for use as a drinking water supply irrespective of any contributions related to waste at the Site. However, the following section describes the risk drivers that would be expected if it groundwater was used as drinking water source.

Future Receptors

Both cancer risk and non-cancer hazards exceeded their respective regulatory thresholds for future child and adult residents. The cancer risks are driven primarily by exposure to:

- Benzene CRs = 5×10^{-3} and 1×10^{-2}, respectively)
- Arsenic (CRs = 1×10^{-3} and 2×10^{-3}, respectively)
- 1,4-Dichlorobenzene (CR = 2×10^{-4} and 4×10^{-4}, respectively)
- Benzo(b)fluoranthene (CR = 2×10^{-4} and 4×10^{-4}, respectively)

Non-cancer hazards for the future child and adult residents are driven primarily by:

- Benzene (HQ = 300 and 100, respectively)
- Chlorobenzene ((HQ = 50 and 20, respectively)
- Arsenic (HQ = 30 and 10, respectively)
- Toluene ((HQ = 10 and 5, respectively)
- Chromium (HQ = 8 and 4, respectively)
- Iron (HQ = 6 and 2, respectively)
- 1,4-Dichlorobenzene (HQ = 5 and 2, respectively)

Hypothetical Future Indoor Air

Based on the high vapor pressure of many of the compounds detected, a vapor intrusion evaluation will need to be conducted prior to the construction of occupied buildings at the site. Based on the vapor intrusion evaluation, preventative measures may be included in the design and construction of buildings at the Site to mitigate the risk of exposure to on-Site soil gas. Such measures may include the use of a vapor barrier or the installation of a venting system, such as at the groundwater treatment plant.

1. Introduction

This report presents the results of a human health risk assessment (HHRA) of potential impacts to public health related to the presence of chemical substances at the Willis Avenue Chlorobenzene Site (the Site) in Geddes, New York. The objective of the HHRA was to assess potential risks to human health associated with Site-related chemical substances under current and reasonably foreseeable future land uses and to facilitate the consideration and evaluation of possible future remedial actions.

The HHRA was performed as part of the Remedial Investigation (RI) performed by O'Brien & Gere Engineers, Inc. (O'Brien & Gere) on behalf of Honeywell International Inc. (Honeywell) pursuant to Consent Order R7-0201-87-08 (Order) between AlliedSignal and the New York State Department of Environmental Conservation (NYSDEC) dated August 12, 1990. An HHRA Report was submitted to NYSDEC in June 1999 (Appendix L of the RI/FS report; O'Brien & Gere 1999). The NYSDEC issued comments on that report on January 25, 2002 and the HHRA report was resubmitted in June 2002 (O'Brien & Gere 2002). Comments on the 2002 report were issued by the NYSDEC on July 19, 2004. The HHRA report was resubmitted in October 2004 (O'Brien & Gere 2004) and a summary of the revisions was provided to NYSDEC in a letter from Honeywell dated December 2, 2004. NYSDEC provided comments on the October 2004 HHRA in a letter to Honeywell dated March 13, 2007. This document presents the revised HHRA report that addresses the March 13, 2007 comments of NYSDEC, as well as subsequent comments on RAGS D Tables submitted as interim deliverables.

The HHRA focuses on chemical substances detected in soil, sediment and groundwater at and down gradient of the Site. The assessment does not address Site-related chemical substances that may have migrated to Onondaga Lake since Onondaga Lake was investigated and evaluated under a separate Consent Order.

1.1. Risk Assessment Guidance

The following United States Environmental Protection Agency (USEPA) documents were used as principal guidance in the preparation of the HHRA:

- *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A) Interim Final* (USEPA 1989a)

- *Guidance for Risk Characterization* (USEPA 1995)

- *Exposure Factors Handbook* (USEPA 1997a)

A chemical substance may pose a risk to human health only if receptor populations have the potential to be exposed to the chemical substance in sufficient quantities to affect the health of exposed individuals. As such, a Site-specific health risk assessment involves the following:

- identification of Site-related chemical substances;
- identification of potential mechanisms by which human receptors may be exposed;
- estimation of the concentrations of the chemicals that may be present at locations where receptors may contact them (exposure point concentrations); and

- evaluation of potential adverse effects that may result from the estimated dose of the chemicals if absorbed by receptors.

1.2. Approach

Consistent with the cited guidance, the HHRA was conducted in the following phases:

- *Description of Site Areas (Section 2)*. The first step in the assessment was to identify and describe the physical locations and general characteristics of the Site and related AOS.

- *Conceptual Site Model (Section 3)*. The goal of the conceptual Site model was to characterize the Site with respect to its physical characteristics as well as those of the human populations at or near the Site. The output of this step was a qualitative evaluation of the Site and surrounding populations with respect to those characteristics that potentially influence exposure.

- *Data Evaluation (Section 4)*. The objective of the data evaluation step was to organize the data into a form appropriate for use in the assessment, to evaluate the quality of the data for HHRA purposes, and identify chemicals of potential concern (COPCs).

- *Exposure Assessment (Section 5).* In the exposure assessment, the pathways by which receptors may be exposed to On-Site chemical substances were identified and exposure point concentrations of COPCs were estimated for each complete exposure pathway.

- *Toxicity Assessment (Section 6).* In the toxicity assessment, available toxicological data for Site-related compounds were gathered and reviewed. Dose-response relationships between the extent of potential exposure and the occurrence/severity of potential adverse health effects were evaluated.

- *Risk Characterization (Section 7).* In the risk characterization step, the toxicity and exposure assessments were integrated into quantitative estimates of potential human health risk.

- *Uncertainty Analysis (Section 8).* In this section, the major uncertainties in the calculated risk estimates were discussed.

2. Description of Site Areas

The Willis Avenue Chlorobenzene Site is comprised of the Willis Ave Plant Study Area and three additional Areas of Study (AOS), which are presented in Figures L-1 and L-2. The AOS were either associated with the former production processes but were not located on or immediately adjacent to the Site, or have been included in the study at the request of the NYSDEC. The Willis Avenue Plant Study Area consists of:

- Plant Area
- Former Chlorination Building
- On-Site Ditches
- Southwest Off-Site/Outfall 006 Exposure Area
- State Fair Blvd./Northwest Off-Site/Outfall004 Exposure Area
- Lakeshore Area

The additional AOS consist of:

- Petroleum Storage Area,
- Chlorobenzene Hot-Spot Area,
- Tributary 5A.

A brief description of the various areas comprising the Site is presented below. A more detailed discussion is presented in Section 1 of the RI Report (O'Brien & Gere 2002).

2.1. Willis Avenue Plant Study Area

The Willis Ave Plant Study Area consists of the Willis Ave Plant Area (Plant Area); the On-Site Ditches; the Former Chlorination Building (FCB); Outfall 006 and the associated drainage ditch and mounded area; Outfall 004 and the associated drainage ditch; and the Lakeshore Area (Figure L-2).

Plant Area, On-Site Ditches, and FCB. The Plant Area (Figure L-3) is bounded by State Fair Boulevard to the north, Willis Avenue to the east, CSX railroad tracks to the south, and the Honeywell Semet Residue Ponds to the west. The FCB (Figure L-4) two On-Site Ditches (Figure L-5) are located within the Plant Area, but are treated as separate Exposure Areas in this HHRA to account for potential localized areas of contamination in the On-Site Ditches or FCB. Except for the grassy area near the former office/laboratory, the former plant area is sparsely vegetated. Surface materials consist primarily of concrete building foundations, associated debris, asphalt and gravel. Shallow subsurface materials (approximately 0 to 30 ft) consist of fill materials composed of sand and gravel, ash, cinders, brick fragments, and Solvay Waste. The former office/laboratory is the only building remaining in the plant area and is currently vacant. The Plant Area is completely surrounded by an eight-foot high chain link fence and the only point of access is a gate, which can only be opened by Honeywell personnel. Due to these security measures, there has been no evidence of trespassing or dumping On-Site.

The principal activity of the plant was the production of chlorinated benzene products (monochlorobenzene and dichlorobenzenes) from 1918 until production operations were discontinued

in 1977. The Site has been inactive since 1977 except as a warehouse for various products produced at the Main Plant Site (1977-1986). A fire occurred at the chlorination building in 1930 making it a potential site for the formation of dioxins and furans (Syracuse Herald Journal, July 4th, 1930). Additional operations that reportedly took place at the plant included the production of caustic potash (potassium hydroxide), caustic soda (sodium hydroxide), and chlorine gas. Caustic potash and chlorine were produced by the electrolysis of potassium chloride brine solution. Initially, this was done in diaphragm cells, but mercury cells were installed to manufacture these products in 1947. The process operations that took place at this facility have been described in detail in the *History of the Willis Avenue Plant, Petroleum Storage Facility, and Associated "Hot-Spots" Report* (O'Brien & Gere 1990; Appendix A of the RI Report).

Outfall 006, drainage ditch and mounded area (Southwest Off-Site/Outfall 006 Exposure Area). Outfall 006 is situated to the southwest of the fenced Plant Area and approximately 30 ft north of the CSX railroad tracks (Figure L-6). A shallow drainage ditch extends from the outfall north towards the Plant Area. The above ground portion of the drainage ditch is approximately 75 ft in length and the remainder is below ground. Historic information gathered from State Pollutant Discharge Elimination System (SPDES) discharge permit sampling data indicates that the ditch is dry throughout the year, with the exception of heavy rainfall or snowmelt events. The mounded area is the area extending from the southern plant area boundary back to the CSX railroad tracks. The area is approximately 350 ft by 200 ft in area and vegetation is patchy with scattered pioneer grasses, wild flowers, and tree saplings (brushy cleared land). Access to this area is not restricted; however, the area is remote and generally only accessed by railroad workers or utilities workers.

Outfall 004, drainage ditch, and Niagara Mohawk Utility Line Area (State Fair Blvd./Northwest Off-Site/Outfall 004 Exposure Area)[1]. This area contains three key aspects: proximity to State Fair Boulevard, presence of Outfall 004 and a drainage ditch, and a Niagara Mohawk utility line.

- State Fair Boulevard is situated immediately adjacent to this Exposure Area and is a regularly driven road with minimal pedestrian traffic.

- Outfall 004 is situated approximately 25 ft north and 200 ft west of the northwest corner of the Plant Area fence and near State Fair Boulevard (Figure L-7). The outfall is located along a shallow drainage ditch (approximately 1 to 1.5 ft in depth) that runs in the east-west direction parallel to, and approximately 10 ft south of, State Fair Boulevard. The ditch starts at the corner of Willis Avenue and continues west until it terminates at Tributary 5A near Crucible Specialty Metals. The ditch is dry throughout the year, with the exception of heavy rainfall or snowmelt events.

- A Niagara Mohawk (NIMO) utility line extends along the length of the Exposure Area.

- Cover type in this area is classified as mowed roadside/pathway, which consists of grasses and sedges and vines and low shrubs. Access to this area is not restricted.

[1] Site "Northwest Off-Site/Outfall 004 Exposure Area" was called "State Fair Boulevard/Outfall 004 area" in previous revisions. This represents a change in naming conventions, not a change in the description of the site itself.

Lakeshore Area. The Lakeshore Area is situated to the north of the plant area and between the southern shore of Onondaga Lake and the westbound lane of I-690. The Lakeshore Area is bounded by Onondaga Lake to the north and the fence along I-690 to the south. The Lakeshore Area is presented in Figure L-8. The extent of the Lakeshore Area to the west is defined by the 84-inch water intake at the lake, and the eastern extent is defined by the PA sewer and western end of the East Flume. The area consists of a narrow strip of mowed lawn to the north of I-690 and a concrete pier along the lake, which is accessible by boat from Onondaga Lake. The Lakeshore Area widens as it approaches the Upper East Flume. An eight-foot high chain fence with a locking gate surrounds the area, but boaters can access the area. As described in the RI report, a chlorobenzene dense non-aqueous phase liquid (DNAPL) recovery Interim Remedial Measure (IRM) is on-going at the Lakeshore Area.

2.2. Other Areas of Study

Tributary 5A. Tributary 5A is a small stream that courses for about 3000 ft and discharges into Onondaga Lake (Figure L-9). The stream contains a three-foot diameter culvert (approximately 300 ft long) under I- 690 and a two-foot diameter culvert (over 200 ft long) under a set of railroad tracks. The stream is generally six inches deep and contains several small pools with an average depth of one to two feet. Access to the area is limited by thick vegetation and steep-sided banks; there is also limited open water for fishing in Tributary 5A.

The fish sampling survey conducted in November 2001 by O'Brien & Gere indicated that the game fish present in Tributary 5A are insufficient in size or palatable quality for consumption. Specifically, the largest game fish collected was a largemouth bass, which was 160 mm in length and therefore below the current legal size limit. This fish could not be legally retained for personal consumption. The largest sunfish (pumpkinseed) collected was 123 mm and too small for cleaning and personal consumption. The pumpkinseed may be considered a game fish but does not have a regulated size limit. In addition to the game fish, a creek chub collected was 305 mm long and carp were observed to be eight to twelve inches long. Sport fishermen do not generally consider these fish for personal consumption.

Based on the shallow stream depth and lengthy culverts, upstream migration of the relatively larger fish is considered unlikely. The relatively larger fish that were collected or observed (described above) are likely residents of the small pools. These fish have potentially reached an optimal adult size for the habitat provided in Tributary 5A.

Petroleum Storage Area. The Petroleum Storage Area (PSA) is located to the southwest of the Plant Area. It is bounded to the north by the CSX railroad tracks, to the southeast by a railroad siding and to the west by the Salt City soft coal storage area (Figure L-10). The PSA is mostly covered by concrete and asphalt; access to the area is restricted by fencing and Honeywell surveillance.

Chlorobenzene Hot-Spots Area. The Chlorobenzene Hot-Spot Area (CHSA) is situated to the south of the Plant Area and the PSA, and adjacent to the Suez Power Plant, formerly Trigen (Figure L-11). The area is covered with industrial buildings, concrete, and asphalt; access is restricted by fencing to the north. The southern portion of the CHSA, between the fencing and Industrial Drive, is an accessible piece of sparsely vegetated land. This area contained an underground pipeline that leaked historically creating the present contamination issues.

3. Conceptual Site Model

This section presents the conceptual site model (CSM) for the Site. The CSM describes the Site and additional AOS. The CSM presents hypotheses regarding the contaminants present, their routes of migration, and their potential impact on human receptors, forming the basis for the HHRA approach and assumptions. A general CSM for the Site is presented in Section 3.1 below. The CSM is based on information and analytical data presented in Sections 1 through 4 of the RI report (O'Brien & Gere 2002).

To facilitate the HHRA, the Site and additional AOS were organized into Exposure Areas based on the likely current and future land uses and potential current and future receptor populations.

A conceptual model for each of the defined Exposure Areas is presented in Sections 3.2 through 3.9 and summarized on RAGS D Tables 1.1a through 1.1h.

3.1. General CSM

General descriptions of the Site Areas that support the CSM were provided in Section 2. Process-related constituents, primarily chlorinated benzene products and mercury, have been detected in surface soils, subsurface soils, sediment, and groundwater at the Site. In addition, elevated mercury and chlorinated benzene concentrations have been detected in drainage ditches, outfalls, utility conduits, dredge spoils areas, and other migration pathways at and in the immediate vicinity of the Plant Area.

Currently, there are no routine activities conducted on-site. The Plant Area, FCB, and one of the On-Site Ditches are surrounded by an eight-foot high fence and are monitored by Honeywell surveillance personnel during working hours. Off-Site areas accessible by the public include the Southwest Off-Site/Outfall 006 Exposure Area, Sate Fair Blvd./Northwest Off-Site/Outfall 004 Exposure Area, Tributary 5A, the Lakeshore Area, PSA, and portions of the CHSA. However, based on historical observations, exposures at these areas are expected to be infrequent and of short duration. Based on current conditions at the Site, the current receptor populations per Exposure Area were identified:

Table 3.1. *Identified receptors for the Exposure Areas*.

	Current receptors			**Future Receptors**					
Exposure Area	T/Tr	SW	UW	T/Tr	SW	IW	CW	UW	R
Plant Area	A/Ad[1]	Ad		A/Ad[1]	Ad	Ad	Ad	Ad	
FCB	A/Ad[1]	Ad		A/Ad[1]	Ad	Ad	Ad	Ad	
On-Site Ditches	A/Ad[1]	Ad		A/Ad[1]	Ad	Ad	Ad	Ad	
Southwest Off-Site/Outfall 006	A/Ad[1]			A/Ad[1]		Ad	Ad		
Northwest Off-Site/Outfall 004	A/Ad[2]		Ad	A/Ad[2]				Ad	

Table 3.1. *Identified receptors for the Exposure Areas*.

	Current receptors			Future Receptors					
Lakeshore Area	A/Ad[1]		Ad	A/Ad[1]				Ad	
Tributary 5A	A/Ad[1]		Ad	A/Ad[1]				Ad	
PSA	A/Ad[1]			A/Ad[1]		Ad	Ad	Ad	
CHSA	A/Ad[1]			A/Ad[1]		Ad	Ad	Ad	
Drinking Water Source area									C/Ad

NOTES:

A = adolescent; Ad = adult; C = Child

CW = construction worker; IW = industrial worker

SW = surveillance worker; T/Tr = trespasser/transient;

UW = utility worker, R = resident

[1] = adolescent and adult trespasser; [2] = adolescent and adult trespasser/adult transient

Source: O'Brien & Gere Engineers, Inc.

The adolescent trespasser is assumed to be on foot for all Exposure Areas except the State Fair Blvd./Northwest Off-Site/Outfall 004 Exposure Area, where bicycle traffic is possible. The other Exposure Areas are either surrounded by a security fence, have a remote location, or are highly industrialized. This is discussed in Sections 5.2 through 5.8. It should be noted that no evidence of trespassing has been observed at the Site.

The Site is not expected to be developed into residential areas, since the areas are located in heavily industrialized settings and are zoned industrial (Town of Geddes Zoning Maps). Based on this consideration, additional receptors were identified under reasonably foreseeable future conditions and included in the table above.

Receptors may be exposed to surface soils (0-2 ft; trespassers, transients, industrial workers), upper soils (0-10 ft; construction workers, utility worker), or deep soils (> 10 ft; utility workers). In addition, future industrial workers may also be exposed to volatile organic compounds (VOCs) in upper soils and groundwater that may infiltrate indoor air via soil vapor migration. Recreational fishermen may be exposed to surface water and sediment from Tributary 5A.

Groundwater occurs at a depth of approximately 15 to 20 ft bgs for the Plant Area, On-Site Ditches, and FCB, while it occurs at approximately 4 to 5 ft at the CHSA, PSA, and Lakeshore Area. Groundwater at the Site is not used as a drinking or industrial water supply and is highly unlikely to be used as a drinking or industrial supply in the future, since the area is supplied by municipal water from OCWA. Furthermore, the yield of the overburden groundwater unit is inadequate for water supply wells, and the high salinity of the bedrock aquifer (approximately 3,000 mg/l chlorides)

precludes its use as drinking water. However, as discussed previously in section 2.2 and in accordance with the NYSDEC's request, the hypothetical drinking water scenario for the Site is evaluated in the risk assessment.

3.2. Plant Area, On-Site Ditches, and Former Chlorination Building

Because the On-Site Ditches and FCB are located within the boundary of the Plant Area, all three areas have the same receptors and media (discussed below). Chemical residues detected in these areas are chlorinated benzenes in surface soils, upper soils, deep soils, and groundwater and mercury in surface soils, upper soils, deep soils, groundwater, and drainage ditches (RAGS D Tables 2.1 to 2.3 and 2.8). Chlorinated dioxins and furans (dioxins and furans) were detected in the surface soils in the vicinity of the FCB[2] (RAGS D Tables 2.4 and 2.5; Section 4.3 of the RI report).

The surface of these areas is mostly covered by concrete building foundations, which limited the number of surface soil samples. Non-concrete portions have been covered by approximately three feet of crushed stone and soil cover following discontinuation of production operations. It should be noted that soil samples collected from 0 to 2 ft bgs are considered surface soil, while samples collected from 0 to 2 ft below the concrete building foundations are considered upper soils (0-10 ft).

Groundwater at Plant Area, On-Site Ditches, and FCB occurs at a depth of approximately 25 - 30 ft bgs. Groundwater is not used as a potable or industrial water supply and is highly unlikely to be used as a potable or industrial supply in the future, since the area is supplied by municipal water from OCWA.

The plant area may be developed as an industrial facility in the future. It is highly unlikely that the plant area would be developed as a residential area, since the area is zoned industrial; the surrounding area is highly industrialized and is expected to remain as such in the reasonably foreseeable future (Town of Geddes Zoning Maps).

Potential current receptors at the Plant Area, On-Site Ditches, and FCB are identified as trespassers who may occasionally climb the fence and access the Site and surveillance workers monitoring the area. Potential future receptors are identified as construction workers, On-Site industrial workers, and utility workers.

3.3. Southwest Off-Site/Outfall 006 Exposure Area

As discussed in Section 2.1, the southwest Off-Site area includes the location of Outfall 006 and mounded area. This area is situated to the south of the fenced plant area and approximately 30 ft north of the CSX railroad tracks and the plant area (Figure L-6).

Chemical residues detected in Outfall 006 surface soils include mercury, chlorobenzene, and polychlorinated biphenyls (PCBs) including Aroclor 1260, as well as concentrations of chlorinated VOCs. Constituents detected in the upper soils from the mounded area include mercury, benzene and

2 Soils were sampled and analyzed for dioxins and furans at the direction of the NYSDEC to evaluate the potential formation of dioxins and furans following a fire at the chlorination building in 1930. (Syracuse Herald Journal, July 4th, 1930)

substituted benzenes (petroleum-based constituents), dichlorobenzenes, and chlorinated VOCs (RAGS D Tables 2.12 and 2.13; Section 4.3 of the RI report).

Potential current receptors at the Southwest Off-Site/Outfall 006 Exposure Area are identified as trespassers who may occasionally be present at the area, as well as railroad or utility workers. Potential future receptors are identified as construction workers and industrial workers.

3.4. State Fair Blvd./Northwest Off-Site/Outfall 004/ Exposure Area

As discussed in Section 2.1, Outfall 004 is situated approximately 25 ft north and 200 ft west of the northwest corner of the plant area fence and near State Fair Boulevard (Figure L-3).

Chemical residues detected in the Exposure Area surface soils include mercury, chlorobenzenes, and PCBs consisting of Aroclor 1260, as well as low concentrations of chlorinated VOCs. Chemical residues detected in upper soils around the NIMO utility line include mercury, chlorobenzenes, Aroclor 1260, as well as chlorinated VOCs and petroleum constituents (Tables 2.14 and 2.15; Section 4.3 of the RI report).

Potential current and future receptors for this area are identified as:

- adolescent trespassers
- adult transients (during the State Fair)
- NIMO utility workers

These exposure pathways are discussed in RAGS D Table 1.1c (Attachment L).

3.5. Lakeshore Area

As discussed in Section 2.1, the Lakeshore Area is situated to the north of the plant area, between the south shore of Onondaga Lake and the westbound lane of I-690 (Figure L-2).

Chemical residues, notably chlorobenzenes and naphthalene, have been detected in upper soils and surface soils on the Lakeshore Area. Constituents detected in groundwater on the Lakeshore Area included benzene, toluene, and chlorinated benzenes.

Additional current and future receptors in this area are utility workers and adolescent and adult trespassers. Current and future receptors at this area are identified as Honeywell workers who are operating the product recovery system. However, these workers are working under an approved health and safety plan (HASP) and are required to utilize appropriate personal protective equipment as specified in the HASP. As such, these receptors were not evaluated in the risk assessment.

3.6. Tributary 5A

As discussed in Section 2.2, Tributary 5A is a small stream that courses through the Site for approximately 3000 ft and discharges into Onondaga Lake (Figure L-9).

Chemical residues detected in Tributary 5A sediment include select metals, polycyclic aromatic hydrocarbons (PAHs), and PCBs (Aroclor 1254). Chemical residues from the surface water include chlorinated VOCs and select metals.

The current and future receptors considered for Tributary 5A are the adolescent and adult trespasser and a utility worker. Based on the potential for fish migration, consideration of the habitat, fish sampling data and limited access for fishermen (Section 2.2.4), edible fish are not likely to be caught in Tributary 5A. The fisherman/fish consumer scenario is not considered probable and, this, was not evaluated.

3.7. Petroleum Storage Area

As discussed in Section 2.2, the PSA is located to the southwest of the former Willis Avenue Plant (Figure L-10).

Three monitoring wells were installed by Groundwater Technology in the early 1980s to detect possible petroleum product leakage. No. 2 fuel oil was not detected in the groundwater during the study; however, benzene, toluene, and xylenes (BTX) and naphthalene were detected. In addition, PCBs (Aroclor 1254), PAHs, and mercury were detected in surface and upper soils. In addition, total petroleum hydrocarbons (TPH) concentrations were detected in 0 to 2 ft soil (100 to 600 mg/kg) and in 2 to 10 ft soil (100 to 800 mg/kg).

Potential current receptors at the PSA are identified as adult and adolescent trespassers who may occasionally be present at the area. In addition, potential future receptors are identified as trespassers, construction workers, industrial workers, and utility workers.

3.8. Chlorobenzene Hot-Spot Area

As discussed in Section 2.2, the CHSA is situated to the south of the plant area and the PSA, adjacent to the Suez Power Plant, formerly Trigen (Figure L-11).

Previous reports have identified benzene and chlorobenzene at monitoring well MW-111 (Blasland & Bouck 1987). Depth to groundwater in this area is approximately 4 to 5 ft bgs. Blasland & Bouck (1987) attributed the source of these compounds to leakage from the chlorobenzene pipeline, which is approximately 5 ft bgs. In addition, chlorobenzenes, PAHs, and mercury were detected in surface and upper soils.

Potential current receptors at the CHSA are identified as adult and adolescent trespassers who may occasionally be present at the area. In addition, potential future receptors are identified as trespassers, construction workers, industrial workers, and utility workers.

3.9. Hypothetical Drinking Water Source Area

On-Site groundwater occurs at a depth of approximately 15 to 20 ft bgs, while Off-Site it occurs at approximately 4 to 5 ft at the CHSA, PSA, and Lakeshore Area. The location of the hypothetical Drinking Water Source Area (on-site and off-site groundwater wells) is presented in Figure L-12.

Groundwater is not used as a drinking or industrial water supply and is highly unlikely to be used as a drinking or industrial supply in the future, since the area is supplied by municipal water from OCWA. Furthermore, the yield of the overburden groundwater unit is inadequate for water supply wells, whereas the high salinity of the bedrock aquifer (approximately 3,000 mg/l chlorides) precludes its use as drinking water.

However, the New York State groundwater classification for the Site and surrounding area is GA (*i.e*,. suitable for drinking use). In accordance with NYSDEC's request, the hypothetical drinking water scenario is therefore evaluated in the risk assessment, which assumes residential development of portions of the Site. The HHRA includes a quantitative evaluation for both child and adult residents hypothetically ingesting groundwater as potable water.

3.10. Evaluation of Soil Vapor Intrusion Pathway

3.10.1. General Considerations

As discussed above, VOCs, notably chlorobenzene and benzene, and elemental mercury, have been detected in soil and groundwater at the Site. VOCs may volatilize from soil and groundwater sources into the unsaturated zone above the water table (soil vapor). If current or future buildings are located above or near contaminated soil or groundwater source, volatile constituents in soil vapor may intrude into the indoor air of buildings via cracks or seams in the foundation. Soil vapor intrusion may occur via the two principal mechanisms of advection or diffusion. Advection refers to the bulk movement of soil gas from the unsaturated zone to indoor air due to a pressure differential between the soil gas and the indoor space. Typically, in temperate climates, advective transport may occur during the winter months when a negative pressure environment is created indoors as a result of indoor heating in well insulated and sealed structures. Since advection requires the bulk movement of air through the soils, advective transport is negligible in very low permeability soils but may be the operative transport pathways in high permeability soils (Johnson and Ettinger 1991).

Diffusive transport reflects the movement of VOCs from the source to the indoor air due to the concentration gradient between the source and the indoor space. Since diffusive transport does not require the bulk movement of air, it may be the operative transport mechanism in low permeability soils or if there is no pressure gradient between the indoor space and the soil vapor. Because molecular diffusion of VOCs occurs much more rapidly in air than in water, the extent of diffusive transport in soils is primarily dependant on the moisture content of the soil as well as the total porosity. VOCs volatilizing from groundwater must first diffuse through the capillary fringe, which is the semi-saturated zone above the water table, before migrating to the unsaturated zone. The capillary fringe has a high moisture content and therefore, the height of the capillary fringe is an important factor in determining the rate of migration of VOCs from groundwater to soil gas. Low permeability "tight" soils, such as clays and silts, typically have significantly larger capillary fringes as compared with high permeability soils such as sands. As such, the rate of diffusive transport is lower in low permeability soils as compared with high permeability soils (Little *et al*. 1992).

3.10.2. Site-Specific Considerations

As part of the HHRA, the potential future migration of VOCs in groundwater to the indoor air of future On-Site industrial buildings was screened.

Screening of groundwater concentrations against vapor intrusion screening values: Groundwater screening values protective of potential vapor intrusion to indoor air were taken from *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance*, USEPA 2002a). For each VOC constituent, SVOC constituent, and mercury the maximum groundwater concentration was compared to screening values in USEPA (2002a) Table 2c. For most chemicals, these are the groundwater concentrations corresponding to target indoor air concentrations where the soil gas to indoor air attenuation factor is 0.001. However, when this attenuation factor results in a groundwater concentration that is below the MCL, the screening value in Table 2c defaults to the MCL. The screening process for this site did not use these MCL-defaulted values; rather the groundwater concentration based on the attenuation factor was used regardless of whether it is less than the MCL. Constituents were also retained in if no screening value was available The results of the groundwater screening protective of indoor air are summarized in RAGS D Tables 2.5, 2.24, and 2.28.

Because of the lack of occupied structures on the property at the time of sampling, there is no complete human exposure through the vapor intrusion pathway at this time. In the future, however, a building may be erected on the property (such as the groundwater treatment plant) that potentially could be impacted by the migration of vapors from the subsurface. Because the impact of the vapor intrusion pathway can be affected by a wide a variety of factors, including building size, ventilation rate, integrity of the foundation, *etc*., it is not possible to estimate the potential risks associated with vapor intrusion. Therefore, at this stage of evaluation, only COPCs can be identified. As noted above COPCs were identified by comparing groundwater concentrations to groundwater screening values protective of potential vapor intrusion to indoor air. Constituents detected in groundwater above screening levels include; naphthalene and mercury in the Petroleum Storage Area; benzene, chlorobenzene, methylene chloride, and mercury in the Plant Area intermediate ground water; and hexachlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, benzene, chlorobenzene, and mercury in the Chlorobenzene Hot-spot Area shallow groundwater. These constituents are present in groundwater at levels that have the potential to impact the quality of indoor air in a future building if erected on the Site.

4. Data Evaluation

The results of the risk assessment are used to assess if remedial actions are necessary at a site and to identify remedial action objectives and medium-specific remedial goals, if necessary. Therefore, it is important that the risk assessment is based on high quality, technically defensible analytical data with respect to the identification and quantification of site-related chemicals. The objectives of the data evaluation were to:

- Evaluate the quality of existing analytical data with respect to risk assessment needs;
- Evaluate the quantity, spatial coverage, and appropriateness of sample locations;
- Evaluate the appropriateness of analytical methods and detection limits'
- Identify data gaps; and,
- Identify COPCs for the Site.

The data evaluation process was conducted in three steps:

A. Data compilation and general review
B. Data usability assessment
C. Identification of COPCs.

4.1. Data Compilation and General Review

4.1.1. Data Sources

The data collected during the RI were used as the input data for the risk assessment. As discussed in the RI report, Site samples were collected from groundwater, surface soils, upper soils, deep soils, and sediments at the Exposure Areas (Appendix A). A summary of the remedial investigation sampling activities (including the 1999 Baseline Ecological Risk Assessment sample collection) is presented in Table 1. Table 2 presents a summary of samples collected from each Exposure Area. The entire data set used in this HHRA is provided as Appendix B. It should be noted that the Exposure Areas for each sample are included in the data set provided in Appendix B.

Data from surface soils, sediments, upper soils, and deep soils were used in the HHRA and are discussed below. A detailed discussion of the analytes detected in those media is presented in Section 4.3 of the RI report.

4.1.2. Chemical Analyses

Consistent with the agreed Work Plan, the RI sampling activities focused on VOCs, semi volatile organic compounds (SVOCs), PCBs/pesticides, and mercury analyses. Metals other than mercury were analyzed in select samples specified by the NYSDEC. The Site is covered with fill material mixed with Solvay waste, which contains elevated metals concentrations (Table 16 of the RI report). The metals concentrations detected in soil samples collected from the Site are comparable to the concentrations reported for Solvay waste (Table 16 of the RI report). As such, the available metals data provide representative estimates of metals concentrations across the Site.

A brief discussion of available data from each of the previously identified Exposure Areas is presented below. Summaries of the detected analytes are presented in the RAGS D Table 2 series.

4.1.3. Plant Area

A sampling summary is provided in Appendix A, and a summary of the constituents detected in soils is presented on RAGS D Tables 2.1 through 2.3. Surface, upper, and deep soil samples were collected from the Plant Area and analyzed as follows:

- Surface soil samples were analyzed for VOCs, SVOCs, PCBs/pesticides, and metals and 16 for polychlorinated dibenzo-p-dioxins and furans (PCDD/Fs).
- Additional upper soil samples were analyzed for VOCs and 10 for mercury.
- Deep soil samples were analyzed for VOCs, SVOCs, and metals.

It should be noted that both mercury and methyl mercury were analyzed in subsurface (upper and intermediate) soil samples collected from the vicinity of the former mercury cell building at the Plant Area. The treatment of unspeciated mercury in the HHRA is described in Section 4.3.3.

In addition, 18 groundwater samples were collected from 11 wells at the Plant Area and analyzed for VOCs, SVOCs, and metals (RAGS D Tables 2.4 and 2.5).

4.1.4. Former Chlorination Building

A sampling summary is provided in Appendix A and a summary of the constituents detected in soils is presented in RAGS D Tables 2.6 through 2.8. Surface, upper, and intermediate soil samples were collected from the FCB and analyzed as follows:

- Surface soil samples were analyzed for PCBs/pesticides, metals and PCDD/Fs.
- Additional upper soil samples were analyzed for PCDD/Fs.
- No intermediate soil samples were collected.

4.1.5. On-Site Ditches

A sampling summary is provided in Appendix A and a summary of the constituents detected in soils is presented on RAGS D Tables 2.9 through 2.11. Surface, upper, and intermediate soil samples were collected from the FCB and analyzed as follows:

- Surface soil samples were analyzed for PCDD/Fs and one sample was analyzed for VOCs, SVOCs, PCBs/pesticides, and metals; these samples provide a representative estimate of conditions at this area based on the dimensions of the On-Site Ditches and will also be used as representative of the upper soils (0-10 ft bgs).

- No additional upper soil samples or intermediate soil samples were collected.

4.1.6. Southwest Off-Site/Outfall 006 Exposure Area

A sampling summary and summary of the constituents detected in surface and upper soils at Southwest Off-Site/Outfall 006 Exposure Area are presented in Appendix A and RAGS D Tables 2.12 and 2.13, respectively. Based on the dimensions of the subsite, the samples provide a representative characterization of surface soil conditions at this location and are as follows:

- Surface soil samples were analyzed for VOCs, PCBs/pesticides, and mercury and two for PCDD/Fs.

- Additional upper soil samples were analyzed for VOCs and PCBs/pesticides and mercury.
- No intermediate soil samples were collected.

4.1.7. State Fair Blvd./Northwest Off-Site/Outfall 004 Exposure Area

A sampling summary and summary of the constituents detected in surface and upper soils at Northwest Off-Site/Outfall 004 Exposure Area are presented in Appendix A and RAGS D Tables 2.14 and 2.15, respectively. Based on the dimensions of the subsite, the samples provide a representative characterization of constituent concentrations at the outfall location and are as follows:

- Four surface soil samples were analyzed for VOCs, PCBs/pesticides, and mercury and two for PCDD/Fs.
- Additional samples from the upper soils were analyzed for VOCs, SVOCs, PCBs/pesticides, and metals.
- No intermediate soil samples were collected.

The samples from the upper soils were collected based on field observations of materials in the test pits. As such, the samples provide a conservative representation of potential conditions around the NIMO utility line. It should be noted that a non-aqueous phase liquid (NAPL) was observed along State Fair Boulevard during the excavations around the NIMO gas pipeline.

4.1.8. Tributary 5A

Surface water and sediment samples were analyzed for VOCs, SVOCs, PCB/pesticides, metals, PCDD/Fs, and methyl mercury from four locations (5A-SED/SW-1 through 4). A sampling summary and summary of the detected constituents in Tributary 5A sediment and surface water are presented in Appendix A and RAGS D Tables 2.19 and 2.20, respectively.

4.1.9. Lakeshore Area

A sampling summary and summary of the detected constituents in the Lakeshore Area surface and upper soils are presented in Appendix A and RAGS D Tables 2.16 and 2.17. A summary of constituents detected in groundwater is presented in RAGS D Table 2.18. These samples are briefly summarized below.

- Surface soil samples were analyzed for VOCs, SVOCs, PCBs/ pesticides, metals, PCDD/Fs.
- No additional upper soil samples or intermediate soil samples were collected, but the surface soils were considered representative of the upper soils (0-10 ft bgs).
- Groundwater samples were analyzed for VOCs, SVOCs, and metals.

4.1.10. Petroleum Storage Area

A sampling summary and summary of the constituents detected at the PSA surface and upper soils are presented in Appendix A and RAGS D Tables 2.21 and 2.22, respectively. A summary of constituents detected in groundwater is presented in RAGS D Tables 2.23 and 2.24. Based on the dimensions of the subsite, the samples provide a representative characterization of constituent concentrations at the PSA and are as follows:

- Four surface soil samples were analyzed for VOCs, PCBs/pesticides, and metals and one sample for PCDD/Fs.

- Additional soil samples were analyzed for VOCs, SVOCs, PCBs/pesticides, and metals.
- No intermediate soil samples were collected.
- Groundwater samples were analyzed for VOCs, SVOCs, and metals.

4.1.11. Chlorobenzene Hot-Spots Area

A sampling summary and summary of the constituents detected in surface and upper soils at the CHSA are presented in Appendix A and RAGS D Tables 2.25 and 2.26, respectively. A summary of the detected constituents in groundwater is presented in RAGS D Tables 2.27 and 2.28. Based on the dimensions of the subsite, the samples provide a representative characterization of constituent concentrations at the CHSA and are as follows:

- Surface soil samples were analyzed for VOCs, SVOCs, PCBs/pesticides, and metals and one sample for VOCs, PCBs/pesticides, metals, mercury, and PCDD/Fs.
- Additional upper soil samples were analyzed for VOCs, SVOCs, PCBs/pesticides, and metals.
- No intermediate soil samples were collected.
- Groundwater samples were analyzed for VOCs, PCBs/pesticides, and metals.

4.1.12. Hypothetical Drinking Water Source Area

In order to assess the hypothetical drinking water scenario, analytical data from groundwater samples at or down gradient of the General Plant Area, CHSA, PSA, and Lakeshore Area were compiled and reviewed. A total of 30 wells, shown on Figure L-12 were identified as being appropriate for the hypothetical drinking water assessment. The selected wells have been sampled and analyzed over multiple rounds for various analytical parameters consisting of VOCs, SVOCs, and metals. The total number of samples for different analytes across the monitoring events conducted between 1991 and 2002 are summarized on RAGS D Table 2.29. Based on an initial review of the available data, no systematic increasing time-related trends are evident in the constituent concentrations. Therefore, for the purposes of the risk assessment, the data were analyzed as a single dataset (*i.e.,* the data were not segregated by monitoring event). The total number of samples by constituent from the 30 wells sampled is presented on RAGS D Table 2.29. This dataset consists of all groundwater samples collected from the Plant Area, Lakeshore Area, PSA, and CHSA, as these are the most recent samples collected.

4.2. Data Usability Assessment

The data usability assessment was conducted in general conformance with *Guidance for Assessing Data Usability for Risk Assessment* (USEPA 1992a).

4.2.1. Data Quality Objectives

Data quality objectives (DQOs) for the Site investigation were developed as part of the approved Work Plan for the RI (O'Brien and Gere 1990). Data quality objectives are qualitative or quantitative measures of the minimum required *sensitivity*, *accuracy*, *precision*, and *representativeness* of the collected data for risk assessment purposes. Sensitivity reflects the ability of the chemical analysis to detect chemical residues at concentrations, which allow the quantitative assessment of human health risk. Precision is a measure of the uncertainty in the reported concentration due to variability in the sample collection and analysis process and spatial variability in the chemical concentrations. Accuracy is a measure of the extent to which the reported chemical concentrations in a sample are

consistent with the actual concentrations. Representativeness is a more subjective measure and refers to the extent to which the collected data represent actual conditions at the Site. Representativeness is a function of the sampling locations, number of samples collected, the types of chemical analyses performed, and the accuracy and precision of the collected data.

The objective of the Data Usability Assessment was to evaluate the quality of the analytical data generated as part of the RI relative to the DQOs.

4.2.2. Data Validation

Data validation is an evaluation of the accuracy and precision of the reported analytical measurements. Data validation involves the reconstruction of the analytical process and an evaluation of whether the analysis has been performed correctly. Data validation qualifiers, which reflect the accuracy, precision, and usability of the data, are then applied to individual data points based on USEPA specified guidelines.

The data were validated as described in Appendix I of the RI report. As described in the data validation report, 100% of the pesticide/PCB data, 100% of the dioxin data, 97.3% of the VOC data, 98.4% of the SVOC data, 98.2% of the metals data, and 100% of the PCDD/F data were determined to be usable for qualitative and quantitative purposes.

The following actions were taken with respect to assigned data validation qualifiers:

- R - The data were qualified as unusable for qualitative and quantitative purposes according to data validation guidance. “R”-qualified data were not utilized in the risk assessment.

- J - The analyte was positively identified; the associated numerical value was the approximate concentration of the analyte in the sample. The analytical data were not adjusted to compensate for potential high or low bias in the analytical result, due to uncertainty regarding the magnitude of the bias.

4.3. Identification of Constituents of Potential Concern

The goal of the COPC selection process was to streamline the assessment by focusing on Site-related analytes that may contribute to potential human health risks. Consistent with USEPA procedures (USEPA 1997a) chemical constituents detected at concentrations which are highly unlikely to result in adverse human health effects were not selected as COPCs (*i.e.*, they were not carried through the quantitative risk assessment process).

A list of COPCs for the HHRA was developed based on the data evaluation. Consistent with HHRAs performed previously for Superfund sites in New York State and as approved by USEPA and NYSDEC (O’Brien & Gere 1997), a sequence of comparisons was performed to identify the COPCs for the Site; these are outlined in section 4.3.2.

4.3.1. Media Definitions

This section describes the media that are relevant to this assessment. Appendix A provides a comprehensive list of samples used in this deliverable. Appendix B provides the Site database

organized by Exposure Area and medium. Only data with acceptable qualifiers ("U", "J", "UJ", or no qualifier) were utilized in the RAGS D Table 2 series.

Surface Soil – Surface soil is defined as soil collected from 0 to 2 ft bgs. The soil database contains a start depth and an end depth for a given sample. Surface soil was sorted from the entire soil database by selecting samples with an end depth that was less than or equal to 2 ft. Thus, a sample collected from 1 ft (start depth) to 3 ft (end depth) would not have been included in the RAGS 2 Tables that evaluated surface soils, but rather in tables that evaluated Upper and Intermediate Soils (see below).

Upper and Intermediate Soil – Three exposure scenarios (construction worker, and utility worker,) required the evaluation of surface and subsurface soil combined. This exposure medium was defined as soil collected from 0 to 10 ft bgs (upper soil) with the exception of the Former Chlorination Building, Plant Area, and On-Site Ditches, where the utility worker reaches a depth of up to 20 ft bgs. In these latter Exposure Areas for the utility worker receptor, the exposure medium is considered 0 to 20 ft bgs (intermediate soil). Upper and intermediate soil was sorted from the entire soil database by selecting samples with an end depth that was less than or equal to 10 or 20 ft bgs, respectively

Shallow and Intermediate Groundwater – Two exposure scenarios (construction worker and utility worker scenarios) required the evaluation of direct exposure to shallow or intermediate groundwater. This exposure medium was defined as groundwater samples collected from monitoring wells that contained a depth to water from 0 to 10 ft bgs (shallow groundwater), with the exception of the Former Chlorination Building, Plant Area, and On-Site Ditches, where the PA sewer occurs at a depth of up to 20 ft bgs. For these latter Exposure Areas for the utility worker receptor, the exposure medium was 0 to 20 ft bgs (intermediate groundwater). Shallow and intermediate groundwater was sorted from the Site database by selecting data with a start depth less than or equal to 10 ft bgs or 20 ft bgs, respectively. The start depth was used to sort for shallow and intermediate groundwater samples because of the abundance of samples with start depth less than or equal to 10 ft bgs and 20 ft bgs, respectively.

Sediment - Sediment collected from the 0 to 1 ft bgs interval was sorted from the entire sediment database by selecting samples with an end depth that was less than or equal to 1 ft. Thus, a sample collected from 0 ft (start depth) to 2 ft (end depth) would not have been included in the RAGS Part D Table 2 series that evaluate surface sediment.

Surface Water - Surface water present in water bodies (Tributary 5A) of the Site were evaluated in this assessment.

Site-Wide Groundwater – One exposure scenario (hypothetical drinking water scenario) required the evaluation of all Site groundwater collected from monitoring wells, regardless of depth. This scenario was evaluated for the adult and child resident.

4.3.2. Comparison with Risk-Based Screening Values

Consistent with USEPA guidance (USEPA 1989a), a conservative screening process was applied to select COPCs. To develop the COPC list, the maximum detected concentrations of the detected constituents in surface soil, subsurface soil, surface water, surface sediment, shallow groundwater, and Site-wide groundwater were compared to conservative screening values for the protection of human health.

The screening values utilized were the lowest of the USEPA Region 9 Preliminary Remediation Goals (PRGs) or the USEPA Region 3 Risk Based Concentrations (RBCs) (USEPA October 2007a). RBC and PRGs for tap water were applied to screen surface water and groundwater detections. RBCs and PRGs for residential soils were applied to screen the soil and sediment concentrations. RBCs and PRGs utilized in the screening process corresponded to a cancer risk of 10^{-6} or a hazard quotient of 0.1.

If the maximum detected concentration was less than the identified screening values, it was concluded that exposure to the constituent does not represent an unacceptable risk to human health, and no further evaluation of that exposure was necessary. If the maximum detected concentration exceeded the selected screening value, the constituent was selected as a COPC and retained for further evaluation in this assessment. All Class A carcinogens were retained as COPCs regardless of the levels at which they were found.

Naturally occurring compounds were eliminated from the COPC list if they were essential nutrients. Based on this consideration, calcium, magnesium, potassium, and sodium were not carried forward as COPCs for the risk assessment.

Constituents detected in media that do not have established RBCs or PRGs were carried forward for further evaluation in the risk assessment. Constituents that were not detected in a given Exposure Area were not included in the quantitative evaluation for that Exposure Area.

Risk-based screening values were applied in order to select the COPCs for further evaluation in the HHRA process. The risk-based screening was conducted as follows:

Region III Risk Based Concentrations (RBCs) and Region 9 Preliminary Remediation Goals (PRGs): USEPA Region III (USEPA 2007a) and USEPA Region 9 (USEPA 2004a) have published analyte-specific risk-based screening concentrations. If the maximum detected concentration of a chemical in Site media is less than the published screening value it is highly unlikely that the chemical may represent a significant risk to human health and may be deleted as a COPC. The lower of the Region 3 RBCs or Region 9 PRGs were selected as the screening values for COPC selection. Consistent with previously approved risk assessments in New York State (O'Brien and Gere 1997), the screening values correspond to an excess lifetime cancer risk of 10^{-6} for carcinogens and a hazard quotient of 0.1 for non-carcinogens. If the maximum detected concentration in the Exposure Area was less than the screening level, the analyte was not retained as a COPC. For soils and sediments, the residential soil screening values were used. For groundwater and surface water, the published RBCs and PRGs for tap water were used. The chemical-specific health-based screening values applied in selecting the COPCs are presented in the RAGS D Tables 2 series.

Vapor Intrusion Screening Values for groundwater: Groundwater screening values protective of potential vapor intrusion to indoor air were taken from *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance;* USEPA 2002a).For each VOC and SVOC constituent, the representative groundwater concentration was compared to screening values in USEPA (2002a) Table 2c. USEPA (2002a) Table 2c provides screening concentrations for VOCs that represent a 10^{-6} cancer risk. Constituents are also screened in if no screening value is available.

Background - In accordance with USEPA (2003a) guidance, background concentrations were not used to screen Site-related compounds for the baseline human health risk assessment. However, the USEPA (2003a) guidance allows for the use of background concentrations, based on statistical evaluation, to be considered for the development of remedial options. In the future, background concentrations may be used in the development of remedial options, as appropriate.

Evaluation of Essential Nutrients - Naturally occurring compounds were eliminated from the COPC list if they were essential nutrients, present at concentrations only slightly elevated above naturally occurring levels, and toxic only at very high doses. Based on this consideration, calcium, sodium, potassium, and magnesium were not included as COPCs for the risk assessment and these compounds were eliminated from the screening tables.

The list of selected COPCs for each Exposure Area is presented in the RAGS D Tables 2 series. At most Exposure Areas, mercury, dioxin toxicity equivalents (TEQs), polychlorinated biphenyls (PCBs), and chlorobenzenes were identified as COPCs. In addition, certain petroleum constituents were identified as COPCs in the Southwest Off-Site/Outfall 006 Exposure Area.

4.3.3. Notes on Specific Constituent Groups

Dioxins: Dioxin congeners were detected in some Site media. During the development of the RAGS D Table 2 series, toxic equivalency factors (TEFs) were applied to individual congeners to extrapolate a combined toxicity equivalent to that of 2,3,7,8-tetrachloro-dibenzo-p-dioxin (2,3,7,8-TCDD), with TEFs obtained from Van den berg *et al*. (2006). The concentration of each dioxin/furan congener was multiplied by the TEF to derive the 2,3,7,8-TCDD equivalent concentration. Once this approach was applied to all congeners, the 2,3,7,8-TCDD equivalents were summed for each sample location and the resulting total 2,3,7,8-TCDD equivalent value was treated as a unique constituent for that location. The maximum TEQ from all sample locations within the Exposure Area was compared to USEPA Region 3 RBCs (USEPA 2007a) and Region 9 PRGs (USEPA 2004a) values for 2,3,7,8-TCDD.

Polychlorinated Biphenyls: Calculation of PCB concentrations for use in determining exposure point concentrations combined individual Aroclors into two groups. "Less chlorinated" PCBs (Aroclor 1016, 1221, 1232, and 1242) were combined for analysis and determination of the exposure point concentration, and were screened in the RAGS D Table 2 series against the screening values for Aroclor 1016. "Highly chlorinated" PCBs (Aroclor 1248, 1254, and 1260) were combined for analysis and determination of the exposure point concentration, and were screened in the RAGS D Table 2 series against the screening values for Aroclor 1254.

Group A Carcinogens: All detected Group A carcinogens (arsenic, benzene, and hexavalent chromium) were retained as COPCs even if their maximum detected concentration did not exceed their respective screening criterion.

Unspeciated mercury and chromium: In cases where chromium was not speciated, RBCs and PRGs values for hexavalent chromium (Cr^{+6}) were utilized. Unspeciated mercury in soil and sediment was screened against RBC and PRG values for mercury compounds, while unspeciated mercury in groundwater was screened against values for methyl mercury.

Chlordane constituents: All chlordane constituents were summed and screened against the chlordane RBC and technical chlordane PRG criteria.

5. Exposure Assessment

The exposure assessment identifies the mechanisms by which receptors may be exposed to site COPCs. The assessment derives the chemical concentrations to which receptors may be exposed and the chronic daily intake of constituents by receptors.

A summary of the receptor populations and complete exposure pathway for each area is also presented in the RAGS D Table 1 series. For each Exposure Area, the following elements are included:

1. Potentially exposed populations
2. Identification and evaluation of exposure pathways
3. Quantification of exposure
4. Exposure point concentrations (EPCs)
5. Intake equations and parameter estimates
6. Calculation of chemical intakes

5.1. Land Use Assumptions

The risk assessment assumes that future land use at the Plant Area, FCB, On-Site Ditches, and the Southwest Off-Site/Outfall 006 Exposure Area will be industrial (*i.e.*, the areas will not be developed as residential areas). This assumption is based on the consideration that the areas are located in heavily industrialized settings and are zoned industrial.

5.2. Exposure Pathway Analysis

An exposure pathway analysis for the Site is provided in the RAGS D Table 1 series. An exposure pathway describes the course a chemical takes from the source to the exposed individual. An exposure pathway analysis links the sources, locations, and types of environmental releases with population locations and activity patterns to determine the significant pathways of human exposure.

An exposure pathway consists of four elements:

- a source and mechanism of chemical release;
- a retention or transport medium;
- a point of potential human contact with the contaminated medium (referred to as the exposure point); and
- an exposure route (*e.g.*, ingestion) at the contact point.

A pathway is considered to be complete if all of the conditions listed above are satisfied for that pathway. If one or more of these conditions are not met, there is no physical means by which a receptor may be exposed to the compounds of potential concern, and the pathway is classified as incomplete. Incomplete pathways are not considered further in the HHRA.

5.3. Quantification of Exposure

The next step in the exposure assessment is to quantify the magnitude, frequency, and duration of exposure for the complete exposure pathways. General considerations and considerations for Site-specific calculations are presented below.

General Considerations - The exposure quantification was performed in accordance with the following USEPA guidance for exposure assessment activities:

- *Guidelines for Exposure Assessment* (USEPA 1992b)
- *Risk Assessment Guidance for Superfund* (USEPA 1989a)
- *RAGS Volume I: Human Health Evaluation Manual Supplemental Guidance* (USEPA 1991)
- *Supplemental Guidance to RAGS: Calculating the Concentration Term* (USEPA 1992c)
- *Exposure Factors Handbook* (USEPA 1997a)
- *RAGS Volume I: Human Health Evaluation Manual, Part D* (USEPA 2001a)
- *Calculating the Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (USEPA 2002b).

For each complete exposure pathway, the chronic daily intake (CDI) was estimated for the COPCs. There may be considerable uncertainty relating to the estimated CDI for a given receptor group. This uncertainty results from the random variability in exposure parameters, including the estimated exposure point concentrations (EPCs). Uncertainty in the *exposure point concentration* may arise from spatial and temporal variations in the chemical concentration at the exposure point. Variability in the *exposure parameters* occurs because each individual in the population has differences in activity patterns, behavior, and physical and biological characteristics. To account for this inherent variability, USEPA discusses the "average" and "high end" or "upper bound" *exposure estimates* (USEPA 1992b).

Average exposures refer to the estimated CDI for most of the individuals in the exposed population. The average estimate can be derived by using an average value (usually the median value) as the exposure factor. This results in Central Tendency (CT) estimates. Reasonable Maximum Exposure (RME) estimates represent a conservative scenario for the risk estimate. The RME estimate may be used to develop a statement that the risk "is unlikely to exceed" the calculated bounding value. The RME estimate is derived by combining a series of default average and upper bound exposure factor estimates in calculating the CDI. If the calculated RME risks exceed acceptable levels, the CT exposure estimates may be derived and considered in risk management decisions for the Site.

Consideration for Site-Specific Calculations - Consistent with USEPA guidance, RME and CT exposure estimates were derived for the HHRA, as discussed in Section 5.6. The methods, assumptions and results of the exposure assessment are presented below for each of the previously discussed Exposure Areas at the Site. The potential uncertainties inherent in the derived exposure estimates are discussed qualitatively in Section 8 - Uncertainty Assessment

5.4. Derivation of Exposure Point Concentrations

5.4.1. Calculating Exposure Point Concentrations for Soil, Sediment, Surface Water, and Groundwater

Statistical and procedural methods were applied to the data in order to develop an estimate of the EPC for COPCs selected for each Exposure Area, on a medium-specific basis. The general approach is as follows:

- Where a given data set contained less than five sample points or only one unique detected sample, the maximum value for each analyte in that data set was used as the EPC.
- For data sets with five or more data points, and at least two unique detected samples, statistical methods were applied.

In the latter case, the ProUCL statistical software package (Version 4.0; USEPA, 2007b) was used to examine the data distribution and develop an upper confidence level on the arithmetic mean (UCL).

ProUCL was run using Regression on Order Statistics (ROS), which is a method for accounting for non-detect samples in the data set. ROS infers values for non-detect samples based on the distribution of detected data. ProUCL recommends the most appropriate UCL to use given the distribution type. The UCL recommended by ProUCL was subsequently applied as the EPC.

It should be noted that in some cases the 95% UCL is less than the reported average concentration. This is because the arithmetic average reported in the Table 3 series is the mean detected concentration. In instances where the detection frequency is low and non-detect samples largely outnumber detected samples, the 95% UCL recommended by ProUCL V.4 can be smaller than the mean detected concentration, since it reflects the large number of non-detect samples.

5.4.2. EPCs for Air Exposures

The inhalation of air particulates and volatile compounds arising from Site soils will be evaluated in the Site HHRA. The calculation of the particle emission factor (PEF) and the volatilization factors (VFs) are discussed in this section.

Because the methods used to develop the USEPA Region 9 PRG screening values included the inhalation exposure pathway (both particulate and volatile compounds), any soil constituent that screened out during the RAGS D Table 2 series process will not be considered as a COPC for these air pathways. Of those soil constituents that were retained, a VF was calculated for compounds listed in the USEPA Region 3 RBC Table as volatile (Appendix C). The remainder of these constituents will be evaluated as particulate emissions (Appendix C). The derivation of EPCs for evaluating these two pathways is discussed in turn.

5.4.3. Derivation of EPCs for Volatile Compounds

The following equation was used to derive EPCs of volatile compounds in outdoor air for inhalation exposure pathways:

$$C_{air} = \left(\frac{C_{soil}}{VF} \right)$$

where:

C_{air}: Concentration of volatiles in air (mg/m^3)
C_{soil}: Concentration in soil (UCL, mg/kg)
VF: Soil-to-air Volatilization Factor (m^3/kg)

The VF is used for defining the relationship between the concentration of volatile organic constituents in soil and the volatilized constituents in outdoor air. A VF is specific to each volatile compound and each Exposure Area. VFs for this assessment were calculated using Equation 4-8 from the *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (USEPA 2002c) and can be found in Appendix C.

5.4.4. Derivation of EPCs for Fugitive Dust

The PEF is required to calculate the constituent concentration in fugitive dust. The following equation will be used to derive concentrations of inorganics, semi volatiles, PCBs, and pesticides in outdoor air for inhalation exposure pathways (see Appendix C for proposed dust constituent list):

$$C_{air} = \left(\frac{C_{soil}}{PEF} \right)$$

where:

C_{air}: Concentration of inorganic particulates in air (mg/m^3)
C_{soil}: Concentration in soil (mg/kg)
PEF: Particle Emission Factor (m^3/kg)

The PEF is used to convert concentrations of constituents in soil to concentrations in air as a result of fugitive dust emissions from bare surface soils. The USEPA provides the methodology required to calculate the PEF in Appendix C of the *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (USEPA 2002c). Equation 5-5 (USEPA 2002c) was used to derive a PEF for the construction worker scenario. The details of these calculations can be found in Appendix D of this submittal.

5.4.5 Derivation of EPCs for Lead in Site-Wide Groundwater

USEPA (2007d) provides guidance on how to derive a value for the lead exposure point concentration term (PbS) for the child resident exposure scenario. The PbS is the only input parameter of the

Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) for which a Site-specific value is always required. As stated in the Guidance Manual for the IEUBK Model (USEPA, 2002d), the average, or arithmetic mean lead concentration should be used for the PbS. The water concentrations obtained by these averaging procedures give appropriate central tendency exposure concentration estimates for use in estimating blood lead levels for residential children.

5.5. Intake Equations

The next step in the assessment was to generate estimates of chronic daily intakes (CDIs) based on the magnitude, frequency, and duration of exposure for each identified complete exposure pathway. In accordance with USEPA guidance (USEPA 1989a), RME exposure factors were applied to estimate the CDI from the incidental ingestion, dermal contact, and inhalation pathways. The intake equations applied in the assessment are presented below. The specific variables used in each calculation and their values are defined in the subsections that follow.

Incidental ingestion of COPC from soil or sediment

$$CDI = \frac{C_{soil} \times CF \times IR \times FI \times EF \times ED}{BW \times AT}$$

Dermal uptake of COPC from soil or sediment

$$DAD = \frac{C_{soil} \times CF \times SA \times ABS \times AF \times EF \times ED}{BW \times AT}$$

Incidental ingestion of COPC in surface, ground, or drinking water

$$CDI = \frac{C_{water} \times IR \times EF \times ED}{BW \times AT}$$

Dermal uptake of COPC in surface or groundwater

$$DAD = \frac{C_{water} \times CF \times SA \times PC \times ET \times EF \times ED}{BW \times AT}$$

Inhalation of airborne constituents in the Exposure Area

$$CDI = \frac{C_{air} \times InR \times ET \times EF \times ED}{BW \times AT}$$

where:

ABS = Dermal absorption factor (unitless)

AF = Soil to skin adherence factor (mg/cm^2)
AT = Averaging time (days)
BW = Body weight (kg)
C_{air} = COPC concentration in air (mg/m^3) (Derivation is presented in Section 2.4.7)
$C_{sediment}$ = Sediment exposure point concentration (mg/kg)
C_{sw} = Concentration of each constituent in surface water (mg/L)
C_{water} = Concentration of each constituent in drinking water (mg/L)
CDI = Chronic daily intake (mg/kg-day)
CF = Conversion factor (10^{-6} kg/mg for soil and 10^{-3} L/mL for water)
DAD = Dermal absorbed dose (mg/kg-day)
ED = Exposure duration (years)
EF = Exposure frequency (days/year)
ET = Exposure time (hours/day)
FI = Fraction ingested from contaminated source (unitless)
IR = Ingestion rate for soil (mg/day) or water (L/day)
InR = Inhalation rate (m^3/hour)
PC = Permeability Coefficient (cm/hour)
SA = Skin surface area for dermal absorption (cm^2)

5.6. RME and CT Parameter Estimates

The RAGS D Table 4 series and Appendix E present the parameter values used for each receptor and the rationale for selecting each value. The parameters are also summarized below.

ABS: Dermal absorption factor (unitless). The dermal absorption factor represents the fraction of the constituent in soil that may be absorbed through the skin over each exposure event. These values are chemical-specific and are presented in Appendix F.

AF: Soil to skin adherence factor (mg/cm^2). Soil to skin adherence factors (AF) represent the average mass of soil which adheres to the skin over each exposure event. Based on the July 19, 2004 comments from NYSDEC on the 2002 HHRA report, the adherence factors for particular receptors were updated to reflect conditions under the RME and CT scenarios. These new values were taken from *RAGS E Supplemental Guidance for Dermal Risk Assessment* (USEPA 2004b). These values are presented in RAGS D Tables 4.1 RME through 4.16 CT.

AT: Averaging time (days). The averaging time is the period of time over which exposure is averaged. In accordance with USEPA guidance (USEPA 1989a), the averaging time for exposure to potential carcinogenic compounds is 25,550 days. This accounts for averaging of exposure to a carcinogenic substance over a 70-year lifetime. For exposure to non-carcinogens, the averaging time is calculated as the exposure duration (years) multiplied by 365 days per year. Therefore, the averaging time for exposure to non-carcinogenic substances varies for receptors based on their exposure duration. These values are presented in RAGS D Tables 4.1 RME through 4.16 CT.

BW: Body weight (kg). The body weight estimates are receptor-specific for adults, adolescents, and children. For adults, the body weight of 70 kg (USEPA 1991) was applied as a default, which is slightly less than the mean body weight for men and women aged 18 to 74 years in the United States (71.8 kg). For adolescents, a body weight of 45 kg was used, which is the value recommended by

USEPA based on body weight for males aged 7 to 16 in the United States (USEPA 2000). For children, a body weight of 15 kg was used which corresponds to the average body weight for males and females aged 6 months to 6 years in the United States (USEPA 1997a). These values are presented on RAGS D Table 4 Series.

C_{water} and $C_{soil/sed}$: Concentration of each constituent in ground/surface water (μg/L) and soil/sediment (mg/kg). The lower of the 95 percent upper confidence limit (UCL) and the maximum concentration was selected as the RME exposure point concentration. These values are presented in the RAGS D Tables 3 Series.

$C_{air:}$: Inhalation exposure point concentration (mg/m^3). The concentrations of constituents in ambient air were estimated using the algorithms presented by USEPA for exposure to airborne VOCs and dust (USEPA 1996, 2002a). The PEF and VF values used to calculate the inhalation EPC from the soil EPC are derived in Appendices F and G, respectively. The C_{air} values are presented on RAGS D Table 7.5.

ED: Exposure duration (years). The exposure duration estimates the time period over which a receptor is exposed. This parameter is receptor-specific. These values are presented in the RAGS D Table 4 series and Appendix E.

EF: Exposure frequency (days/year). The exposure frequency is a receptor-specific parameter that estimates the time period over which the receptor exposure occurs. These values are presented in the RAGS D Table 4 series and Appendix E

ET: Exposure time (hours/day). This parameter is receptor-specific for dermal contact with water. These values are presented in the RAGS D Table 4 series and Appendix E

IR_{water}: Ingestion rate for water (L/hour). The ingestion rate applied to the adolescent trespasser at Tributary 5A is for incidental ingestion during temporary contact with water. These values are presented on RAGS D Table 4.11a RME and CT, and Appendix B. Since the Site is also being considered as a hypothetical drinking water source area, an incidental ingestion rate was applied for the hypothetical adult and child resident. These values are presented on RAGS D Table 4.16 RME and CT and Appendix E.

IR_{soil}: Incidental ingestion rate for soil (mg/day). Incidental ingestion rates were applied to the potential receptors for incidental ingestion during activities on the Exposure Areas. These values are presented in the RAGS D Table 4 series and Appendix E.

InR: Inhalation rates (m^3/hour). InR are affected by several individual characteristics, including age, gender, weight, health status, and activity level (sitting, running, walking, etc.). These values are presented in the RAGS D Table 4 series and Appendix E.

PC: Permeability Coefficient (cm/hour). The permeability coefficient represents the rate at which dissolved constituents in water migrate across the skin into the bloodstream. Chemical specific dermal permeability coefficients compiled and published by USEPA (2004a) were applied. The constituent specific values are presented in Appendix F.

SA: Skin surface area for dermal absorption (cm^2). This parameter represents the exposed surface area of the skin, which may contact water or soil. These values are presented in the RAGS D Table 4 series and Appendix E.

The revised RAGS D Table 4 series reflects Honeywell's September 5, 2007 letter detailing responses to NYSDEC comments on the Revised 2004 HHRA (Appendix G1) as well as Honeywell's 2008 responses to NYSDEC comments (Appendix G2). The revised RAGS D Table 4 series also reflects specific comments discussed during a conference call with NYSDEC, USEPA, Honeywell, and O'Brien & Gere on May 30, 2007. The exposure factors utilized for the selected receptors for this assessment are presented in the RAGS D Table 4 series and are summarized in Appendix E. For those exposure factors that could not be easily explained in Appendix E, further justification for selection of these factors is provided below.

5.6.1. Mutagenic Mode of Action Constituents

Chemicals exhibiting a mutagenic mode of action (MMOA) were addressed in the HHRA using Age-Dependent adjustment factors (ADAFs) as described in USEPA's "Supplemental Guidelines for Assessing Susceptibility From Early Life Exposure to Carcinogens" ("Supplemental Guidance") (USEPA 2005). This ADAF evaluation required the modification of the Table 4 Series to include the specific age categories (bins) identified in the Supplemental Guidance (0 to 2 years, 2 to 16 years, >16 years, and all subgroups within these age bins). This ADAF evaluation was derived specifically for this assessment by using the Wastebeds 1-8 Bike Trail HHRA (USEPA 2007c) as an example. The ADAF evaluation is also included in the RAGS D Table 7 series for the child and adolescent receptors.

5.6.2. Exposure Frequency for Industrial Worker

The revised RAGS D Table 4 series includes an exposure frequency for outdoor exposure to surface soil of 188 days per year for a reasonable maximum exposure (RME) scenario and 164 days per year for a central tendency (CT) exposure scenario. These values are departures from the recommended 250 days per year (RME) and 219 days per year (CT) value as noted in USEPA (2004b) RAGS Part E.

The RME EF of 188 days assumes 250 work days per year with exposure reduced by 25% due to snow cover. Similarly for the CT EF, 219 work days per year reduced by 25% due to snow cover yields a CT value of 164 days.

The snow cover percentage of 25% is derived from a thirty year (1972-2000) temperature and snowfall record for Syracuse, NY from the National Weather Service (available at http://www.erh.noaa.gov/bgm/climate/syr/syr_normals.shtml). During the months of December, January, and February, there is on average measurable snowfall (28.6, 33.2, and 24.0 inches, respectively), and average temperatures are below freezing (28.6, 22.7, and 24.5 °F, respectively). Therefore, it can be assumed that snow that falls during these months does not readily melt and provides continuous snow cover. Since the three months include 90 of the 365 days in a year, snow cover percentage of 25% is derived. This percentage is conservative in that the months of March and November are not included. March and November on average have measurable snowfall (18.8 and 11.1 inches, respectively), but also have average temperatures above freezing (33.6 and 39.7 °F, respectively).

The Climate of New York issued by the New York State Climate Office (http://nysc.eas.cornell.edu) also describes a three month period of snow cover for the Syracuse area: "The Southern Plateau, Great Lakes Plain in southern portions of western upstate New York, and the Hudson Valley experience a continuous snow cover from about mid-December to mid-March, with maximum depths usually occurring in February."

5.6.3. Exposure Frequency for Adolescent Trespasser

The RME and CT exposure frequencies for the adult and adolescent trespassers are 42 and 32 days/year, respectively. These values are consistent with the Wastebed B/Harbor Brook HHRA. The 42-day EF is based on the assumption that the trespassing occurs twice per week during the ten summer weeks and once per week during the 22 weeks when the temperature is above 50°F (Appendix G2).

5.6.4. Exposure Frequency for Surveillance Worker

The exposure frequency for the surveillance worker is 31 days/year for the RME scenario and 5 days per year for the CT exposure scenario. These values are adjusted for the amount of time per day spent on the Site outside the vehicle. The RME scenario assumes that the surveillance worker is outside of his or her vehicle for one hour each day. The RME for industrial workers is 250 days/year. This value (250 days/year) is multiplied by 0.125 (1/8 or one hour of exposure divided by an eight hour workday) yielding an exposure frequency of 31 days/year. The exposure frequency for the CT scenario was developed in a similar manner but assumes that the surveillance worker is exposed to Site-related constituents for 10 minutes a day. This approach is consistent with NYSDEC comment 49 in Honeywell's December 2, 2004 response letter to NYSDEC (Honeywell 2004; Appendix H), as well as NYSDEC (2008) comment 11.

5.6.5. Incidental Ingestion of Water for the Construction Worker, Utility Worker, and Adolescent Trespasser

With regard to the incidental ingestion of water for the construction worker, utility worker, adolescent trespasser, and adult trespasser the RME and CT ingestion rates are 0.03 and 0.01 L/day, respectively. Section 6.6.1 of RAGS Part A presents an incidental ingestion rate of 0.05 L/hr for a swimmer (USEPA 1989a). For a non-swimmer, the RME incidental ingestion rate has been estimated to be lower (0.03 L/hr for 1 hr/day), resulting in an ingestion rate of 0.03 L/day. For the CT incidental ingestion rate, a value of 0.01 L/day is used based on best professional judgment.

5.7. Site Exposure Pathway Analyses

The receptor populations, exposure medium, exposure frequencies, and duration are discussed for current and future land uses below.

Current/Future Adolescent and Adult Trespassers: The adolescent and adult trespasser receptors may be exposed to constituents in surface soils via incidental ingestion and dermal contact in all the Exposure Areas except Tributary 5A and groundwater. In the Tributary 5A, they may be exposed to sediment and surface water through ingestion and dermal contact.

Current/Future Surveillance Workers: Surveillance workers in the Plant Area, On-Site Ditches, and FCB may ingest or have dermal contact with surface soils.

Current/Future Utility Workers: Utility workers in the State Fair Blvd./Northwest Off-Site/Outfall 004 Exposure Area may have dermal contact or incidental ingestion of upper soils. Utility workers at the Lakeshore Area may have dermal contact or incidental ingestion of upper soils or shallow groundwater.

Current/Future Transient Adult: The State Fair Blvd./Northwest Off-Site/Outfall 004 area includes a transient adult receptor that may be exposed to surface soil through dermal contact or incidental ingestion.

Future Construction Workers: Construction workers in the Plant Area, On-Site Ditches, FCB, Southwest Off-Site/Outfall 006, PSA, and CHSA may be exposed to constituents in upper soils via dermal contact, incidental ingestion, or inhalation. In addition, construction workers in the PSA and CHSA may be exposed to shallow groundwater through dermal contact or incidental ingestion.

Future Industrial Workers. Future industrial workers in the Plant Area, On-Site Ditches, FCB, SW Off-Site/Outfall 006, PSA, and CHSA may be exposed to constituents in surface soils via incidental ingestion or dermal contact. In addition, a soil vapor survey performed at the Site detected concentrations of chlorobenzenes, benzene, and mercury in soil vapor at certain locations of the Site. Constituents in soil vapor may migrate to indoor air of buildings constructed at the Plant Area, PSA, and CHSA in the future.

Future Utility Workers: Utility workers at the Plant Area, On-Site Ditches, and FCB may be exposed to intermediate soils as well as intermediate groundwater through dermal contact and incidental ingestion. Utility workers in the PSA and CHSA may be exposed to constituents in upper soils and shallow groundwater through dermal contact and incidental ingestion. Utility workers in Tributary 5A may have dermal contact or ingestion of upper sediment or surface water.

Future Adult and Child Residents: Adult and child residents could be exposed to constituents through ingestion of site-wide groundwater as potable water.

6. Toxicity Assessment

In the toxicity assessment, available toxicological data summaries for Site-related compounds are reviewed and the relationships between the extent of exposure to a specific contaminant and the increased likelihood and/or severity of adverse effects are estimated. The potential toxicological effects induced by a given dose of a chemical are classified according to two criteria: 1) carcinogenic effects and 2) non-carcinogenic effects.

6.1. Non-Carcinogenic Effects

Non-carcinogenic health effects occur as a result of damage to cells in one or more human organ, which cause the organ(s) to function less efficiently. Due to the ability of the body to cope with small doses of a chemical, a non-cancer health effect will not occur if intake of a chemical is less than a certain critical dose. This is referred to as a no-observed-adverse-effect-level (NOAEL) for a constituent. If the calculated intake of a chemical is less than the NOAEL for that constituent in a given species, no adverse non-cancer health effects are expected as a result of that exposure.

The specific non-carcinogenic toxic effects that may occur depend on the exposure concentration and the duration of exposure. If an individual is exposed to very high concentrations of a constituent, severe organ dysfunction can occur in a short period of time. This is termed an acute toxic effect. If an individual is exposed to lower levels of a chemical regularly for a long period of time, smaller amounts of repeated damage to the organ can accumulate and ultimately cause the organ to malfunction. These are termed sub-chronic or chronic toxic effects (depending on the exposure duration).

6.1.1. Reference Doses

In order to evaluate potential non-carcinogenic effects following exposure of human populations to chemicals, the USEPA derives chemical-specific “reference doses” (RfDs). If the calculated intake of a chemical is less than the published RfD, no adverse non-carcinogenic effects are expected in the exposed population. A brief discussion of the methods by which RfDs are derived is presented below.

For some constituents, RfDs are derived directly from data on human exposures. Such data includes data relating to occupational exposures that are known to have no adverse effects, normal dietary levels of certain chemicals, therapeutic doses of certain chemicals and epidemiological data relating to populations with background exposures. For most constituents, the USEPA derives RfDs based on laboratory studies, which exposes experimental animals to different concentrations of a constituent and estimates a NOAEL. If data from several animal studies are available, the USEPA seeks to identify the species that is most comparable to humans based on knowledge of specific biologic properties. However, if adequate comparative data is not available, the USEPA selects the study on the most sensitive animal species as the critical study for the basis of the NOAEL. The NOAEL is then used to derive an RfD for potential adverse effects in human populations.

6.1.2. RfD Uncertainty Factors

In most cases, there is considerable uncertainty regarding the extension of toxicological data from animal studies to humans. In other words, the actual RfD for humans or sensitive sub-populations of humans would not be precisely known based on data in animal species. This uncertainty arises because there may be differences between the animal and human species regarding factors such as the metabolism of the chemical, the distribution and clearance rate of the chemical from the body, and the sensitivity of specific organ systems to the chemical. Therefore, the USEPA derives RfDs that are designed to be protective of the public at large, including sensitive sub-populations. The USEPA applies a series of "uncertainty" factors to calculate the final RfD values. Depending on the data, the NOAEL may be divided by an uncertainty factor ranging from 1 to 10,000. Specifically, uncertainty factor values may be used to account for one or more of the following sources of uncertainty:

- to account for variation in the general population and to protect sensitive subpopulations;
- to extrapolate from animal bioassays to human populations (interspecies variability);
- when a NOAEL derived from a subchronic study instead of a chronic study is used as a basis for a chronic RfD; and
- when a LOAEL is used instead of a NOAEL.

6.2. Carcinogenic Effects

The other health effect of concern in the exposure of humans to chemicals in the environment is the induction of cancer. Carcinogenic effects are discussed by weight of evidence (Section 6.2.1) and slope factors (Section 6.2.2).

6.2.1. Weight of Evidence

The USEPA classifies chemicals according to their potential to induce cancer in humans. In general, the USEPA reviews and evaluates available data regarding the potential carcinogenic effects of a constituent, and assigns a "carcinogenicity" classification according to a weight of evidence classification (RAGS D Tables 6.1 and 6.2; Attachment A). A constituent may be classified into one of five groups with respect to the weight of evidence for human carcinogenicity.

- Group A - Known Human Carcinogen. A constituent is classified as Group A if there is sufficient[3] evidence from human observations (epidemiological studies) to support an association between exposure to a chemical agent and cancer in humans.

- Group B - Probable Human Carcinogen. A constituent may be classified as a B1 or a B2 carcinogen. An agent is classified as a B1 carcinogen if there is sufficient evidence for carcinogenicity based on animal studies and limited[3] (suggestive but not conclusive) evidence based on human observations. A B2 carcinogen is an agent for which there is sufficient evidence for carcinogenicity in animals and inadequate evidence for carcinogenicity in humans.

3 The definition of the terms “sufficient”, limited, and adequate are given in USEPA 1986, Guidelines for Carcinogenic Risk Assessment, (51 FR 33992).

- Group C - Possible Human Carcinogen. An agent is classified as a Group C carcinogen if there is limited evidence for carcinogenicity in animals and inadequate evidence for carcinogenicity in humans.

- Group D - An agent is classified as a Group D agent if there is insufficient data available with which to evaluate the carcinogenicity of the chemical.

- Group E - An agent is classified as a Group E agent if there is no evidence for carcinogenic effects based on at least two technically adequate animal studies.

6.2.2. Slope Factors

For group A, B, or C constituents, the USEPA derives chemical-specific cancer slope factors (RAGS D Tables 6.1 and 6.2; Attachment A). A cancer slope factor (CSF) is a number which, when multiplied by the estimated chemical-specific CDI, provides an estimate of the "excess cancer risk" associated with that exposure. Theoretically, the excess cancer risk represents the probability (greater than background) that a carcinogenic event would occur in an individual as a result of a given exposure or pattern of exposures. However, it is important to note that for many constituents the excess cancer risk as calculated by the USEPA procedure may result in a highly conservative estimate of the potential cancer risk. As acknowledged by USEPA (Federal Register 1986), the procedure "does not necessarily give a realistic prediction of the risk. The true value of the risk is unknown, and may be as low as zero."

6.3. Toxicity Summaries

For each constituent that was retained as a COPC, human toxicological effects, including chronic RfDs and CSFs were compiled from the following hierarchy of sources as outlined in the OSWER Directive 9285.7-53, *Human Health Toxicity Values in Superfund Risk Assessments* (USEPA 2003b):

- Tier 1 - EPA's Integrated Risk Assessment System (IRIS).
- Tier 2 - Provisional Peer-Reviewed Toxicity Values (PPRTV) used in USEPA's Superfund Program.
- Tier 3 - Other (peer-reviewed) toxicity values, including:
  - Minimal Risk Level produced by the Agency for Toxic Substances and Disease Registry (ATSDR),
  - California Environmental Protection Agency (CalEPA) values, and
  - EPA Health Effects Assessment Summary Table (HEAST) values.

Third tier toxicological values were not used in this assessment unless these values were supplied by the USEPA Superfund Technical Support Center (STSC).

The non-cancer toxicity values applied in the risk characterizations of oral/dermal exposures evaluated in this report are presented in RAGS D Table 5-1. Non-cancer toxicity values applied for the inhalation of outdoor air is presented in RAGS D Table 5-2. The CSF applied in the risk characterizations of oral/dermal exposures evaluated in this document are presented in RAGS D Table 6-1. Cancer Unit Risk factors used to evaluate the exposure to outdoor air through the inhalation pathway are presented in RAGS D Table 6-2. All values in RAGS D Tables 5 and 6 were

taken either from IRIS or were supplied by the STSC. Toxicity profiles for select COPCs, which significantly contribute to the derived risk estimates, are presented in Attachment L-D.

The values provided by the STSC can be divided into two groups. The first group of toxicity values provided by the STSC is labeled as "PPRTV" in RAGS D Tables 5 and 6. The PPRTV label indicates that the value was presented in a PPRTV Information report supplied to Honeywell by the USEPA. The date associated with the PPRVT value is the date of the specific report for that constituent (*e.g.*, RfC for aluminum, PPRTV report dated October 23, 2006).

The second group of toxicity values provided by the STSC is labeled in RAGS D Tables 5 and 6 according to their original source (ATSDR, HEAST, CalEPA, *etc*.). The use of these toxicity values was approved by the USEPA in electronic mail communications to Honeywell (Appendix I) but there are no PPRTV reports associated with these toxicity values. For example, a March 27, 2008 email (USEPA 2008) from R. Nunes (US EPA Region II) to T. Conklin and P. Sinha (O'Brien & Gere) contained a spreadsheet that endorsed values for several constituents from these sources (ATSDR, HEAST, and CalEPA). This spreadsheet lists a CalEPA value for the arsenic RfC. The source of the RfC is listed as CalEPA (STSC) in the RAGS D Table 5.2 to indicate that this value originated from the CalEPA website and was approved by the STSC as per the March 27, 2008 email. The dates listed on RAGS D Tables 5 and 6 series for the toxicity values selected from these sources follows USEPA protocol (current dates for electronic sources (CalEPA) and date of publication for non-electronic sources).

6.3.1. Constituents with a Mutagenic Mode of Action

Those constituents listed in the USEPA's 2006 Memorandum (USEPA 2006a) as having a MMOA are subject to adjustment by an ADAF, which will be applied to the risk calculations performed for the RAGS D Table 7 series. It should be noted that other PAHs are considered toxicologically related to benzo(a)pyrene, based on the *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons* (USEPA 1993a). Although these are not included on the list of chemicals with a MMOA (USEPA 2006a), they are subject to an ADAF as well.

6.3.2. Adjustment for Dermal Toxicity

Assessing toxicity associated with dermal exposure to constituents in soil and water requires special considerations. Dermal toxicity of a substance depends on factors including the analyte concentration, the potential dose, the area of skin surface exposed, the exposure duration, the absorption of the analyte through the skin, the absorbed dose, and the amount of analyte that can be delivered to a target organ (*i.e.*, biologically effective dose) (USEPA 1997a).

In most instances, it was necessary to use oral toxicity data to estimate dermal toxicity. The dermal chronic daily intake (CDI) represents the absorbed dose of the analyte. However, for many constituents, the oral toxicity data is based on the administered dose rather than the absorbed dose. Therefore, in order to assess dermal exposures, the oral toxicity values were adjusted to reflect the absorbed dose in accordance with USEPA guidance (USEPA 2004b) as follows:

$$RfD_{dermal} = RfD_{oral} \times \text{Gastrointestinal Absorption Efficiency}$$

$$CSF_{dermal} = CSF_{oral} / \text{Gastrointestinal Absorption Efficiency}$$

The absorption efficiency data used for evaluating dermal exposures were obtained from Exhibit 4-1 in RAGS Part E (USEPA 2004b).

6.4. Evaluation of Toxicity for Special Constituent Classes

Special constituent classes that required additional evaluation include chlorinated dioxins and furans (Section 6.4.1), PCBs (Section 6.4.2), PAHs (Section 6.4.3), and chromium (Section 6.4.4), as discussed below. The approach used to apply surrogate compounds for the evaluation of compounds that do not have toxicity data is also discussed (Section 6.4.5). IRIS provides toxicity reference values for mercuric chloride, which is a more toxic form of mercury than elemental mercury. For the assessment of mercury, the toxicity values of mercuric chloride were applied with recognition of the conservative nature of its application.

6.4.1. Toxicity Equivalents for Chlorinated Dioxins and Furans

Toxic Equivalency Factors (TEFs) were applied to assess the human health risks related to exposure to chlorinated dioxins and chlorinated furans. TEFs utilized within this report were provided by Van den Berg *et* al. (2006). The TEFs are located in the *Derivation of toxicity equivalents for dioxins* tables in the RAGS Table 2 Series. A discussion of the TEFs used for quantitative health risk assessment of dioxin and furans is presented below. A more detailed discussion of dioxin toxicity in animals and humans is presented in Section 8.

To facilitate the evaluation of mixtures of PCDD/Fs regulatory authorities have used a TEF approach, a widely accepted approach used by the scientific and regulatory communities in many parts of the world (USEPA 1989b, ATSDR 1997, WHO 1998). 2,3,7,8-tetrachloro-dibenzo-p-dioxin (2,3,7,8-TCDD) is the most widely studied chlorinated dioxin; most of the PCDD/F congeners have not been tested as extensively as 2,3,7,8-TCDD. Available data indicates that some of the congeners may display toxic properties, even though they are less potent than 2,3,7,8-TCDD. The TEF approach assigns a relative potency factor (relative to 2,3,7,8-TCDD) for each PCDD/F congener. The TEFs are based on observed structure activity relationships for PCDD/F compounds, receptor binding affinity or enzyme induction.

6.4.2. Polychlorinated Biphenyls

The IRIS database provides toxicity data for Aroclors 1016, 1248, and 1254. The Aroclors detected at the site consisted of Aroclors 1016, 1242, 1248, 1254, 1260, and 1268. Aroclors with the percent chlorine less than or equal to 42 (*i.e.*, Aroclor 1016 and 1242) will use the RfD for Aroclor 1016. Aroclors with percent chlorine greater than 42 (*i.e.*, Aroclor 1248, 1254, 1260 and 1268) will use the RfD for Aroclor 1254.

6.4.3. Polycyclic Aromatic Hydrocarbons

The USEPA IRIS database has published a CSF for benzo(a)pyrene of 7.3×10^{0} $(mg/Kg\text{-}day)^{-1}$. Using this value and TEFs for carcinogenic PAHs, the oral CSF can be calculated for benzo(a)anthracene (TEF = 0.1), benzo(b)fluoranthene (TEF = 0.1), benzo(k)fluoranthene (TEF = 0.01), chrysene (TEF = 0.001), dibenzo(a,h) anthracene (TEF = 1.0), and indeno(ghi)pyrene (TEF = 0.1) (ORNL 2004).

The CSFs for benzo(a)pyrene for oral, dermal and inhalation exposures are 7.3×10^{0} $(mg/Kg\text{-}day)^{-1}$, 2.4×10^{1} $(mg/Kg\text{-}day)^{-1}$, and 3.1×10^{0} $(mg/Kg\text{-}day)^{-1}$, respectively. Utilizing the above TEFs, the CSFs were calculated for the carcinogenic PAHs for dermal exposure. The inhalation CSF was calculated

from the inhalation unit risk as described in supplemental guidance from the *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons* (USEPA 1993a).

6.4.4. Chromium

In this report, the toxicity value of hexavalent chromium was used as a surrogate for unspeciated chromium; this is a conservative assumption. The USEPA IRIS database provides a discussion on the carcinogenicity of hexavalent chromium and a published CSF for inhalation of 4.2×10^{1} $(mg/Kg\text{-}day)^{-1}$.

6.4.5. Surrogates

Surrogate compounds were utilized in the absence of toxicity data as summarized as summarized below. The selection of the surrogate compounds was based on professional judgment regarding the similarity of the COPC to the surrogate compound.

Table 6.1. *Summary of Surrogates*.

Constituent	Notes
Chromium	Because chromium was not speciated, RfC, RfD, and inhalation unit risk values for chromium VI were utilized.
Less Chlorinated PCBs	Less chlorinated includes Aroclors 1221, 1232, 1016, and 1242. RfD values for Aroclor-1016 (CAS# 126741120) utilized.
Highly Chlorinated PCBs	Highly Chlorinated includes Aroclors 1248, 1254, 1260 [and higher if reported]. RfD values for Aroclor-1254 (CAS# 11097691) utilized.
Mercury	RfC and RfDi for elemental mercury were used because the corresponding values for methyl mercury were unavailable. Mercuric chloride used as a surrogate for oral/dermal RfD value.
PAH's	For carcinogenic PAHs, relative potency approach with respect to benzo(a)pyrene applied to estimate Oral Cancer Slope Factor (see USEPA 1993a *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons*, EPA/600/R-93/089).
Vanadium	Vanadium pentoxide as surrogate for oral/dermal RfD value.
Endosulfan I	Endosulfan used as a surrogate for oral/dermal RfD value.

7. Risk Characterization

In this section of the HHRA, the toxicity and exposure assessments are summarized and integrated into numerical values that may be used to evaluate the likelihood of adverse health effects in populations potentially exposed to Site-related chemicals. RME and CT estimates of potential health risks were developed for each potentially exposed receptor at the Site.

Chronic non-cancer health effects were evaluated by comparing the chemical-specific CDIs with the respective chronic RfD as given below.

1. For each receptor identified during the exposure assessment and each individual exposure pathway, the chemical-specific hazard quotients (HQs) were calculated where HQ is given by:

   Hazard Quotient = CDI/RfD

2. For each exposure pathway, the chemical-specific hazard quotients were summed to calculate the Hazard Index (HI) for that pathway. For each receptor, the pathway specific hazard indexes were summed to obtain the total HI for that receptor. A total HI of less than one indicates that it is highly unlikely that chronic non-cancer toxic effects would occur for the given receptor.

To evaluate carcinogenic effects, the incremental cancer risk associated with exposure to chemicals of concern was calculated using chemical-specific slope factors as described below.

1. For each receptor identified during the exposure assessment and each exposure pathway, the chemical-specific risk is given by:

   Cancer risk = CDI * slope factor.

2. For each receptor, the total incremental excess cancer risk was calculated by summing the pathway specific cancer risk. This calculated risk estimate was then compared with an acceptable range of excess cancer risks of between 10^{-4} and 10^{-6} (40 CFR §300.430[e][2][I][A][2]; CFR 2004).

Details of the chemical-specific, pathway-specific and total HIs or cancer risk for each Exposure Area and receptor are given on RAGS D Tables 7.1 RME through 7.10 CT. Summaries of HIs and cancer risks for each receptor are given by AOS in RAGS D Tables 9.1 RME through 9.25 CT. A brief discussion of the RME risk estimates associated with each receptor is presented below.

7.1. Plant Area

7.1.1. Current/Future Receptors

Adolescent Trespasser

The calculated RME HI for the current and future adolescent trespasser is 1.3 and the calculated cancer risk is 4×10^{-5} (RAGS D Table 7.1a RME; Attachment A). The corresponding CT HI and cancer risk are 0.9 and 2×10^{-5}, respectively (RAGS D Table 7.1a CT). There are no unacceptable cancer risks or non-cancer hazards for this receptor.

Adult Trespasser

The calculated total RME HI for the current and future adult trespasser is 0.5, and the calculated cancer risk is 4×10^{-5} (RAGS D Table 7.2a RME). The corresponding CT HI and cancer risk are 0.3 and 6×10^{-6}, respectively (RAGS D Table 7.2a CT). There are no unacceptable cancer risks or non-cancer hazards for this receptor.

Surveillance Worker

The calculated RME HI for the current and future surveillance worker in the Plant Area is 0.6 and the calculated cancer risk is 3×10^{-5} (RAGS D Table7.3a RME; Attachment A). The corresponding CT HI and cancer risk are 0.05 and 1×10^{-6}, respectively (RAGS D Table7.3a CT). There are no unacceptable cancer risks or non-cancer hazards for this receptor.

7.1.2. Future Receptors

Industrial Worker

The calculated RME HI for the future industrial worker in the Plant Area is 1.9 and the calculated RME cancer risk is 9×10^{-5} (RAGS D Table 7.4a RME; Attachment A). The calculated CT HI and cancer risk are 1.4 and 2×10^{-5}, respectively (RAGS D Table 7.4a CT). The HI for the industrial worker under future Site conditions only marginally exceeds the HI threshold of 1, and is driven by the target HI for autoimmune effects (1.3) arising from the ingestion of mercury in surface soils.

Construction Worker

The calculated RME HI for the future construction worker in the Plant Area is 26 and the calculated RME cancer risk is 3×10^{-5} (RAGS D Table 7.5a RME; Attachment A). The calculated CT HI and cancer risk are 14 and 2×10^{-5}, respectively (RAGS D Table 7.5a CT). The HI for the construction worker under future Site conditions exceeds the HI threshold of 1, and is driven by the target HI for nasal/respiratory effects (18) arising from the inhalation of nickel in upper soils.

Utility Worker

The calculated RME HI for the future utility worker in the Plant Area is 5.3 and the calculated cancer risk is 9×10^{-6} (RAGS D Table 7.7a RME; Attachment A). The calculated CT HI and cancer risk are 5.1 and 7×10^{-6}, respectively (RAGS D Table 7.7a CT). The HI for the utility worker under current and future Site conditions exceeds the HI threshold of 1, and is driven by the target HI for autoimmune effects (4) arising from the ingestion of mercury in intermediate soils.

7.2. On-Site Ditches

7.2.1. Current/Future Receptors

Adolescent Trespasser

The adolescent trespasser RME and CT cancer risks at the On-Site Ditches are 6×10^{-5} and 4×10^{-5}, respectively (RAGS D Tables 7.1b RME and 7.1b CT). The RME and CT HIs for these areas are 6.3 and 4.4, respectively (exceeding the HI threshold of 1). The HI is driven by the target value for autoimmune effects (3.5) arising from ingestion of mercury in surface soils, and developmental effects arising from ingestion of 2,3,7,8-TCDD equivalent in surface soils (2.7). There are no unacceptable cancer risks for this receptor.

Adult Trespasser

The adult trespasser RME and CT cancer risks at the On-Site Ditches are 9×10^{-5} and 2×10^{-5}, respectively (RAGS D Tables 7.2b RME and 7.2b CT). The RME and CT HIs for these areas are 2.6 and 1.6, respectively. The HI marginally exceeds the threshold as a result of contributions from autoimmune effects (1.3) arising from ingestion of mercury and developmental effects arising from the ingestion 2,3,7,8-TCDD equivalent in surface soils (1.3). There are no unacceptable cancer risks for this receptor.

Surveillance Worker

The surveillance worker RME and CT cancer risks at the On-Site Ditches are 7×10^{-5} and 3×10^{-6}, respectively (RAGS D Tables 7.3b RME and 7.3b CT). The RME and CT HIs for these areas are 2.9 and 0.3, respectively. The HI marginally exceeds the threshold as a result of contributions from autoimmune effects (1.6) arising from the ingestion of mercury in surface soils. There are no unacceptable cancer risks for this receptor.

7.2.2. Future Receptors

Industrial Worker

The calculated RME HI for the future industrial worker at the On-Site Ditches is 9.1 and the calculated RME cancer risk is 2×10^{-4} (RAGS D Table 7.4b RME; Attachment A). The calculated CT HI and cancer risk are 6.7 and 5×10^{-5}, respectively (RAGS D Table 7.4b CT). The RME cancer risk exceeds the acceptable regulatory range of 1×10^{-4} – 1×10^{-6} and is driven by the target risk value for ingestion of 2,3,7,8-TCDD equivalent in surface soils. The HI for the industrial worker under future Site conditions exceeds the HI threshold, and is driven by the target HI for autoimmune effects (5.1) arising from the ingestion of mercury in surface soils.

Construction Worker

The calculated RME HI for the future construction worker at the On-Site Ditches is 48 and the calculated RME cancer risk is 5×10^{-5} (RAGS D Table 7.5b RME; Attachment A). The calculated CT HI and cancer risk are 39 and 3×10^{-5}, respectively (RAGS D Table 7.5b CT). The HI for the construction worker under future Site conditions exceeds the HI threshold of 1, and is driven by the target HI for autoimmune (29) and nervous system (33) effects arising from the ingestion & inhalation of mercury in upper soils. There are no unacceptable cancer risks for this receptor.

Utility Worker

The utility worker RME and CT cancer risks at the On-Site Ditches are 2×10^{-5} and 2×10^{-5}, respectively (RAGS D Tables 7.7b RME and 7.7b CT). The RME and CT HIs for these areas are 26 and 24, respectively (exceeding the HI threshold of 1). The HI is driven by the target value for autoimmune effects (17) arising from ingestion of mercury in surface soils, and developmental effects arising from ingestion of 2,3,7,8-TCDD equivalent in intermediate soils (9). There are no unacceptable cancer risks for this receptor.

7.3. Former Chlorination Building

7.3.1. Current/Future Receptors

Adolescent Trespasser

The adolescent trespasser RME and CT cancer risks at the Former Chlorination Building are 4×10^{-4} and 3×10^{-4}, respectively (RAGS D Tables 7.1c RME and 7.1c CT), exceeding the 1×10^{-4} threshold. The RME and CT HIs for these areas are 22 and 15, respectively, exceeding the HI threshold of 1. Cancer risk exceeds the acceptable regulatory range of 1×10^{-4} – 1×10^{-6} and is driven by ingestion of 2,3,7,8-TCDD equivalent in upper soils. The non-cancer hazard is driven by developmental effects arising from the ingestion of 2,3,7,8-TCDD equivalent in surface soils (22).

Adult Trespasser

The adult trespasser RME and CT cancer risks at the Former Chlorination Building are 7×10^{-4} and 1×10^{-4}, respectively (RAGS D Tables 7.2c RME and 7.2c CT), exceeding the 1×10^{-4} threshold. The RME and CT HIs for these areas are 11 and 6, respectively, exceeding the HI threshold of 1. Cancer risk exceeds the acceptable regulatory range of 1×10^{-4} – 1×10^{-6} and is driven by ingestion of 2,3,7,8-TCDD equivalent in upper soils. HI exceeds its threshold of 1 and is driven by developmental effects arising from the ingestion of 2,3,7,8-TCDD equivalent in surface soils (10).

The IEUBK model default exposure parameters and Site-specific parameters were to estimate the geometric mean blood lead level in residential children for the site wide potable water ingestion scenario (Appendix J). The predicted geometric mean blood lead level (58.97 ug/L) was combined with the default model geometric standard deviation for child blood lead (1.6 µg/dL) to generate a distribution of blood lead in resident children. The variability in the distribution is due to differences in lead uptake rates for children exposed to the same environmental lead concentrations (Appendix J). The child blood lead distribution was converted to a probability distribution to determine the

probability of exceeding the target blood lead level. This value was calculated to be 10.6%, exceeding the regulatory target of 5%.

Surveillance Worker

The surveillance worker RME and CT cancer risks at the Former Chlorination Building are 5×10^{-4} and 2×10^{-5}, respectively (RAGS D Tables 7.3c RME and 7.3c CT). The RME and CT HIs for these areas are 9.9 and 1, respectively. Cancer risk exceeds the acceptable regulatory range of 1×10^{-4} – 1×10^{-6} and is driven by ingestion of 2,3,7,8-TCDD equivalent in surface soils. HI exceeds its threshold of one and is driven by developmental effects arising from the ingestion and dermal contact of 2,3,7,8-TCDD equivalent in surface soils (9.9).

7.3.2. Future Receptors

Industrial Worker

The calculated RME HI for the future industrial worker at the Former Chlorination Building is 32 and the calculated RME cancer risk is 2×10^{-3} (RAGS D Table 7.4c RME; Attachment A). The calculated CT HI and cancer risk are 21 and 4×10^{-4}, respectively (RAGS D Table 7.4c CT). Cancer risk exceeds the acceptable regulatory range of 1×10^{-4} – 1×10^{-6} and is driven by ingestion of 2,3,7,8-TCDD equivalent in upper soils. HI exceeds its threshold of 1 and is driven by developmental effects arising from the ingestion and dermal contact of 2,3,7,8-TCDD equivalent in surface soils (32).

Construction Worker

The calculated RME HI for the future construction worker at the Former Chlorination Building is 360 and the calculated RME cancer risk is 8×10^{-4} (RAGS D Table 7.5c RME; Attachment A). The calculated CT HI and cancer risk are 339 and 7×10^{-4}, respectively (RAGS D Table 7.5c CT). Cancer risk exceeds the acceptable regulatory range of 1×10^{-4} – 1×10^{-6} and is driven by ingestion of 2,3,7,8-TCDD equivalent in upper soils. HI exceeds its threshold of 1 and is driven by developmental effects arising from the ingestion and dermal contact of 2,3,7,8-TCDD equivalent in surface soils (355).

Utility Worker

The utility worker RME and CT cancer risks at the Former Chlorination Building are 7×10^{-4} and 6×10^{-4}, respectively (RAGS D Tables 7.7c RME and 7.7c CT), exceeding the 1×10^{-4} threshold. The RME and CT HIs for these areas are 312 and 260, respectively (exceeding the HI threshold of 1). Cancer risk exceeds the acceptable regulatory range of 1×10^{-4} – 1×10^{-6} and is driven by ingestion of 2,3,7,8-TCDD equivalent in upper soils. HI exceeds its threshold of 1 and is driven by developmental effects arising from the ingestion and dermal contact of 2,3,7,8-TCDD equivalent in surface soils (310).

7.4. Southwest Off-Site/Outfall 006 Exposure Area

7.4.1. Current Receptors

Adolescent Trespasser

The adolescent trespasser RME and CT cancer risks at the Southwest Off-Site/Outfall 006 Exposure Area are 4×10^{-5} and 2×10^{-5}, respectively (RAGS D Tables 7.1d RME and 7.1d CT). The RME and

CT HIs for these areas are 2.5 and 1.6, respectively (marginally exceeding the HI threshold of 1). The HI is driven by the target value for autoimmune (0.7) and ocular (0.6) effects arising from ingestion and dermal contact of highly chlorinated PCBs and ingestion of mercury in surface soils. There are no unacceptable cancer risks for this receptor.

Adult Trespasser

The adult trespasser RME and CT cancer risks at the Southwest Off-Site/Outfall 006 Exposure Area are 4×10^{-5} and 6×10^{-6}, respectively (RAGS D Tables 7.2d RME and 7.2d CT). The RME and CT HIs for these areas are 1.3 and 0.7, respectively. There are no unacceptable cancer risks or non-cancer hazards for this receptor.

7.4.2. Future Receptors

Industrial Worker

The calculated RME HI for the future industrial worker at the Southwest Off-Site/Outfall 006 Exposure Area is 3.6 and the calculated RME cancer risk is 9×10^{-5} (RAGS D Table 7.4d RME; Attachment A). The calculated CT HI and cancer risk are 2.2 and 1×10^{-5}, respectively (RAGS D Table 7.4d CT). The HI for the industrial worker under future Site conditions only marginally exceeds the HI threshold of 1, and is driven by the target HI for autoimmune effects (3.2) arising from the ingestion of mercury in surface soils. There are no unacceptable cancer risks for this receptor.

Construction Worker

The calculated RME HI for the future construction worker at the Southwest Off-Site/Outfall 006 Exposure Area is 75 and the calculated RME cancer risk is 2×10^{-4} (RAGS D Table 7.5d RME; Attachment A). The RME cancer risk exceeds acceptable regulatory range of 1×10^{-4} – 1×10^{-6}, and is driven by the cancer risk arising from inhalation of benzene in upper soils (1.4×10^{-4}). The calculated CT HI and cancer risk are 45 and 9×10^{-5}, respectively (RAGS D Table 7.5d CT). The HI for the construction worker under future Site conditions exceeds the H1 threshold of 1, and is driven by the target HI for autoimmune (58) effects arising from the inhalation and ingestion of benzene in upper soils.

7.5. State Fair Blvd./Northwest Off-Site/Outfall 004 Exposure Area

7.5.1 Current/Future Receptors

Adolescent Trespasser

The adolescent trespasser RME and CT cancer risks at the State Fair Blvd./Northwest Off-Site/Outfall 004 Exposure Area are 4×10^{-6} and 3×10^{-6}, respectively (RAGS D Tables 7.1e RME and 7.1e CT). The RME and CT HIs for these areas are 0.4 and 0.3, respectively. There are no unacceptable cancer risks or non-cancer hazards for this receptor.

Adult Trespasser

The adult trespasser RME and CT cancer risks at the State Fair Blvd./Northwest Off-Site/Outfall 004 Exposure Area are 6×10^{-6} and 1×10^{-6}, respectively (RAGS D Tables 7.2e RME and 7.2e CT). The

RME and CT HIs for these areas are 0.2 and 0.1, respectively. There are no unacceptable cancer risks or non-cancer hazards for this receptor.

State Fair Boulevard transient

The RME and CT cancer risks at the State Fair Blvd./Northwest Off-Site/Outfall 004 Exposure Area for the State Fair Boulevard transient are 6×10^{-7} and 8×10^{-8}, respectively (RAGS D Tables 7.6 RME and 7.6 CT). The RME and CT HIs for these areas are 0.07 and 0.009, respectively. There are no unacceptable cancer risks or non-cancer hazards for this receptor.

Utility Worker

The utility worker RME and CT cancer risks at the State Fair Blvd./Northwest Off-Site/Outfall 004 Exposure Area are 2×10^{-6} and 1×10^{-6}, respectively (RAGS D Tables 7.7d RME and 7.7d CT). The RME and CT HIs for these areas are 1.2 and 1.1, respectively, only marginally exceeding the HI threshold of 1. Contributors to the HI include developmental effects arising from the ingestion of 2,3,7,8-TCDD equivalent (0.6) and autoimmune effects (0.5), arising from the ingestion of mercury, both in upper soils. There are no unacceptable cancer risks or non-cancer hazards for this receptor.

7.6. Lakeshore Area

7.6.1. Current/Future Receptors

Adolescent trespasser

The adolescent trespasser RME and CT cancer risks at the Lakeshore Area are 3×10^{-5} and 1×10^{-5}, respectively (RAGS D Tables 7.1f RME and 7.1f CT). The RME and CT HIs for these areas are 0.2 and 0.1, respectively. There are no unacceptable cancer risks or non-cancer hazards for this receptor.

Adult Trespasser

The adult trespasser RME and CT cancer risks at the Lakeshore Area are 2×10^{-5} and 3×10^{-6}, respectively (RAGS D Tables 7.2f RME and 7.2f CT). The RME and CT HIs for these areas are 0.1 and 0.05, respectively. There are no unacceptable cancer risks or non-cancer hazards for this receptor.

Utility Worker

The utility worker RME and CT cancer risks at the Lakeshore Area are 4×10^{-5} and 3×10^{-5}, respectively (RAGS D Tables 7.7e RME and 7.7e CT). The RME and CT HIs for these areas are 15 and 14, respectively, exceeding the H1 threshold of 1. The HI is driven by autoimmune effects (10) arising from dermal contact with benzene in shallow groundwater. There are no unacceptable cancer risks for this receptor.

7.7. Petroleum Storage Area

7.7.1. Current Receptors

Adolescent Trespasser

The adolescent trespasser RME and CT cancer risks at the Petroleum Storage Area are 3×10^{-5} and 1×10^{-5}, respectively (RAGS D Tables 7.1g RME and 7.1g CT). The RME and CT HIs for these areas are 0.1 and 0.09, respectively. There are no unacceptable cancer risks or non-cancer hazards for this receptor.

Adult Trespasser

The adult trespasser RME and CT cancer risks at the Petroleum Storage Area are 2×10^{-5} and 3×10^{-6}, respectively (RAGS D Tables 7.2g RME and 7.2g CT). The RME and CT HIs for these areas are 0.06 and 0.04, respectively. There are no unacceptable cancer risks or non-cancer hazards for this receptor.

7.7.2. Future Receptors

Industrial Worker

The calculated RME HI for the future industrial worker at the Petroleum Storage Area is 0.2 and the calculated RME cancer risk is 5×10^{-5} (RAGS D Table 7.4e RME; Attachment A). The calculated CT HI and cancer risk are 0.1 and 8×10^{-6}, respectively (RAGS D Table 7.4e CT). There are no unacceptable cancer risks or non-cancer hazards for this receptor.

Construction Worker

The calculated RME HI for the future construction worker at the Petroleum Storage Area is 7.7 and the calculated RME cancer risk is 9×10^{-6} (RAGS D Table 7.5e RME; Attachment A). The calculated CT HI and cancer risk are 4.7 and 7×10^{-6}, respectively (RAGS D Table 7.5e CT). The HI values exceed the H1 threshold of 1, and are driven by nervous system effects (6), arising from the inhalation of manganese from upper soils. There are no unacceptable cancer risks for this receptor.

Utility Worker

The utility worker RME and CT cancer risks at the Petroleum Storage Area are 5×10^{-6} and 4×10^{-6}, respectively (RAGS D Tables 7.7f RME and 7.7f CT). The RME and CT HIs for these areas are 1.5 and 1.3, respectively, only marginally exceeding the H1 threshold of 1. Contributors to the HI include autoimmune effects (1) arising from dermal contact with benzene in shallow groundwater. There are no unacceptable cancer risks or non-cancer hazards for this receptor.

7.8. Chlorobenzene Hot-Spot Area

7.8.1. Current Receptors

Adolescent Trespasser

The adolescent trespasser RME and CT cancer risks at the Chlorobenzene Hot-Spot Area are 5×10^{-5} and 2×10^{-5}, respectively (RAGS D Tables 7.1h RME and 7.1h CT). The RME and CT HIs for these areas are 4.1 and 2.1, respectively (exceeding the H1 threshold of 1). The HI is driven by ocular (4) and autoimmune (4) effects arising from the ingestion of, and dermal contact with, highly chlorinated PCBs in surface soils. There are no unacceptable cancer risks for this receptor.

Adult Trespasser

The adult trespasser RME and CT cancer risks at the Chlorobenzene Hot-Spot Area are 7×10^{-5} and 9×10^{-6}, respectively (RAGS D Tables 7.2h RME and 7.2h CT). The RME and CT HIs for these areas are 2.7 and 1.2, respectively, only marginally exceeding the H1 threshold of 1. The HI is driven by ocular (3) and autoimmune (3) effects arising from the ingestion of, and dermal contact with, highly chlorinated PCBs in surface soils. There are no unacceptable cancer risks for this receptor.

7.8.2. Future Receptors

Industrial Worker

The calculated RME HI for the future industrial worker at the Chlorobenzene Hot-Spot Area is 6 and the calculated RME cancer risk is 1×10^{-4} (RAGS D Table 7.4f RME; Attachment A). The calculated CT HI and cancer risk are 2.2 and 2×10^{-5}, respectively (RAGS D Table 7.4f CT). The RME cancer risk exceeds the acceptable regulatory range of 1×10^{-4} – 1×10^{-6} and is driven by ingestion and dermal contact with highly chlorinated PCBs in surface soils. The same drivers are responsible for HI, exceeding the threshold of 1; ocular (6) and autoimmune (6) effects are dominant in this respect.

Construction Worker

The calculated RME HI for the future construction worker at the Chlorobenzene Hot-Spot Area is 14 and the calculated RME cancer risk is 3×10^{-5} (RAGS D Table 7.5f RME; Attachment A). The calculated CT HI and cancer risk are 11 and 2×10^{-5}, respectively (RAGS D Table 7.5f CT). The HI values exceed the HI threshold of 1 and are driven by ocular (6) and autoimmune (7) effects arising from the ingestion of highly chlorinated PCBs in upper soils. There are no unacceptable cancer risks for this receptor.

Utility Worker

The utility worker RME and CT cancer risks at the Chlorobenzene Hot-Spot Area are 1×10^{-5} and 9×10^{-6}, respectively (RAGS D Tables 7.7g RME and 7.7g CT). The RME and CT HIs for these areas are 10 and 7, respectively. The HI for this area exceeds the HI threshold of 1 and is driven by ocular (7) and autoimmune effects (8), arising from the ingestion of highly chlorinated PCBs in upper soils. There are no unacceptable cancer risks for this receptor.

7.9. Tributary 5A

7.9.1 Current and Future Receptors

Adolescent Trespasser

The adolescent trespasser RME and CT cancer risks at the Tributary 5A are 3×10^{-5} and 2×10^{-5}, respectively (RAGS D Tables 7.1i RME and 7.1i CT). The RME and CT HIs for these areas are 1.9 and 1.4, respectively (marginally exceeding the HI threshold of 1). The HI is driven by the ingestion of chromium in sediment (1.1). There are no unacceptable cancer risks or non-cancer hazards for this receptor.

Adult Trespasser

The adult trespasser RME and CT cancer risks at the Tributary 5A are 5×10^{-5} and 8×10^{-6}, respectively (RAGS D Tables 7.2i RME and 7.2i CT). The RME and CT HIs for these areas are 0.9 and 0.6, respectively. There are no unacceptable cancer risks or non-cancer hazards for this receptor.

Utility Worker

The utility worker RME and CT cancer risks at the Tributary 5A are 4×10^{-6} and 4×10^{-6}, respectively (RAGS D Tables 7.7h RME and 7.7h CT). The RME and CT HIs for these areas are 6.7 and 6.4, respectively. The HI for this area exceeds the HI threshold of 1 and is driven by the ingestion of chromium in sediment (4). There are no unacceptable cancer risks for this receptor.

7.10. Hypothetical Drinking Water Source Area

As discussed in previous sections of this report, groundwater at the Site is not suitable for use as a drinking water supply irrespective of any contributions related to waste at the Site. The drinking water pathway was included in this section at the request of the NYSDEC.

Adult Resident

The RME and CT cancer risks for the future adult resident are 1×10^{-2} and 4×10^{-3}, respectively (RAGS D Tables 7.8 RME and 7.8 CT). This exceeds the acceptable regulatory range of 1×10^{-4} – 1×10^{-6} and is driven by ingestion of benzene. The RME and CT HIs for these areas are each 175, and are driven by autoimmune effects (122), arising from the ingestion of benzene.

Child Resident

The RME and CT cancer risks for the future child resident are each 7×10^{-3} (RAGS D Tables 7.9 RME and 7.9 CT). This exceeds the acceptable regulatory range of 1×10^{-4} – 1×10^{-6} and is driven by ingestion of benzene. The RME and CT HIs for these areas are each 408, and are driven by autoimmune effects (284), arising from the ingestion of benzene.

7.11. Risk Characterization – Summary

7.11.1. Current Conditions

Under current conditions, cancer risks for receptors in all exposure areas are within the acceptable regulatory range of 10^{-4} to 10^{-6}, except for the Former Chlorination Building, in which RME total cancer risks exceed the regulatory range for the adolescent and adult trespasser, and the surveillance worker.

Under current conditions, hazard indices for receptors in the Plant Area, State Fair Blvd/ Northwest Off-Site/ Outfall 004 Exposure Area, and the Petroleum Storage Area are within the threshold of 1. RME hazard indices that exceed 1 include:

- Adolescent trespasser in the On-Site Ditches, Former Chlorination Building, Southwest Off-Site/Outfall 006 Exposure Area, Chlorobenzene Hot-Spot Area, and Tributary 5A.

- Adult trespasser in the On-Site Ditches, Former Chlorination Building, Southwest Off-Site/Outfall 006 Exposure Area, and Chlorobenzene Hot-Spot Area.
- Surveillance worker in the On-Site Ditches and Former Chlorination Building
- Utility worker in the Lakeshore Area and Tributary 5A.

A summary of estimated cancer risks and non-cancer hazards is presented below in Table 7.1.

Table 7.1. *Summary of current RME and CT estimated cancer risks and hazard indexes*.

Exposure Area	Receptor	RME or CT	Cancer Risk	HI
Plant Area	Adolescent Trespasser	RME	$4x10^{-5}$	$1x10^{0}$
		CT	$2x10^{-5}$	$9x10^{-1}$
	Adult Trespasser	RME	$4x10^{-5}$	$5x10^{-1}$
		CT	$6x10^{-6}$	$3x10^{-1}$
	Surveillance Worker	RME	$3x10^{-5}$	$6x10^{-1}$
		CT	$1x10^{-6}$	$5x10^{-2}$
On-Site Ditches	Adolescent Trespasser	RME	$6x10^{-5}$	$6x10^{0}$
		CT	$4x10^{-5}$	$4x10^{0}$
	Adult Trespasser	RME	$9x10^{-5}$	$3x10^{0}$
		CT	$2x10^{-5}$	$2x10^{0}$
	Surveillance Worker	RME	$7x10^{-5}$	$3x10^{0}$
		CT	$3x10^{-6}$	$3x10^{-1}$
Former Chlorination Building (FCB)	Adolescent Trespasser	RME	$4x10^{-4}$	$2x10^{2}$
		CT	$3x10^{-4}$	$1x10^{1}$
	Adult Trespasser	RME	$7x10^{-4}$	$1x10^{1}$
		CT	$1x10^{-4}$	$6x10^{0}$
	Surveillance Worker	RME	$5x10^{-4}$	$1x10^{1}$
		CT	$2x10^{-5}$	$1x10^{0}$
Southwest Off-Site/Outfall 006 Exposure Area	Adolescent Trespasser	RME	$4x10^{-5}$	$3x10^{0}$
		CT	$2x10^{-5}$	$2x10^{0}$
	Adult Trespasser	RME	$4x10^{-5}$	$1x10^{0}$
		CT	$6x10^{-6}$	$7x10^{-1}$
State Fair Blvd/ Northwest Off-Site/ Outfall 004 Exposure Area	Adolescent Trespasser	RME	$4x10^{-6}$	$4x10^{-1}$
		CT	$3x10^{-6}$	$3x10^{-1}$
	Adult Trespasser	RME	$6x10^{-6}$	$2x10^{-1}$
		CT	$1x10^{-6}$	$1x10^{-1}$
	Adult Transient	RME	$6x10^{-7}$	$7x10^{-2}$
		CT	$8x10^{-8}$	$9x10^{-3}$

Table 7.1. *Summary of current RME and CT estimated cancer risks and hazard indexes*.

Exposure Area	Receptor	RME or CT	Cancer Risk	HI
	Utility Worker	RME	$2x10^{-6}$	$1x10^{0}$
		CT	$1x10^{-6}$	$1x10^{0}$
Lakeshore Area	Adolescent Trespasser	RME	$3x10^{-5}$	$2x10^{-1}$
		CT	$1x10^{-5}$	$1x10^{-1}$
	Adult Trespasser	RME	$2x10^{-5}$	$1x10^{-1}$
		CT	$3x10^{-6}$	$5x10^{-2}$
Lakeshore Area cont.	Utility Worker	RME	$4x10^{-5}$	$1x10^{1}$
		CT	$3x10^{-5}$	$1x10^{1}$
Petroleum Storage Area	Adolescent Trespasser	RME	$3x10^{-5}$	$1x10^{-1}$
		CT	$1x10^{-5}$	$9x10^{-2}$
	Adult Trespasser	RME	$2x10^{-5}$	$6x10^{-2}$
		CT	$3x10^{-6}$	$4x10^{-2}$
Chlorobenzene Hot-Spot Area	Adolescent Trespasser	RME	$5x10^{-5}$	$4x10^{0}$
		CT	$2x10^{-5}$	$2x10^{0}$
	Adult Trespasser	RME	$7x10^{-5}$	$3x10^{0}$
		CT	$9x10^{-6}$	$1x10^{0}$
Tributary 5A	Adolescent Trespasser	RME	$3x10^{-5}$	$2x10^{0}$
		CT	$2x10^{-5}$	$1x10^{0}$
	Adult Trespasser	RME	$5x10^{-5}$	$9x10^{-1}$
		CT	$8x10^{-6}$	$6x10^{-1}$
	Utility Worker	RME	$4x10^{-6}$	$7x10^{0}$
		CT	$4x10^{-6}$	$6x10^{0}$

7.11.2. Future Conditions

Under future conditions, cancer risks for receptors in all exposure areas are within the acceptable regulatory range of 10^{-4} to 10^{-6}, except for the construction worker in the Southwest Off-Site/Outfall 006 Exposure Area and the Former Chlorination Building, in which RME total cancer risks exceed the regulatory range for the adolescent trespasser, adult trespasser, surveillance worker, industrial worker, construction worker, and utility worker.

Under future conditions, hazard indices for receptors in the State Fair Blvd/ Northwest Off-Site/ Outfall 004 Exposure Area are within the threshold of 1. RME hazard indices that exceed 1 include:

- Adolescent trespasser in the On-Site Ditches, Former Chlorination Building, Southwest Off-Site/Outfall 006 Exposure Area, Chlorobenzene Hot-Spot Area, and Tributary 5A.

- Adult trespasser in the On-Site Ditches, Former Chlorination Building, Southwest Off-Site/Outfall 006 Exposure Area, and Chlorobenzene Hot-Spot Area.
- Surveillance worker in the On-Site Ditches and Former Chlorination Building
- Industrial worker in the Plant Area, On-Site Ditches, Former Chlorination Building, Southwest Off-Site/Outfall 006 Exposure Area, and Chlorobenzene Hot-Spot Area
- Construction worker in the Plant Area, On-Site Ditches, Former Chlorination Building, Southwest Off-Site/Outfall 006 Exposure Area, Petroleum Storage Area, and Chlorobenzene Hot-Spot Area
- Utility worker in the Plant Area, On-Site Ditches, Former Chlorination Building, Lakeshore Area, Chlorobenzene Hot-Spot Area, and Tributary 5A
- Child and adult resident in the potable water use scenario

Table 7.2 below summarizes cancer risk and non-cancer hazards for potential future conditions at the Site.

Table 7.2. *Summary of future RME and CT standard cancer risks and hazard indexes*.

Exposure Area	Receptor	RME or CT	Cancer Risk	HI
Plant Area	Adolescent Trespasser	RME	$4x10^{-5}$	$1x10^{0}$
		CT	$2x10^{-5}$	$9x10^{-1}$
	Adult Trespasser	RME	$4x10^{-5}$	$5x10^{-1}$
		CT	$6x10^{-6}$	$3x10^{-1}$
	Surveillance Worker	RME	$3x10^{-5}$	$6x10^{-1}$
		CT	$1x10^{-6}$	$5x10^{-2}$
	Industrial Worker	RME	$9x10^{-5}$	$2x10^{0}$
		CT	$2x10^{-5}$	$1x10^{0}$
	Construction Worker	RME	$3x10^{-5}$	$3x10^{1}$
		CT	$2x10^{-5}$	$1x10^{1}$
	Utility Worker	RME	$9x10^{-6}$	$5x10^{0}$
		CT	$7x10^{-6}$	$5x10^{0}$
On-Site Ditches	Adolescent Trespasser	RME	$6x10^{-5}$	$6x10^{0}$
		CT	$4x10^{-5}$	$4x10^{0}$
	Adult Trespasser	RME	$9x10^{-5}$	$3x10^{0}$
		CT	$2x10^{-5}$	$3x10^{0}$
	Surveillance Worker	RME	$7x10^{-5}$	$3x10^{0}$
		CT	$3x10^{-6}$	$3x10^{-1}$
	Industrial Worker	RME	$2x10^{-4}$	$9x10^{0}$
		CT	$5x10^{-5}$	$7x10^{0}$
	Construction Worker	RME	$5x10^{-5}$	$5x10^{1}$
		CT	$3x10^{-5}$	$4x10^{1}$
	Utility Worker	RME	$2x10^{-5}$	$3x10^{1}$

Table 7.2. *Summary of future RME and CT standard cancer risks and hazard indexes*.

Exposure Area	Receptor	RME or CT	Cancer Risk	HI
		CT	$2x10^{-5}$	$2x10^{1}$
Former Chlorination Building (FCB)	Adolescent Trespasser	RME	$4x10^{-4}$	$2x10^{1}$
		CT	$3x10^{-4}$	$1x10^{1}$
	Adult Trespasser	RME	$7x10^{-4}$	$1x10^{1}$
		CT	$1x10^{-4}$	$6x10^{0}$
	Surveillance Worker	RME	$5x10^{-4}$	$1x10^{1}$
		CT	$2x10^{-5}$	$1x10^{0}$
Former Chlorination Building (FCB) cont.	Industrial Worker	RME	$2x10^{-3}$	$3x10^{1}$
		CT	$4x10^{-4}$	$2x10^{1}$
	Construction Worker	RME	$8x10^{-4}$	$4x10^{2}$
		CT	$7x10^{-4}$	$3x10^{2}$
	Utility Worker	RME	$7x10^{-4}$	$3x10^{2}$
		CT	$6x10^{-4}$	$3x10^{2}$
Southwest Off-Site/Outfall 006 Exposure Area	Adolescent Trespasser	RME	$3x10^{-5}$	$3x10^{0}$
		CT	$2x10^{-5}$	$2x10^{0}$
	Adult Trespasser	RME	$4x10^{-5}$	$1x10^{0}$
		CT	$6x10^{-6}$	$7x10^{-1}$
	Industrial Worker	RME	$9x10^{-5}$	$4x10^{0}$
		CT	$1x10^{-5}$	$2x10^{0}$
	Construction Worker	RME	$2x10^{-4}$	$8x10^{1}$
		CT	$9x10^{-5}$	$4x10^{1}$
State Fair Blvd/ Northwest Off-Site/ Outfall 004 Exposure Area	Adolescent Trespasser	RME	$4x10^{-6}$	$4x10^{-1}$
		CT	$3x10^{-6}$	$3x10^{-1}$
	Adult Trespasser	RME	$6x10^{-6}$	$2x10^{-1}$
		CT	$1x10^{-6}$	$1x10^{-1}$
	Adult Transient	RME	$6x10^{-7}$	$7x10^{-2}$
		CT	$8x10^{-8}$	$9x10^{-3}$
	Utility Worker	RME	$2x10^{-6}$	$1x10^{0}$
		CT	$1x10^{-6}$	$1x10^{0}$
Lakeshore Area	Adolescent Trespasser	RME	$3x10^{-5}$	$2x10^{-1}$
		CT	$1x10^{-5}$	$1x10^{-1}$
	Adult Trespasser	RME	$2x10^{-5}$	$6x10^{-2}$
		CT	$3x10^{-6}$	$5x10^{-2}$
	Utility Worker	RME	$4x10^{-5}$	$1x10^{1}$
		CT	$3x10^{-5}$	$1x10^{1}$

Table 7.2. *Summary of future RME and CT standard cancer risks and hazard indexes*.

Exposure Area	Receptor	RME or CT	Cancer Risk	HI
Petroleum Storage Area	Adolescent Trespasser	RME	$3x10^{-5}$	$1x10^{-1}$
		CT	$1x10^{-5}$	$9x10^{-2}$
	Adult Trespasser	RME	$2x10^{-5}$	$6x10^{-2}$
		CT	$3x10^{-6}$	$4x10^{-2}$
	Industrial Worker	RME	$5x10^{-5}$	$2x10^{-1}$
		CT	$8x10^{-6}$	$1x10^{-1}$
	Construction Worker	RME	$9x10^{-6}$	$8x10^{0}$
Petroleum Storage Area cont.	Construction Worker	CT	$7x10^{-6}$	$5x10^{0}$
	Utility Worker	RME	$5x10^{-6}$	$1x10^{0}$
		CT	$4x10^{-6}$	$1x10^{0}$
Chlorobenzene Hot-Spot Area	Adolescent Trespasser	RME	$5x10^{-5}$	$4x10^{0}$
		CT	$2x10^{-5}$	$2x10^{0}$
	Adult Trespasser	RME	$7x10^{-5}$	$3x10^{0}$
		CT	$9x10^{-6}$	$1x10^{0}$
	Industrial Worker	RME	$1x10^{-4}$	$6x10^{0}$
		CT	$2x10^{-5}$	$2x10^{0}$
	Construction Worker	RME	$3x10^{-5}$	$1x10^{1}$
		CT	$2x10^{-5}$	$1x10^{1}$
	Utility Worker	RME	$1x10^{-5}$	$1x10^{1}$
		CT	$9x10^{-6}$	$7x10^{0}$
Tributary 5A	Adolescent Trespasser	RME	$3x10^{-5}$	$2x10^{0}$
		CT	$2x10^{-5}$	$1x10^{0}$
	Adult Trespasser	RME	$5x10^{-5}$	$9x10^{-1}$
		CT	$8x10^{-6}$	$6x10^{-1}$
	Utility Worker	RME	$4x10^{-6}$	$7x10^{0}$
		CT	$4x10^{-6}$	$6x10^{0}$
Potable Water	Child Resident (< 6 years)	RME	$7x10^{-3}$	$4x10^{2}$
		CT	$7x10^{-3}$	$4x10^{2}$
	Adult Resident	RME	$1x10^{-2}$	$2x10^{2}$
		CT	$4x10^{-3}$	$2x10^{2}$

8. Uncertainty Assessment

The risk measures used in this HHRA are not precise, deterministic estimates of risk, but conditional estimates controlled by a considerable number of consecutive upper-bound assumptions regarding exposure and toxicity. They are designed to estimate an upper bound of the potential health risk value, as opposed to present a precise and realistic estimate of actual health risks. This is done by convention, consistent with USEPA protocols. The main sources of uncertainty relative to the assumptions, results, and conclusions of the HHRA are:

- estimation of chemical concentrations,
- estimation of exposure point concentrations,
- evaluation of exposure scenarios,
- estimation of toxicity values, and
- calculation of quantitative risk estimates.

Uncertainties related to these sources are discussed below.

8.1. Estimation of Chemical Concentrations

The data were validated as described in Appendix A of the RI report. Some data were qualified as "J" values, indicating that the reported concentrations were "estimated" values. However, the uncertainty in the reported concentrations was within acceptable levels as specified in the Site-specific Quality Assurance Project Plan (QAPP). As such, the analytical data is representative of the chemical concentrations in Site media. Analytical data that were qualified as rejected, “R,” were not utilized in the HHRA.

8.1.1. Mercury Speciation

Mercury can be present in the environment in organic and inorganic forms, with the organic forms exhibiting greater toxicity to nearly all receptors (ATSDR 1999). The toxic effects of the organic form of mercury, methyl mercury, are most pronounced following exposure because of its high bioavailability and minimal attenuation in tissue. Neither form of mercury is classified as carcinogenic; however, non-cancer hazards can be estimated for each of these compounds via application of the appropriate toxicity data (oral Rfd, dermal Rfd, inhalation Rfc), which vary depending on the type of mercury.

To perform a hazard assessment of mercury, the concentrations of each form of mercury in environmental media must be known. However, laboratory sample analysis did not include mercury speciation for all Exposure Areas or media. In cases where mercury was speciated, conservative health hazard estimates were made for each of these compounds (mercury and methyl mercury). Where data was only available for total mercury, health hazard estimates were completed exclusively for elemental mercury.

Evaluation of mercury health hazards posed to an individual by assessing only the less toxic form of mercury may decrease the conservativeness of the hazard estimate. Consequently, there is a certain amount of uncertainty inherent in the evaluation since it is possible that some fraction of the total mercury is the more bioavailable and toxic form, methyl mercury. To account for potential underestimation of health hazards associated with exposure to unspeciated mercury, a sensitivity analysis was completed.

This sensitivity analysis was completed by developing a ratio of methyl mercury to mercury for all locations where speciated data was available. Table 8.1 presents the Exposure Areas and media where speciated data was both available and unavailable.

Table 8.1. *Prevalence of mercury speciation at the Willis Avenue Site*.

Speciated Mercury		Unspeciated Mercury	
Exposure Area	**Media**	**Exposure Area**	**Media**
Plant Area	Surface Soil, Upper Soil, Intermediate Soil	Plant Area	Intermediate Groundwater
Former Chlorination Building	Surface Soil, Upper Soil, Intermediate Soil		
On-Site Ditches	Surface Soil, Intermediate Soil, Upper Soil	Northwest Off-Site/Outfall 004	Surface Soil, Upper Soil
Southwest Off-Site/Outfall 006	Surface Soil, Upper Soil	Lakeshore Area	Surface Soil, Upper Soil, Shallow Groundwater
Tributary 5A	Sediment, Surface Water	Petroleum Storage Area	Shallow Groundwater
Petroleum Storage Area	Surface Soil, Upper Soil	Chlorobenzene Hot-Spot Area	Shallow Groundwater
Chlorobenzene Hot-Spot Area	Surface Soil, Upper Soil	Site Wide Groundwater Exposure Area	Groundwater – All Depths

Methyl mercury to total mercury ratios were developed based on the average ratio of detected concentrations of these compounds at each sample location within an exposure area. Table 8.2 presents the ratios developed for each Exposure Area and the Exposure Areas to which the ratios will be applied.

Table 8.2. *Methyl mercury to total mercury ratios developed for Exposure Areas and media.*

Exposure Area	Media	Ratio	Applied to Exposure Area:	Rationale
Plant Area	Surface Soil	0.0026	Lakeshore Area – Surface Soil	Close proximity, identical depth
	Upper Soil	0.0026	Lakeshore Area – Upper Soil	Close proximity, identical depth
	Intermediate Soil	0.0026	None	Application to Plant Area groundwater not appropriate
Former Chlorination Building (FCB)	Surface Soil	0.0028	None	Application to FCB groundwater not appropriate
	Upper Soil	0.0028		
	Intermediate Soil	0.0028		
On-Site Ditches	Surface Soil	0.00014	NW Off-Site/ Outfall 004 Exposure Area- Surface Soil and Upper Soil	Same Exposure Area / Close proximity and identical depth
	Intermediate Soil	0.00014		
	Upper Soil	0.00014		
Southwest Off-Site/Outfall 006 Exposure Area	Surface Soil	0.00020	None	None required
	Upper Soil	0.00020	None	None required
Tributary 5A	Sediment	0.023	None	No other location with sediment
Petroleum Storage Area	Surface Soil	0.00024	None	Application to CHSA groundwater not appropriate
	Upper Soil	0.00024	None	
Chlorobenzene Hot-Spot Area (CHSA)	Surface Soil	0.0033	None	Application to CHSA groundwater not appropriate
	Upper Soil	0.0033		

New hazard quotients were found by applying the methyl mercury ratio to the total mercury exposure point concentration for each receptor, media, and Exposure Area (exposure scenario). Similarly, the inverse of the methyl mercury ratio was applied to the total mercury exposure point concentration to calculate the remaining portion that is elemental mercury. New exposure point concentrations were used to calculate chronic daily intakes for each exposure scenario. The hazard quotients for each form of mercury were then determined by dividing the newly calculated chronic daily intake by the appropriate RfD. The hazard quotients for mercury and methyl mercury were then added together for each exposure scenario to obtain a hazard index.

Table 8.3. *Original total mercury and new ratio based methyl mercury hazard estimates*.

Exposure Area	Media	Receptor	Pathway	Original Mercury Hazard Quotient (RME)	Ratio Applied	Calculated Mercury Hazard Quotient (RME)	Calculated Methyl Mercury Hazard Quotient (RME)	Calculated Mercury and Methyl Mercury Hazard (RME)	New HI greater than 1.0 (Y/N)
Northwest Off-Site/Outfall 004 Exposure Area	Surface Soil	Adolescent Trespasser	Ingestion	1.36E-01	0.00014	1.36E-01	5.73E-05	1.36E-01	N
			Dermal	NA	NA	NA	NA	NA	NA
		Adult Trespasser	Ingestion	4.38E-02	0.00014	4.38E-02	1.84E-05	4.38E-02	N
			Dermal	NA	NA	NA	NA	NA	NA
		Adult Transient	Ingestion	2.92E-02	0.00014	2.92E-02	1.23E-05	2.92E-02	N
			Dermal	NA	NA	NA	NA	NA	NA
	Upper Soil	Utility Worker	Ingestion	3.71E-01	0.00014	3.71E-01	1.56E-04	3.71E-01	N
			Dermal	NA	NA	NA	NA	NA	NA
Lakeshore Area	Surface Soil	Adolescent Trespasser	Ingestion	2.60E-03	0.0026	2.60E-03	2.03E-05	2.62E-03	N
			Dermal	NA	NA	NA	NA	NA	NA
		Adult Trespasser	Ingestion	8.37E-04	0.0026	8.35E-04	6.53E-06	8.41E-04	N
			Dermal	NA	NA	NA	NA	NA	NA
	Upper Soil	Utility Worker	Ingestion	9.86E-03	0.0026	9.84E-03	7.69E-05	9.91E-03	N
			Dermal	NA	NA	NA	NA	NA	NA

As shown in Table 7, there is a nominal difference between the hazard quotient for total mercury and the combined hazard index for mercury and methyl mercury. Additionally, no total mercury, elemental mercury, or methyl mercury hazard quotient exceeds 1.0. The reason for such a nominal difference after applying the methyl mercury ratio is twofold. First, the ratios of methyl mercury to mercury were found to be extremely small, meaning only a small fraction of each sample is the more toxic methyl mercury. Second, the oral RfD for methyl mercury was not markedly lower than that of mercury (0.0001 mg/kg-day for methyl mercury and 0.0003 mg/kg-day for mercury). The dermal RfD shows a greater difference for mercury (0.000021 mg/kg-day) and methyl mercury (0.0001 mg/kg-day); however, since no dermal absorption factor exists for mercury or methyl mercury dermal exposure was not applicable. The end result of these contributing factors was a minor difference in unspeciated mercury and speciated mercury hazard indices.

Considering that the methyl mercury concentrations were estimated based on ratios of methyl mercury to mercury in other samples, there is a degree of uncertainty associated with this assessment. However, the uncertainty does not affect the outcome of this risk assessment as none of the newly calculated hazard quotients for mercury or methyl mercury approach an unacceptable level. By comparison, even in the most conservative and unreasonable scenario, assuming that all of the mercury at the areas where mercury was not speciated is assumed to be methyl mercury, then only

one exposure scenario would result in an unacceptable hazard quotient. The Northwest Off-Site/Outfall 004 Utility Worker exposed to upper soil through ingestion would have a hazard quotient of 1.11 if all of the mercury in that Exposure Area were methyl mercury, which is nominally above what is considered acceptable (1.0). This assumption is both highly conservative and highly unlikely and it is therefore concluded that a lack of speciated mercury samples at some Exposure Areas did not alter the conclusions of this risk assessment.

8.2. Calculation of Exposure Point Concentrations

8.2.1. General

Conservative judgments were applied in calculating RME exposure point concentrations. Depending on the Exposure Area and COPC, maximum detected concentrations or UCLs were used as exposure point concentrations (EPC). As such, it is highly unlikely that the estimated EPCs underestimate representative concentrations in the Site media.

In addition, as noted in the text, the maximum detected concentration was applied as a default value if there were less than five detects. This was done as a conservative measure, since there was insufficient number of samples to assess the shape of the underlying distribution.

ProUCL statistical software package (Version 4.0; USEPA 2007b) was used to examine the data distribution and develop an upper confidence level (UCL) on the arithmetic mean. ProUCL was run using Regression on Order Statistics (ROS), which is a method for accounting for non-detect samples in the data set. ROS infers values for non-detect samples based on the distribution of detected data. ProUCL recommends the most appropriate UCL to use given the distribution type. The UCL recommended by ProUCL was subsequently applied as the EPC. The ProUCL output is presented in Appendix K.

Data Temporal Distribution

Analytical data has been collected from various media since January of 1991 in order to support various phases of investigation at the Site. The majority of data collection efforts occurred in two distinct time periods (1991/1992 and 1997/1998). The histogram presented below depicts the number of sample locations sampled for each year of data utilized in this assessment. Data collected during this time period reflected initial investigatory efforts (early 1990s) and significant additional sampling to support remedial investigation efforts (late 1990s).

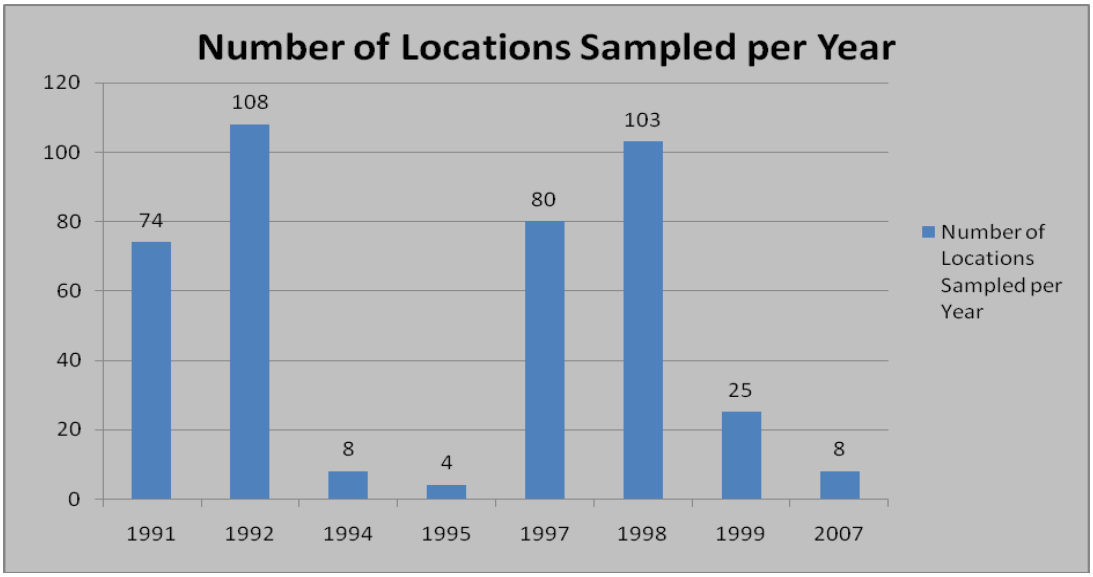

Figure 8.1. *Historical sampling frequency*.

All of the data utilized in this and other assessments were validated in accordance with USEPA specified guidelines. Data validation involves the reconstruction of the analytical process and an evaluation of whether the analysis has been performed correctly. The data validation process was used to determine which data was considered usable in quantitative and qualitative evaluations. For the purposes of this report, data that was qualified as rejected "R" or that was a quality control sample were not utilized in this assessment.

A Data Usability Assessment was also completed in accordance with the Data Quality Objectives specified for the Site. Among other parameters, the Data Usability Assessment evaluated the representativeness of the data which is a measure of whether the collective data represent actual conditions at the Site. The data was confirmed to be representative of Site conditions.

The historical nature of the dataset is still considered to reflect actual Site conditions because constituent concentrations are not expected to increase over time and are actually likely to attenuate. Therefore, the dataset, in its entirety, is legitimately utilized in this HHRA. It is important to note that this HHRA has been an iterative process as the initial version of the report was developed in 2002 as an Appendix (L) to the Remedial Investigation Report. Subsequent revisions to this document include one in 2004 and this revision. The temporal distribution of the data is not expected to affect the overall interpretation of potential human health risk posed by the Site to selected receptors.

8.2.2. Indoor Air Exposures for Future Industrial Workers

As part of the HHRA, the future migration of volatile constituents in groundwater to the indoor air of future On-Site industrial buildings was evaluated. Groundwater concentrations were compared to screening levels, but a quantitative risk was not calculated.

8.2.3. Inhalation Exposures for Future Construction Workers

As discussed in Sec 5.4.4, PEF is used to calculate the constituent concentration in fugitive dust. For this Report, a single PEF value for the construction worker was calculated on the basis of total Site area ("Site-wide PEF"). This section presents a sensitivity analysis to determine the influence of using this single Site-wide PEF versus using a separate PEF for each Exposure Area with a construction worker receptor. The figure below presents the Site-wide PEF and the PEF for individual Exposure Areas as a function of area. For the PEF calculation, each Exposure Area is assumed to be in the shape of a square of the area shown on the X-axis in the figure below. It is further assumed that a road of 6.1m width bisects the exposure point area and thereby entrains particulate matter in the air immediately above it, which is subject to inhalation by a receptor at the exposure point.

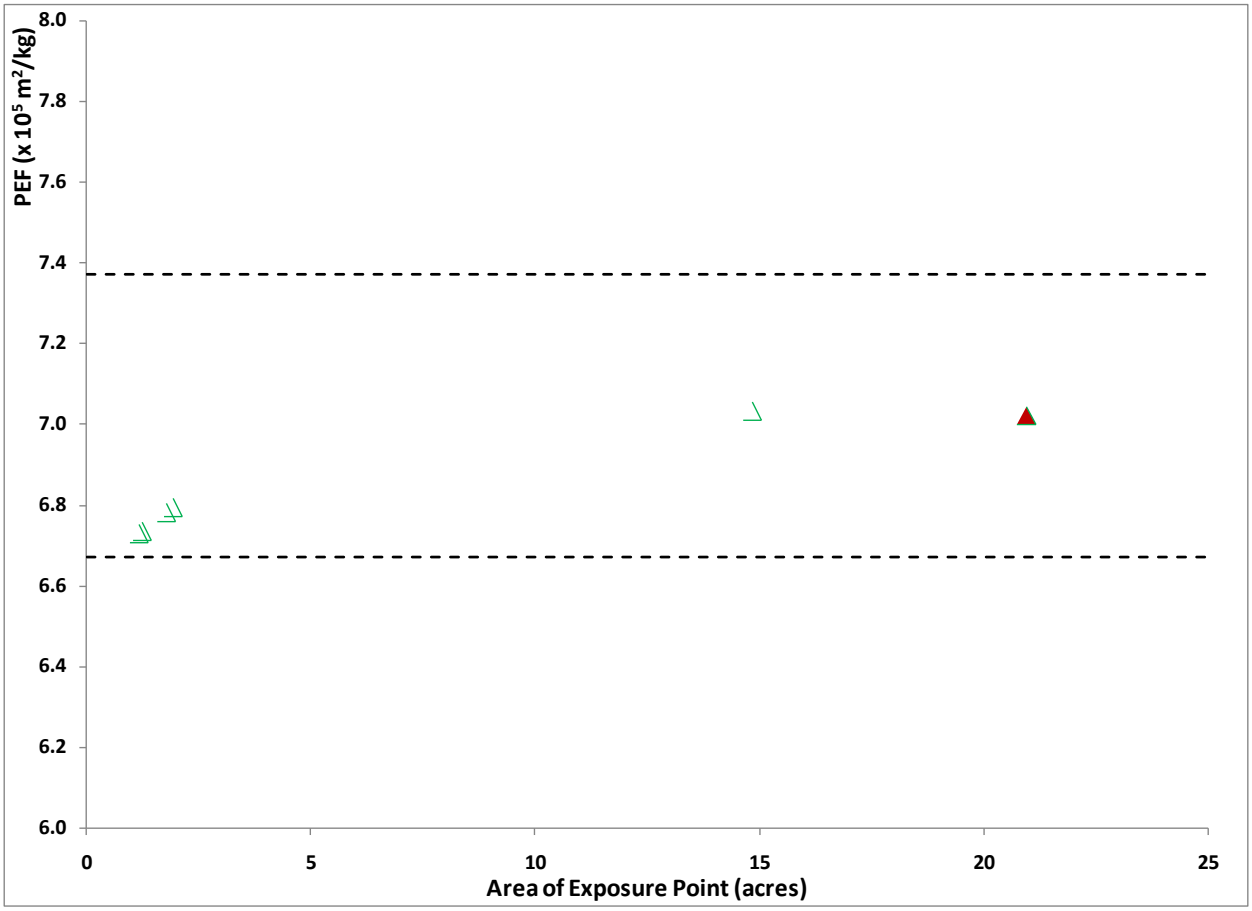

Figure 8.2. *Exposure area and Site-wide PEF values as a function of area.*

The unfilled triangles represent the calculated PEFs for the various exposure points within the Site (with the exception of the On-Site Ditches), while the red filled triangle represents the calculated PEF using total Site area, ("Site-wide PEF"). The dotted lines represent the ±5% range around the red filled triangle. The PEFs are of the order of 7×10^5 for the exposure points shown in the figure, and are within 5% of the Site-Wide PEF. The one exception to this trend is the calculated PEF for the On-Site Ditches (not shown), which has a value of $\sim2\times10^8$. The figure below presents the area (orange squares) and PEF value (blue bars) for each Exposure Area and the Site-Wide PEF.

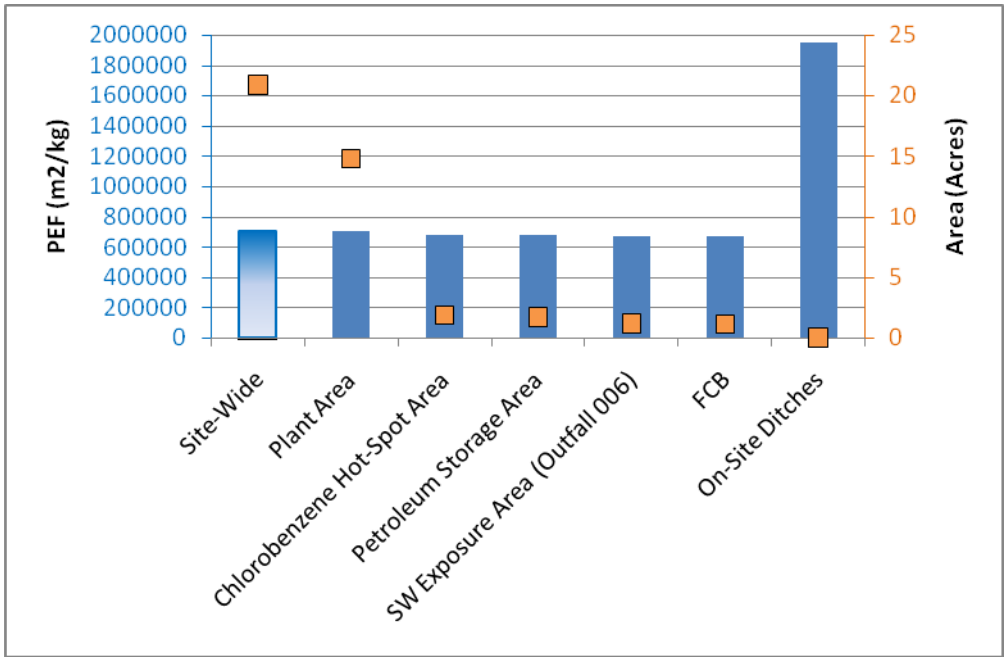

Figure 8.3. *Comparison of Site-wide and individual exposure area PEF values.*

While the PEF for the On-Site Ditches differs from the Site-Wide value, it is important to note that the ditches are long narrow trenches and would ordinarily not have a roadway bisecting them. Furthermore, the total area of the On-Site Ditches is 0.04 acres; a hypothetical road 6.1 m wide running the entire length of the ditch would occupy approximately 0.02 acres, or 50% of the exposure point area itself. These two factors suggest that it is highly unlikely that a road would be constructed through the On-Site Ditches, and any calculated result for the PEF would therefore be implausible and can be removed from the analysis.

Therefore, as seen in the figures above, the remaining PEF values for the individual Exposure Areas all lie within 5% of the Site-wide PEF, and we conclude that the Site-wide PEF reasonably captures the concentration of constituents in fugitive dust for the inhalation pathway for the construction worker.

8.3. Toxicity Values

8.3.1. General

A general discussion of the uncertainties and conservatism inherent in the USEPA approach for deriving RfDs and cancer slope factors has been presented in Section 6 of the HHRA and is briefly summarized below.

Reference Doses (RfDs) - For some chemicals, RfDs are derived directly from data on human exposures. Such data includes occupational exposures that are known to have no adverse effects, normal dietary levels of certain chemicals, therapeutic doses of certain chemicals, and epidemiological data relating to populations with background exposures. For most chemicals, USEPA derives RfDs based on laboratory studies in which experimental animals were exposed to different concentrations of a chemical, and a NOAEL is estimated. If data from several animal studies are available, USEPA seeks to identify the species that is most comparable to humans based on knowledge of specific biologic properties. If adequate comparative data is not available, USEPA selects the study on the most sensitive animal species as the critical study for the basis of the NOAEL. The NOAEL is then used to derive a RfD for potential adverse effects in human populations.

RfD Uncertainty Factors - In most cases, there is considerable uncertainty regarding the extension of toxicological data from animal studies to humans. In other words, the actual RfD for humans or sensitive sub-populations of humans would not be precisely known based on data in animal species. This uncertainty arises because there may be differences between the animal and human species regarding factors such as the metabolism of the chemical, the distribution and clearance rate of the chemical from the body, and the sensitivity of specific organ systems to the chemical. Therefore, the USEPA derives RfDs that are designed to be protective of the public at large, *including sensitive sub-populations*. The USEPA applies a series of "uncertainty" factors to calculate the final RfD values. Depending on the data, the NOAEL may be divided by an uncertainty factor ranging from 1 to 10,000. For human data, in most cases, the uncertainty factor of 10 is applied for the application of data from the public at large to sensitive sub-populations. For animal data a typical uncertainty factor of 100 (10 for sensitive sub-population and 10 for animal-human extrapolation) is applied for deriving the human RfD.

Cancer Slope Factors - Additional uncertainty arises from the USEPA use of the linearized multi-stage model for estimating the cancer slope factor. The linearized multi-stage model is one mathematical model, which may describe the carcinogenic process. The model assumes that at low doses, there is a linear relationship between the dose of a chemical and the excess cancer risk. In addition, the model assumes that there is no threshold dose for the induction of cancer. However, there are many instances in which this assumption may not hold true for the carcinogenic process. Examples of such effects are chemicals that cause an increased high dose cancer incidence due to stimulated cell proliferation rates (Cohen and Ellwein 1990; Ames and Gold 1990), chemicals for which metabolic parameters limit the delivered dose to the target organ (Zeise and Wilson 1986), promoters, or in instances where DNA repair mechanisms may be dose dependent (Zeise and Wilson 1986). In these instances, the linearized multi-stage model may provide a "plausible upper limit" of potential cancer risk (51 FR 33992). However, as acknowledged by USEPA (51 FR 33992), "such an estimate does not necessarily give a realistic prediction of the risk. The true value of the risk is unknown, and may be as low as zero."

8.3.2. Uncertainty of TCDD Equivalents

The toxicity equivalency factor (TEF) scheme compares the relative toxicity of individual dioxin-like compounds to that of TCDD, which is the most toxic congener. The toxicity equivalent (TEQ) is calculated by multiplying the exposure level of a particular dioxin-like compound by its TEF. The sum of each dioxin/furan toxicity equivalent at a given location equals the total sample TEQ.

Dioxin TEQs were a contributor to risk estimates calculated and presented in this HHRA. However, there is considerable uncertainty as to the potential carcinogenic and non-cancer chronic impacts of

TEQs to humans. Given this uncertainty, and the application of the TEF approach, which assumes 2,3,7,8-TCDD-like activity to the range of PCDD/F congeners, there is a high likelihood that the actual human health risks associated with the detection of PCDD/Fs at the site are lower than the estimates presented in this HHRA.

The 2,3,7,8-TCDD is considered to be the most potent of the PCDD/F compounds with respect to potential toxic effects. 2,3,7,8- TCDD may induce a wide range of toxic effects in laboratory animals including effects on the liver, sex hormone balance, immune system, and *in utero* development (ATSDR 1998). In addition, 2,3,7,8-TCDD has been shown to induce cancer in laboratory animals at relatively low administered doses (USEPA 1992d). There may be considerable variability in the toxic potency of 2,3,7,8-TCDD depending on the test animal species and toxic effect being considered (ATSDR 1998). Guinea pigs are generally the most dioxin-sensitive mammalian species. By comparison, the hamster may be 5,000 to 10,000 times more resistant in similar toxicity tests.

Very few of the toxic effects of 2,3,7,8-TCDD observed in animal species have been reported in exposed human populations (USEPA 1992d). The only toxic effect that has been definitively associated with TCDD exposure in human populations is chloracne (an acne-like skin condition) in heavily exposed individuals (USEPA 1992d). Numerous studies and health surveys of human populations exposed to relatively high levels of TCDD have failed to detect a clear association between TCDD exposure and the adverse health effects reported in laboratory animal studies (USEPA 1992d). However, certain studies of occupationally exposed workers in the United States (Fingerhut *et al*. 1991) and Germany (Manz *et al.* 1991) have reported a possible increase in lung cancer and thyroid cancer rates in occupationally exposed workers. A significant reduction in breast cancer rates was observed in women living in Seveso, Italy, which was the Site of a large dioxin release in July 1976 (Bertazzi *et al*. 1993). This observation is consistent with a similar reduction in mammary tumor risk in laboratory animals.

The IRIS database does not contain a weight-of-evidence cancer classification for 2,3,7,8-TCDD. The USEPA is currently re-evaluating the risks and hazards from exposures to PCDD/Fs. In its proposed rule to add a chemical category that includes dioxin and dioxin-like compounds to the list of toxic chemicals subject to release reporting requirements, the USEPA acknowledged that existing data shows "2,3,7,8-TCDD is a potent toxicant in animals and has the potential to produce a wide spectrum of toxic effects in humans" (USEPA 1997b). In the preamble of the rule, the USEPA further states that "available human data cannot clearly demonstrate whether a cause and effect relationship exists between 2,3,7,8-TCDD exposure and increased incidence of cancer.

There is little direct evidence regarding the toxic effects and potency PCDD/F compounds other than 2,3,7,8-TCDD. As a conservative assumption, USEPA and other regulatory agencies assume that other PCDD/F compounds may induce the same toxic effects as TCDD, though they are likely to be less potent than TCDD (USEPA 1989b). It is recognized that chlorination at the 2,3,7,8 positions is required for a PCDD/F compound to potentially exert toxic effects (USEPA 1989b). Therefore, in order to evaluate the toxic potential of PCDD/F mixtures, Van den Berg et al. (2006) publishes a TEF for each PCDD/F compound. The TEFs are based on observed structure activity relationships for PCDD/F compounds, receptor binding affinity or enzyme induction. The TEF approach assumes that receptor binding is necessary (but not exclusive) for biological activity of PCDD/F compounds and the affinity of a given PCDD/F congener to the receptor reflects the relative biologic potency of a given congener. However, it is important to recognize a given toxic response in a biological organism probably involves many physiologic events other than receptor activation. As such, it is

reasonable to assume that the congener-specific relative toxic potency may not be the same as the relative receptor affinity. In fact, given the diverse mechanisms for different toxic responses, it is reasonable to assume that the relative potencies may be different for different toxicological endpoints.

As of the revision of this HHRA, the IRIS database did not contain a CSF or RfD for PCDD/Fs. The NYSDEC requested that a qualitative discussion of non-cancer PCDD/F exposures be presented in the uncertainty section, with references to advisory levels prepared by the ATSDR (or other agencies). The following information appears in the ATSDR toxicological profile on PCDD/Fs (ATSDR 1998) as compiled and referenced in the ATSDR Toxicological Profiles (on CD; ATSDR 2003).

It is the ATSDR's policy to use health guidance values (*i.e.*, Minimal Response Levels and Environmental Media Evaluation Guides) derived for 2,3,7,8-TCDD for other dioxin-like compounds as total TEQs. The ATSDR has derived an acute-duration oral minimal response level (MRL) of 0.0002 μg/day (2×10^{-4} μg/kg/day) for 2,3,7,8-TCDD based on its ability to suppress serum total hemolytic complement activity in $B6C3F_1$ mice (White *et al*. 1986). An intermediate-duration oral MRL of 0.00002 μg/day (2×10^{-5} μg/kg/day) was derived based on observed decreases in thymus weight in guinea pigs (Decaprio *et al*. 1986). A chronic-duration oral MRL of 0.000001 μg/day (1×10^{-6} μg/kg/day) was derived for 2,3,7,8-TCDD based on altered social interaction with peers in monkeys exposed to 2,3,7,8-TCDD prenatally and during lactation (Schantz *et al*. 1992). Neither a reference concentration (RfC) nor a RfD is listed in IRIS (USEPA 2004c) for any of the PCDD/Fs.

To further examine the exposure to dioxins on the Site, dioxin equivalents were compared to the ATSDR Minimal Risk Level (MRL) for 2,3,7,8-TCDD. The MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancer health effects over a specified duration of exposure (ATSDR 1998). These substance specific estimates, which are intended to serve as screening levels, are used by ATSDR health assessors and other responders to identify contaminants and potential health effects that may be of concern at hazardous waste sites (ATSDR 1998).

ATSDR uses the no observed adverse effect level/uncertainty factor (NOAEL/UF) approach to derive MRLs for hazardous substances. MRLs, based on non-cancer health effects only, are presented in units of μg/mg/day. MRLs are derived for the acute (1 to 14 days), intermediate (>14 to 364 days), and chronic (365 days and longer) exposure durations. The table below presents the TEQ values which represent the maximum sample TEQ of the cohort of samples for a particular Exposure Area and media. All Exposure Area TEQs exceeded acute, intermediate, and chronic ATSDR MRL values.

Table 8.4. *Exposure Area TEQ Comparison to ATSDR MRLs. "X" designates an exceedance.*

Exposure Area	Medium	Exposure Area TEQ (mg/kg)	ATSDR Acute MRL (2,3,7,8-TCDD) **2.0E-07** (mg/kg/day)	ATSDR Intermediate MRL (2,3,7,8-TCDD) **2.0E-08** (mg/kg/day)	ATSDR Chronic MRL (2,3,7,8-TCDD) **1.0E-09** (mg/kg/day)
Plant Area	Surface Soil	$2.09x10^{-3}$	X	X	X
Plant Area	Upper Soil	$2.09x10^{-3}$	X	X	X
Plant Area	Intermediate Soil	$2.09x10^{-3}$	X	X	X
Former Chlorination Building	Surface Soil	$2.23x10^{-1}$	X	X	X
Former Chlorination Building	Upper Soil	$2.52x10^{-1}$	X	X	X
Former Chlorination Building	Intermediate Soil	$2.52x10^{-1}$	X	X	X
On-Site Ditches	Surface Soil	$7.54x10^{-3}$	X	X	X
On-Site Ditches	Upper Soil	$7.54x10^{-3}$	X	X	X
On-Site Ditches	Intermediate Soil	$7.54x10^{-3}$	X	X	X
Southwest Offsite/Outfall 006	Surface Soil	$6.96x10^{-4}$	X	X	X
Southwest Offsite/Outfall 006	Upper Soil	$6.96x10^{-4}$	X	X	X
Northwest Offsite/Outfall 004 Area	Surface Soil	$5.28x10^{-4}$	X	X	X
Northwest Offsite/Outfall 004 Area	Upper Soil	$5.28x10^{-4}$	X	X	X
Lakeshore Area	Surface Soil	$7.62x10^{-5}$	X	X	X
Lakeshore Area	Upper Soil	$7.62x10-^{5}$	X	X	X
Tributary 5A	Sediment	$2.66x10^{-5}$	X	X	X

ATSDR recommends a decision matrix approach to aid in drawing conclusions about the public health implication of certain compounds. This approach is based on the use of a decision framework that compares Site-specific TEQ concentrations to ranges of values to which a particular action is assigned. The ranges are identified as screening level range (< 50 ppt), evaluation level range (> 50 ppt but < 1 ppb), and action level range (>1 ppb). Depending on how a particular TEQ compares to these values, one of three response decisions may be concluded. If the Exposure Area TEQ is below or equal to 50 parts per trillion, no further evaluation is required. Second, should the TEQ fall within the evaluation level range, evaluation of Site-specific factors is recommended. Site specific factors that may be evaluated include bioavailability, ingestion rates, pathway analysis, soil cover, climate, other constituents, community concerns, demographics, and background exposures. Thirdly, an Exposure Area TEQ that is greater than or equal to 1 part per billion is within the action level range, which may trigger the potential consideration of public health actions. Examples of public health actions may include surveillance, research, health studies, community education, and exposure investigations.

Table 8.5. *Dioxin TEQ decisions matrix screening*.

RAGS Table	Exposure Area	Medium	Location TEQ (mg/kg)	Screening Level Range (<0.00005 mg/kg)	Evaluation Level Range (0.00005 mg/kg – 0.001 mg/kg)	Action Level Range (> 0.001 mg/kg)
2.1	Plant Area	Surface Soil	$2.09x10^{-3}$			X
2.2	Plant Area	Upper Soil	$2.09x10^{-3}$			X
2.3	Plant Area	Intermediate Soil	$2.09x10^{-3}$			X
2.6	Former Chlorination Building	Surface Soil	$2.23x10^{-1}$			X
2.7	Former Chlorination Building	Upper Soil	$2.52x10^{-1}$			X
2.8	Former Chlorination Building	Intermediate Soil	$2.52x10^{-1}$			X
2.9	On-site Ditches	Surface Soil	$7.54x10^{-3}$			X
2.10	On-site Ditches	Upper Soil	$7.54x10^{-3}$			X
2.11	On-site Ditches	Intermediate Soil	$7.54x10^{-3}$			X
2.12	Southwest Offsite/ Outfall 006	Surface Soil	$6.96x10^{-4}$		X	
2.13	Southwest Offsite/ Outfall 006	Upper Soil	$6.96x10^{-4}$		X	
2.14	Northwest Offsite/ Outfall 004 Area	Surface Soil	$5.28x10^{-4}$		X	
2.15	Northwest Offsite/ Outfall 004 Area	Upper Soil	$5.28x10^{-4}$		X	
2.16	Lakeshore Area	Surface Soil	$7.62x10^{-5}$		X	
2.17	Lakeshore Area	Upper Soil	$7.62x10^{-5}$		X	
2.19	Tributary 5A	Sediment	$2.66x10^{-5}$	X		

The decision matrix described above was applied to the Exposure Area TEQs developed for this Site and is presented in Table 8. One Exposure Area TEQ (Tributary 5A, sediment), was below the screening action level. Six Exposure Area TEQs were within the evaluation level range indicating that Site-specific conditions should be considered in decision making. The TEQs within this range are for surface soil and upper soil of the Southwest Offsite/Outfall 006, Northwest Offsite/Outfall 004, and the Lakeshore Area. Nine Exposure Area TEQs were within the action level range of the decision matrix which represents the dioxin equivalent concentrations present in surface soil, upper soil, and intermediate soil for the Plant Area, Former Chlorination Building, and On-Site Ditches.

Although some of the Exposure Area TEQ fall within the action level range of the ATSDR decision matrix, current and expected use of the site along with anticipated remedial action renders specific dioxin-related action unwarranted. Further, RME non-cancer hazard results indicate that many 2,3,7,8-TCDD hazard quotients are within below one. Those HQ that are not below one generally exceed one by less than one order of magnitude. Although the ATSDR action level can reflect, in certain instances, a concentration of dioxin TEQ at which consideration of action to interdict/prevent exposure occurs, a site-specific evaluation may indicate that none of these actions may be necessary.

8.3.3. Lead in Drinking Water

Groundwater data from all available depths was used to evaluate a potable use scenario for the adult and child resident at the Site. The maximum concentration of lead in groundwater is high and well above EPA's action level of 15 µg/L. The lack of cancer or non-cancer toxicity data precludes the

development of risk or hazard estimates. However, for the child resident, exposure to lead in drinking water has been evaluated using the IEUBK model.

This pathway has been evaluated because the current use designation for this aquifer is as a potable water supply and the National Contingency Plan states the groundwater must be returned to its most beneficial use. The Site is zoned as industrial and is unlikely to be developed as a residential area. Therefore, residential use of the Site is highly unlikely. Municipal water currently supplies existing buildings and facilities with potable water and therefore Site groundwater is not used as a potable water source. Because the affected nature of the groundwater is known, potable water wells are not likely be drilled or authorized in the future.

A change in zoning from industrial to residential is more likely than the use of groundwater as a potable water supply. Any residential or other structure built on the Site in the future will undoubted be connected to municipal water supply. It may be interesting to note that most lead enters the home after it leaves the municipal water supply or well (USEPA 1993b) by leaching out of the pipes or solder during corrosion reactions. The USEPA and scientific data indicates that the newer the home, the greater the risk of lead contamination (USEPA 1993b). This is because mineral deposits that form a coating over the surface of the solder connections and protect against leaching can take up to five years to form. As such, more likely than not, water in buildings less than five years old has high levels of lead contamination. Should the area be zoned differently and residential homes be built, the piping and solder within the newly constructed homes is more likely to contribute to elevated levels of lead than other sources.

8.3.4. Carcinogenicity of Trichloroethene

Trichloroethene (TCE) is a chemical with known cancer risk and non-cancer hazard effects. A draft assessment of health risks due to TCE by the USEPA (2001b) provided a range of cancer slope factors (2×10^{-2} to 4×10^{-1} mg/kg-d) to evaluate cancer risk. The RAGS Table D series in the present report were developed using the upper bound of this range (*i.e.*, 4×10^{-1} mg/kg-d) for the dermal, ingestion, and inhalation exposure pathways. The estimate of cancer risk due to TCE in this report is therefore a conservative one.

There are currently no recommended values for assessing non-cancer exposure to TCE. However, the New York State Department of Health (NYSDOH) guideline for TCE in air is 5 $\mu g/m^3$ (NYSDOH, 2006). For comparison, in the present risk assessment, TCE was detected under only one receptor/exposure point combination (Southwest Off-Site/Outfall 006; future construction), for which the exposure point air concentration was found to be 1.33×10^{-5} mg/m^3 or 1.33×10^{-2} $\mu g/m^3$, well below the guideline. Similarly, the New York State MCL for TCE in groundwater (as well as the drinking water standard; NYSDOH, 2006) is 5 $\mu g/l$; in comparison, no TCE was detected in either groundwater or surface water samples in this report.

8.3.5. Carcinogenicity of Naphthalene through Inhalation

Naphthalene is carcinogenic through inhalation exposure. CalEPA provides a PPRTV unit risk for naphthalene of $3.4x10^{-5}$ $(ug/m^3)^{-1}$. This corresponds to a screening value for indoor air of 72 ug/L, which is lower than the value used in this HHRA. However, usage of the 72 ug/L value would not affect whether naphthalene is above screening level in the RAGS D Table 2 series.

8.3.6. Carcinogenicity of Hexavalent Chromium

The RAGS D Table 6 series includes an inhalation unit risk value for chromium based on hexavalent chromium, but oral and dermal cancer slope factors were not available. However, the National Toxicology Program has identified chromium as carcinogenic through the oral pathway and EPA is in the process of developing an oral toxicity value for hexavalent chromium.

8.3.7. Dichlorobenzene Toxicity

At the time of this report, 1,2-, 1,3-, and 1,4- dichlorobenzene were in the IRIS review process. This process will lead to an updated non-carcinogenic endpoint for 1,3-dichlorobenzene and updated carcinogenic and non-carcinogenic endpoints for 1,2- and 1,4-dichlorobenzene.

8.4. Calculation of Quantitative Risk Estimates

8.4.1. Non-Carcinogenic Effects

For each exposure pathway, the chemical-specific hazard quotients were summed to calculate the HI for that pathway. For each receptor, the pathway-specific hazard indexes were summed to obtain the total HI for that receptor.

The additivity assumption for calculating hazard indexes is based on the concept that multiple chemicals, acting on the same target organ or by the same mechanism of toxicity, will have an additive effect with respect to the potential damage that is caused to that organ. The additivity assumption does not hold true for chemicals that do not act on the same target organ or by the same mechanism of toxicity. Therefore, USEPA guidance states that if the total HI for the Site exceeds 1, the COPCs may be segregated according to target organ, and the HIs re-derived for each sub group of chemicals. As previously discussed, for receptors and areas for which the HI exceeded 1, the derived risks were dominated by one or two chemicals. As such, segregation of the HI by target organ would have resulted in the same overall conclusions.

8.4.2. Carcinogenic Effects

Uncertainties associated with the Linearized Multistage Model for low dose cancer risk assessments have been discussed in Section 8.4.1. As described in that section, the model and associated assumptions likely result in a conservative estimate of potential lifetime excess cancer risk.

8.5. Central Tendency Estimates

Central tendency (CT) risk calculations were completed for Exposure Areas and receptors for which the HI exceeded 1 or the cancer risk exceeded 1×10^{-6}. The input parameters and calculated CT risk estimates are presented in the RAGS D Table 4, 7, 9, and 10 series. Based on the NYSDEC's direction, the RME exposure point concentrations were applied as exposure point concentrations for the CT calculations. For other input parameters, average values were estimated based on data

published in the *Exposure Factors Handbook* (USEPA 1997a) or professional judgment regarding site specific exposure frequency and duration estimates.

8.6. Multiple Exposure Scenarios

Current and future expected exposures assume that receptors will be exposed to one Exposure Area. The tables below summarize the risks and hazards to each current and future receptor for each Exposure Area. The largest contributor to the risk or hazard is shown in bold. These tables show that the FCB leads to unacceptable risks and hazards for most receptors. However, it is unlikely that a receptor such as the surveillance worker would spend all of their time in the FCB. Thus the risks and hazards shown for the FCB are likely an overestimate, and the true risk to a receptor would likely be a weighted average of the risks from several Exposure Areas.

Table 8.6. *Summary of current RME and CT cancer risks and hazard indexes by receptor*.

Receptor	Exposure Area	RME or CT	Cancer Risk	HI
Adolescent Trespasser	Plant Area	RME	$4x10^{-5}$	$1x10^{0}$
	On-Site Ditches Area	RME	$6x10^{-5}$	$6x10^{0}$
	Former Chlorination Building (FCB)	**RME**	**$4x10^{-4}$**	**$2x10^{1}$**
	Southwest Off-Site/Outfall 006 Exposure Area	RME	$4x10^{-5}$	$3x10^{0}$
	State Fair Blvd/ Northwest Off-Site/ Outfall 004 Exposure Area	RME	$4x10^{-6}$	$4x10^{-1}$
	Lakeshore Area	RME	$3x10^{-5}$	$2x10^{-1}$
	Petroleum Storage Area	RME	$3x10^{-5}$	$1x10^{-1}$
	Chlorobenzene Hot-Spot Area	RME	$5x10^{-5}$	$4x10^{0}$
	Tributary 5A	RME	$3x10^{-5}$	$2x10^{0}$
Adult Trespasser	Plant Area	RME	$4x10^{-5}$	$5x10^{-1}$
	On-Site Ditches Area	RME	$9x10^{-5}$	$3x10^{0}$
	Former Chlorination Building (FCB)	**RME**	**$7x10^{-4}$**	**$1x10^{1}$**
	Southwest Off-Site/Outfall 006 Exposure Area	RME	$4x10^{-5}$	$1x10^{0}$
	State Fair Blvd/ Northwest Off-Site/ Outfall 004 Exposure Area	RME	$6x10^{-6}$	$2x10^{-1}$
	Lakeshore Area	RME	$2x10^{-5}$	$1x10^{-1}$
	Petroleum Storage Area	RME	$2x10^{-5}$	$6x10^{-2}$
	Chlorobenzene Hot-Spot Area	RME	$7x10^{-5}$	$3x10^{0}$
	Tributary 5A	RME	$5x10^{-5}$	$9x10^{-1}$
Surveillance Worker	Plant Area	RME	$3x10^{-5}$	$6x10^{-1}$
	On-Site Ditches Area	RME	$7x10^{-5}$	$3x10^{0}$
	Former Chlorination Building (FCB)	**RME**	**$5x10^{-4}$**	**$1x10^{1}$**
Adult Transient	State Fair Blvd/ Northwest Off-Site/ Outfall 004 Exposure Area	RME	$6x10^{-7}$	$7x10^{-2}$
Utility Worker	Plant Area	RME	$9x10^{-6}$	$5x10^{0}$
	On-Site Ditches Area	RME	$2x10^{-5}$	$3x10^{1}$

Table 8.6. *Summary of current RME and CT cancer risks and hazard indexes by receptor*.

Receptor	Exposure Area	RME or CT	Cancer Risk	HI
	Former Chlorination Building (FCB)	**RME**	**$7x10^{-4}$**	**$3x10^{2}$**
	State Fair Blvd/ Northwest Off-Site/ Outfall 004 Exposure Area	RME	$2x10^{-6}$	$1x10^{0}$
	Lakeshore Area	RME	$4x10^{-5}$	$1x10^{1}$
	Petroleum Storage Area	RME	$5x10^{-6}$	$1x10^{0}$
	Chlorobenzene Hot-Spot Area	RME	$1x10^{-5}$	$1x10^{1}$
	Tributary 5A	RME	$4x10^{-6}$	$7x10^{0}$
Adolescent Trespasser	Plant Area	CT	$2x10^{-5}$	$9x10^{-1}$
	On-Site Ditches Area	CT	$4x10^{-5}$	$4x10^{0}$
	Former Chlorination Building (FCB)	**CT**	**$3x10^{-4}$**	**$1x10^{1}$**
	Southwest Off-Site/Outfall 006 Exposure Area	CT	$2x10^{-5}$	$2x10^{0}$
	State Fair Blvd/ Northwest Off-Site/ Outfall 004 Exposure Area	CT	$3x10^{-6}$	$3x10^{-1}$
	Lakeshore Area	CT	$1x10^{-5}$	$1x10^{-1}$
	Petroleum Storage Area	CT	$1x10^{-5}$	$9x10^{-2}$
	Chlorobenzene Hot-Spot Area	CT	$2x10^{-5}$	$2x10^{0}$
	Tributary 5A	CT	$2x10^{-5}$	$1x10^{0}$
Adult Trespasser	Plant Area	CT	$6x10^{-6}$	$3x10^{-1}$
	On-Site Ditches Area	CT	$2x10^{-5}$	$2x10^{0}$
	Former Chlorination Building (FCB)	**CT**	**$1x10^{-4}$**	**$6x10^{0}$**
	Southwest Off-Site/Outfall 006 Exposure Area	CT	$6x10^{-6}$	$7x10^{-1}$
	State Fair Blvd/ Northwest Off-Site/ Outfall 004 Exposure Area	CT	$1x10^{-6}$	$1x10^{-1}$
	Lakeshore Area	CT	$3x10^{-6}$	$5x10^{-2}$
	Petroleum Storage Area	CT	$3x10^{-6}$	$4x10^{-2}$
	Chlorobenzene Hot-Spot Area	CT	$9x10^{-6}$	$1x10^{0}$
	Tributary 5A	CT	$8x10^{-6}$	$6x10^{-1}$
Surveillance Worker	Plant Area	CT	$1x10^{-6}$	$5x10^{-2}$
	On-Site Ditches Area	CT	$3x10^{-6}$	$3x10^{-1}$
	Former Chlorination Building (FCB)	**CT**	**$2x10^{-5}$**	**$1x10^{0}$**
Adult Transient	State Fair Blvd/ Northwest Off-Site/ Outfall 004 Exposure Area	CT	$8x10^{-8}$	$9x10^{-3}$
Utility Worker	Plant Area	CT	$7x10^{-6}$	$5x10^{0}$
	On-Site Ditches Area	CT	$2x10^{-5}$	$2x10^{1}$
	Former Chlorination Building (FCB)	**CT**	**$6x10^{-4}$**	**$3x10^{2}$**
	State Fair Blvd/ Northwest Off-Site/ Outfall 004 Exposure Area	CT	$1x10^{-6}$	$1x10^{0}$
	Lakeshore Area	CT	$3x10^{-5}$	$1x10^{1}$
	Petroleum Storage Area	CT	$4x10^{-6}$	$1x10^{0}$
	Chlorobenzene Hot-Spot Area	CT	$9x10^{-6}$	$7x10^{0}$

Table 8.6. *Summary of current RME and CT cancer risks and hazard indexes by receptor*.

Receptor	Exposure Area	RME or CT	Cancer Risk	HI
	Tributary 5A	CT	$4x10^{-6}$	$6x10^{0}$

Table 8.7. *Summary of future RME and CT cancer risks and hazard indexes by receptor.*

Receptor	Exposure Area	RME or CT	Cancer Risk	HI
Adolescent Trespasser	Plant Area	RME	$4x10^{-5}$	$1x10^{0}$
	On-Site Ditches Area	RME	$6x10^{-5}$	$6x10^{0}$
	Former Chlorination Building (FCB)	**RME**	**$4x10^{-4}$**	**$2x10^{1}$**
	Southwest Off-Site/Outfall 006 Exposure Area	RME	$4x10^{-5}$	$3x10^{0}$
	State Fair Blvd/ Northwest Off-Site/ Outfall 004 Exposure Area	RME	$4x10^{-6}$	$4x10^{-1}$
	Lakeshore Area	RME	$3x10^{-5}$	$2x10^{-1}$
	Petroleum Storage Area	RME	$3x10^{-5}$	$1x10^{-1}$
	Chlorobenzene Hot-Spot Area	RME	$5x10^{-5}$	$4x10^{0}$
	Tributary 5A	RME	$3x10^{-5}$	$2x10^{0}$
Adult Trespasser	Plant Area	RME	$4x10^{-5}$	$5x10^{-1}$
	On-Site Ditches Area	RME	$9x10^{-5}$	$3x10^{0}$
	Former Chlorination Building (FCB)	**RME**	**$7x10^{-4}$**	**$1x10^{1}$**
	Southwest Off-Site/Outfall 006 Exposure Area	RME	$4x10^{-5}$	$1x10^{0}$
	State Fair Blvd/ Northwest Off-Site/ Outfall 004 Exposure Area	RME	$6x10^{-6}$	$2x10^{-1}$
	Lakeshore Area	RME	$2x10^{-5}$	$1x10^{-1}$
	Petroleum Storage Area	RME	$2x10^{-5}$	$6x10^{-2}$
	Chlorobenzene Hot-Spot Area	RME	$7x10^{-5}$	$3x10^{0}$
	Tributary 5A	RME	$5x10^{-5}$	$9x10^{-1}$
Surveillance Worker	Plant Area	RME	$3x10^{-5}$	$6x10^{-1}$
	On-Site Ditches Area	RME	$7x10^{-5}$	$3x10^{0}$
	Former Chlorination Building (FCB)	**RME**	**$5x10^{-4}$**	**$1x10^{1}$**
Industrial Worker	Plant Area	RME	$9x10^{-5}$	$2x10^{0}$
	On-Site Ditches Area	RME	$2x10^{-4}$	$9x10^{0}$
	Former Chlorination Building (FCB)	**RME**	**$2x10^{-3}$**	**$3x10^{1}$**
	Southwest Off-Site/Outfall 006 Exposure Area	RME	$9x10^{-5}$	$4x10^{0}$
	Petroleum Storage Area	RME	$5x10^{-5}$	$2x10^{-1}$
	Chlorobenzene Hot-Spot Area	RME	$1x10^{-4}$	$6x10^{0}$
Construction Worker	Plant Area	RME	$3x10^{-5}$	$3x10^{1}$
	On-Site Ditches Area	RME	$5x10^{-5}$	$5x10^{1}$
	Former Chlorination Building (FCB)	**RME**	**$8x10^{-4}$**	**$4x10^{2}$**

Table 8.7. *Summary of future RME and CT cancer risks and hazard indexes by receptor.*

Receptor	Exposure Area	RME or CT	Cancer Risk	HI
	Southwest Off-Site/Outfall 006 Exposure Area	RME	$2x10^{-4}$	$8x10^{1}$
	Petroleum Storage Area	RME	$9x10^{-6}$	$8x10^{0}$
	Chlorobenzene Hot-Spot Area	RME	$3x10^{-5}$	$1x10^{1}$
Adult Transient	State Fair Blvd/ Northwest Off-Site/ Outfall 004 Exposure Area	RME	$6x10^{-7}$	$7x10^{-2}$
Utility Worker	Plant Area	RME	$9x10^{-6}$	$5x10^{0}$
	On-Site Ditches Area	RME	$2x10^{-5}$	$3x10^{1}$
	Former Chlorination Building (FCB)	**RME**	**$7x10^{-4}$**	**$3x10^{2}$**
	State Fair Blvd/ Northwest Off-Site/ Outfall 004 Exposure Area	RME	$2x10^{-6}$	$1x10^{0}$
	Lakeshore Area	RME	$4x10^{-5}$	$1x10^{1}$
	Petroleum Storage Area	RME	$5x10^{-6}$	$1x10^{0}$
	Chlorobenzene Hot-Spot Area	RME	$1x10^{-5}$	$1x10^{1}$
	Tributary 5A	RME	$4x10^{-6}$	$7x10^{0}$
Child Resident (< 6 years)	Potable Water	RME	$7x10^{-3}$	$4x10^{2}$
Adult Resident	Potable Water	RME	$1x10^{-2}$	$2x10^{2}$
Adolescent Trespasser	Plant Area	CT	$2x10^{-5}$	$9x10^{-1}$
	On-Site Ditches Area	CT	$4x10^{-5}$	$4x10^{0}$
	Former Chlorination Building (FCB)	**CT**	**$3x10^{-4}$**	**$1x10^{1}$**
	Southwest Off-Site/Outfall 006 Exposure Area	CT	$2x10^{-5}$	$2x10^{0}$
	State Fair Blvd/ Northwest Off-Site/ Outfall 004 Exposure Area	CT	$3x10^{-6}$	$3x10^{-1}$
	Lakeshore Area	CT	$1x10^{-5}$	$1x10^{-1}$
	Petroleum Storage Area	CT	$1x10^{-5}$	$9x10^{-2}$
	Chlorobenzene Hot-Spot Area	CT	$2x10^{-5}$	$2x10^{0}$
	Tributary 5A	CT	$2x10^{-5}$	$1x10^{0}$
Adult Trespasser	Plant Area	CT	$6x10^{-6}$	$3x10^{-1}$
	On-Site Ditches Area	CT	$2x10^{-5}$	$2x10^{0}$
	Former Chlorination Building (FCB)	**CT**	**$1x10^{-4}$**	**$6x10^{0}$**
	Southwest Off-Site/Outfall 006 Exposure Area	CT	$6x10^{-6}$	$7x10^{-1}$
	State Fair Blvd/ Northwest Off-Site/ Outfall 004 Exposure Area	CT	$1x10^{-6}$	$1x10^{-1}$
	Lakeshore Area	CT	$3x10^{-6}$	$5x10^{-2}$
	Petroleum Storage Area	CT	$3x10^{-6}$	$4x10^{-2}$
	Chlorobenzene Hot-Spot Area	CT	$9x10^{-6}$	$1x10^{0}$
	Tributary 5A	CT	$8x10^{-6}$	$6x10^{-1}$
Surveillance Worker	Plant Area	CT	$1x10^{-6}$	$5x10^{-2}$
	On-Site Ditches Area	CT	$3x10^{-6}$	$3x10^{-1}$

Table 8.7. *Summary of future RME and CT cancer risks and hazard indexes by receptor.*

Receptor	Exposure Area	RME or CT	Cancer Risk	HI
	Former Chlorination Building (FCB)	**CT**	**$2x10^{-5}$**	**$1x10^{0}$**
Industrial Worker	Plant Area	CT	$2x10^{-5}$	$1x10^{0}$
	On-Site Ditches Area	CT	$5x10^{-5}$	$7x10^{0}$
	Former Chlorination Building (FCB)	**CT**	**$4x10^{-4}$**	**$2x10^{1}$**
	Southwest Off-Site/Outfall 006 Exposure Area	CT	$1x10^{-5}$	$2x10^{0}$
	Petroleum Storage Area	CT	$8x10^{-6}$	$1x10^{-1}$
	Chlorobenzene Hot-Spot Area	CT	$2x10^{-5}$	$2x10^{0}$
Construction Worker	Plant Area	CT	$2x10^{-5}$	$1x10^{1}$
	On-Site Ditches Area	CT	$3x10^{-5}$	$4x10^{1}$
	Former Chlorination Building (FCB)	**CT**	**$7x10^{-4}$**	**$3x10^{2}$**
	Southwest Off-Site/Outfall 006 Exposure Area	CT	$9x10^{-5}$	$4x10^{1}$
	Petroleum Storage Area	CT	$7x10^{-6}$	$5x10^{0}$
	Chlorobenzene Hot-Spot Area	CT	$2x10^{-5}$	$1x10^{1}$
Adult Transient	State Fair Blvd/ Northwest Off-Site/ Outfall 004 Exposure Area	CT	$8x10^{-8}$	$9x10^{-3}$
Utility Worker	Plant Area	CT	$7x10^{-6}$	$5x10^{0}$
	On-Site Ditches Area	CT	$2x10^{-5}$	$2x10^{1}$
	Former Chlorination Building (FCB)	**CT**	**$6x10^{-4}$**	**$3x10^{2}$**
	State Fair Blvd/ Northwest Off-Site/ Outfall 004 Exposure Area	CT	$1x10^{-6}$	$1x10^{0}$
	Lakeshore Area	CT	$3x10^{-5}$	$1x10^{1}$
	Petroleum Storage Area	CT	$4x10^{-6}$	$1x10^{0}$
	Chlorobenzene Hot-Spot Area	CT	$9x10^{-6}$	$7x10^{0}$
	Tributary 5A	CT	$4x10^{-6}$	$6x10^{0}$
Child Resident (< 6 years)	**Potable Water**	**CT**	**$7x10^{-3}$**	**$4x10^{2}$**
Adult Resident	**Potable Water**	**CT**	**$4x10^{-3}$**	**$2x10^{2}$**

9. Conclusions

In general, under current conditions, cancer risks for receptors in all exposure areas are within the acceptable regulatory range of 10^{-4} to 10^{-6}, except for the Former Chlorination Building, and hazard indices for receptors in the Plant Area, State Fair Blvd/ Northwest Off-Site/ Outfall 004 Exposure Area, and the Petroleum Storage Area are within the threshold of 1.

Under future conditions, cancer risks for receptors in all exposure areas are within the acceptable regulatory range of 10^{-4} to 10^{-6}, except for the Southwest Off-Site/Outfall 006 Exposure Area and the Former Chlorination Building. Under future conditions, hazard indices for receptors in the State Fair Blvd/ Northwest Off-Site/ Outfall 004 Exposure Area are within the threshold of 1.

It should be noted that it is unlikely that a given receptor would spend all of their time in one exposure area. Thus the risks and hazards shown for a given exposure area are likely an overestimate, and the true risk to a receptor would likely be a weighted average of the risks from several exposure areas. A summary of risk drivers is presented in RAGS Table 10 series (Attachment A) and below.

9.1. Plant Area

9.1.1. Current/Future Receptors

There are no unacceptable cancer risks or non-cancer hazards for current/future Site-receptors (adolescent trespasser, adult trespasser, and surveillance worker).

9.1.2. Future Receptors

Under the future exposure scenarios, there are no unacceptable cancer risks associated with any receptor in this exposure area. Non-cancer hazard exceeding the threshold for the future construction worker is driven primarily by exposure to:

- Nickel (HQ = 20)

Non-cancer hazard for the future utility worker is driven primarily by exposure to:

- Mercury (HQ = 3).

9.2. On-Site Ditches

9.2.1. Current/Future Receptors

There are no unacceptable cancer risks for current/future Site-receptors. Likewise, there are no unacceptable chemical-specific hazards for the current/future adult trespasser or surveillance worker. The non-cancer hazards for the adolescent trespasser are driven primarily by exposure to:

- 2,3,7,8-TCDD Equivalents (HQ = 3)
- Mercury (HQ = 3).

9.2.2. Future Receptors

There are no unacceptable cancer risks for future Site-receptors. Non-cancer hazards for the future construction worker are driven by exposure to:

- 2,3,7,8-TCDD Equivalents (HQ = 10)
- Mercury (HQ = 30).

Non-cancer hazards for future utility workers are also driven primarily by exposure to:

- 2,3,7,8-TCDD Equivalents (HQ = 9)
- Mercury (HQ = 20).

To a lesser extent, non-cancer hazards for future industrial workers are also driven primarily by these constituents.

9.3. Former Chlorination Building

9.3.1. Current/Future Receptors

Cancer risk to the adolescent trespasser, adult trespasser, and surveillance worker was estimated at the higher end of the regulatory threshold range of 10^{-4} to 10^{-6}. This risk was driven primarily by potential exposure to:

- 2,3,7,8-TCDD Equivalents (CR range = 4×10^{-4} to 7×10^{-4})

Non-cancer hazards for these receptors also exceeded the regulatory threshold and are also driven by potential exposure to:

- 2,3,7,8-TCDD Equivalents (HQ range = 10 to 20).

9.3.2. Future Receptors

Cancer risks to the future industrial worker, construction worker, and utility worker exceeded the regulatory threshold range of 10^{-4} to 10^{-6}. These risks are driven primarily by potential exposure to:

- 2,3,7,8-TCDD Equivalents (CR range = 2×10^{-3} to 8×10^{-4})

Non-cancer hazards for these receptors also exceeded the regulatory threshold and are also driven by potential exposure to:

- 2,3,7,8-TCDD Equivalents (HQ ranges from 30 to 400).

9.4. Southwest Off-Site/Outfall 006 Exposure Area

9.4.1. Current/Future Receptors

There are no unacceptable cancer risks or non-cancer hazards for current/future Site-receptors in the Southwest Off-Site/Outfall 006 Exposure Area.

9.4.2. Future Receptors

There are no unacceptable cancer risks or non-cancer hazards for future industrial worker. Cancer risk to the future construction worker exceeded the regulatory threshold range of 10^{-4} to 10^{-6}. Cancer risk was driven primarily by exposure to:

- Benzene (CR = 1.5×10^{-4})

Non-cancer hazards for the future construction worker exceeded the regulatory threshold of 1 and were driven primarily by exposure to:

- Benzene (HQ = 40)
- Mercury (HQ = 10)
- Xylenes (HQ = 9)

9.5. State Fair Blvd/Northwest Off-Site/Outfall 004 Exposure Area

9.5.1. Current/Future Receptors

There are no unacceptable cancer risks or non-cancer hazards for the current/future receptor in this exposure area.

9.5.2. Future Receptors

There are no unacceptable cancer risks or non-cancer hazards for anticipated future receptors in this exposure area.

9.6. Lakeshore Property Area

9.6.1. Current/Future Receptors

There are no unacceptable cancer risks or non-cancer hazards for the adolescent trespasser or adult trespasser. There are also no unacceptable cancer risks for the utility worker in this exposure area; however non-cancer hazards for this receptor exceeded the regulatory threshold. The non-cancer hazard was driven primarily by potential exposure to:

- Benzene (HQ = 9)
- Chlorobenzene (HQ = 3)

9.7. Petroleum Storage Area

9.7.1. Current/Future Receptors

There are no unacceptable cancer risks or non-cancer hazards for the adolescent trespasser or adult trespasser in this exposure area.

9.7.2. Future Receptors

There are no unacceptable cancer risks or non-cancer hazards for future industrial or utility worker. There are also no unacceptable cancer risks to the future construction worker; however, non-cancer hazards for the future construction worker exceeded the regulatory threshold of 1 and was driven primarily by exposure to:

- Manganese (HQ = 4)

9.8. Chlorobenzene Hot-Spot Area

9.8.1. Current/Future Receptors

There are no unacceptable cancer risks for the adolescent trespasser or the adult trespasser in the CHSA. Non-cancer hazard, however, did exceed the regulatory threshold and was driven by exposure to:

- PCBs (HQ = 4 and 3, respectively)

9.8.2. Future Receptors

There are no unacceptable cancer risks for future industrial worker in the CHSA. Non-cancer hazard, however, did exceed the regulatory threshold and was driven by exposure to:

- PCBs (HQ = 6)

There are no unacceptable cancer risks for future construction worker in the CHSA. Non-cancer hazards, however, did exceed the regulatory threshold and were driven primarily by exposure to:

- Manganese (HQ = 4)
- PCBs (HQ = 6)

There are no unacceptable cancer risks for future utility worker in the CHSA. Non-cancer hazard, however, did exceed the regulatory threshold and was driven primarily by exposure to:

- PCBs (HQ = 7)

9.9. Tributary 5A

9.9.1. Current/Future Receptors

There are no unacceptable cancer risks or non-cancer hazards for the adolescent trespasser or the adult trespasser in this exposure area.

9.10. Hypothetical Drinking Water Source Area

Groundwater at the Site is not suitable for use as a drinking water supply irrespective of any contributions related to waste at the Site. However, the following section describes the risk drivers that would be expected if it groundwater was used as drinking water source.

9.10.1. Future Receptors

Both cancer risk and non-cancer hazards exceeded their respective regulatory thresholds for future child and adult residents. The cancer risks are driven primarily by exposure to:

- Benzene (CR = 5×10^{-3} and 1×10^{-2}, respectively)
- Arsenic (CR = 1×10^{-3} and 2×10^{-3}, respectively)

- 1,4-Dichlorobenzene (CR = 2×10^{-4} and 4×10^{-4}, respectively)
- Benzo(b)fluoranthene (CR = 2×10^{-4} and 4×10^{-5}, respectively)

Non-cancer hazards for the future child and adult residents are driven primarily by:

- Benzene (HQ = 300 and 100, respectively)
- Chlorobenzene (HQ = 50 and 20, respectively)
- Arsenic (HQ = 30 and 10, respectively)
- Toluene ((HQ = 10 and 5, respectively)
- Chromium (HQ = 8 and 3, respectively)
- Iron (HQ = 6 and 2, respectively)
- 1,4-Dichlorobenzene (HQ = 5 and 2, respectively)

9.11. Hypothetical Future Indoor Air

Based on the discussion in Section 3.10.1 and the high vapor pressure of many of the compounds detected, a vapor intrusion evaluation will need to be conducted prior to the construction of occupied buildings at the site. Based on the vapor intrusion evaluation, preventative measures may be included in the design and construction of buildings at the Site to mitigate the risk of exposure to on-Site soil gas. Such measures may include the use of a vapor barrier or the installation of a venting system, such as at the groundwater treatment plant.

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