New York State Department of Environmental Conservation
Division of Environmental Remediation
Remedial Bureau D, 12th Floor
625 Broadway, Albany, New York 12233-7013
Phone: (518) 402-9676 • **Fax:** (518) 402-9020
Website: www.dec.ny.gov

Joe Martens
Commissioner

August 15, 2014

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

Re: Wastebeds 1 through 8 Site Revised Remedial Investigation

Dear Mr. McAuliffe:

The New York State Department of Environmental Conservation (NYSDEC) has completed its review of the "Wastebeds 1 through 8 Site Revised Remedial Investigation" (RI) dated August 2014 and submitted with your letter dated August 11, 2014 (which included replacement pages for the May 2014 draft RI and CD copies of the complete RI). Based on our review, the RI is approved. If you have any questions, please contact me at 518-402-9796.

Sincerely,

Tracy A. Smith

Tracy A. Smith
Project Manager

ecc:
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August 11, 2014

Mr. Tracy Smith
Project Manager
New York State Department of Environmental Conservation
Remedial Bureau D
625 Broadway, 12th Floor
Albany, New York 12233

Re: Wastebeds 1-8 Consent Order # D-7-0002-02-08
Revised Remedial Investigation Report

Dear Mr. Smith:

This letter provides replacement pages for the Revised Wastebeds 1-8 Site Remedial Investigation Report in Geddes, New York prepared by O'Brien & Gere. The replacement pages include:

- Revised cover pages for the binders
- Revised spines for the binders
- Full text
- Figures 9, 38, 143, 166, 169, and 173
- Table 194
- Revised Appendix CD

Also included is the full electronic copy of the revised report on CD. 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, 3 CD)

cc:		
	Robert Nunes	USEPA (1 copy, 6 CDs)
	Harry Warner	NYSDEC Region 7 (1 copy, 1 CD)
	Mark Sergott	NYSDOH (1 copy, 1 CD)
	Margaret A. Sheen, Esq.	NYSDEC, Region 7 (ltr only)
	Argie Cirillo, Esq.	USEPA (ltr only)
	Brian D. Israel, Esq.	Arnold & Porter (CD)
	David Coburn	O.C. Office of the Environment (1 copy, 1 CD)
	Joseph Heath, Esq.	(ec ltr only)
	Thane Joyal, Esq.	(1 copy, 1 CD)
	Jeanne Shenandoah	Onondaga Nation (1 copy and ec ltr only)
	Curtis Waterman	HETF (CD)

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Alma Lowry	(CD)
Michael Spera	AECOM (1 copy, 1 CD)
David Scheuing	AECOM (1 copy, 1 CD)
William Hague	Honeywell (CD)
Steve Miller	Honeywell (CD/ltr only)
Thomas Conklin	O'Brien & Gere (ec)
Bradley Kubiak	O'Brien & Gere (ec)
Douglas M. Crawford	O'Brien & Gere (ec ltr only)
Christopher C. Calkins	O'Brien & Gere (ec ltr only)

REVISED REPORT

VOLUME 1 – TEXT AND FIGURES

Revised Remedial Investigation
Wastebeds 1 through 8 Site
Geddes, New York

Honeywell

August 2014

O'BRIEN & GERE

1163 | 39642

Revised Remedial Investigation
Wastebeds 1 through 8 Site
Geddes, New York

Prepared for:

Honeywell

Douglas M. Crawford

DOUGLAS M. CRAWFORD, PE, VP
O'BRIEN & GERE ENGINEERS, INC.

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LIST OF ACRONYMS

ACOE	Army Corps of Engineers
amsl	Above Mean Sea Level
APHA	American Public Health Association
ARAR	Applicable or Relevant and Appropriate Requirement
ATSDR	Agency for Toxic Substances and Disease Registry
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
BBL	Blasland, Bouck & Lee
BERA	Baseline Ecological Risk Assessment
bgs	Below Ground Surface
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
BTX	Benzene, Toluene, and Xylenes
C&S	Calocerinos & Spina
CAS	Columbia Analytical Services
CBOD	Carbonaceous Biochemical Oxygen Demand
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980, also known as Superfund; Amended in 1986 by the Superfund Amendments and Reauthorization Act
CFR	Code of Federal Regulations
cm	Centimeter
cm/sec	Centimeter Per Second
CPOI	Chemical Parameters of Interest
CRS	Cultural Resources Survey
CSM	Conceptual Site Model
DAF	Dilution Attenuation Factor
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethene
DDT	Dichlorodiphenyltrichloroethane
EFH	Equivalent Fresh Water Head
ERA	Ecological Risk Assessment
FEMA	Federal Emergency Management Agency
FFS	Focused Feasibility Study
FRI	Focused Remedial Investigation
FS	Feasibility Study
Ft	Foot or Feet
GPS	Global Positioning System
HASP	Health and Safety Plan
HHRA	Human Health Risk Assessment
K_{oc}	Organic Carbon Adsorption Coefficient
K_{ow}	Octanol-Water Partition Coefficient
km	Kilometers
km^2	Square Kilometers
LCS	Laboratory Control Sample
LLS	Licensed Land Surveyor
meq/L	Milliequivalents Per Liter
mg/kg	Milligrams Per Kilogram
µg/kg	Micrograms Per Kilogram
mg/L	Milligrams Per Liter
µg/L	Micrograms Per Liter
MS	Matrix Spike
MSD	Matrix Spike Duplicate
MSL	Mean Sea Level
NAD83	New York State Plane Coordinates

NAVD88	North American Vertical Datum
ng/L	Nanograms Per Liter
NOAA	National Oceanic and Atmospheric Administration
NTU	Nephelometric Turbidity Units
NWI	National Wetlands Inventory
NYCRR	New York Codes, Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDOT	New York State Department of Transportation
NYSFW	New York State Freshwater Wetlands
OCDWEP	Onondaga County Department of Water Environment Protection
OSWER	Office of Solid Waste and Emergency Response
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCDD/Fs	Polychlorinated Dibenzo-p-dioxins and Polychlorinated Dibenzofurans
PCE	Tetrachloroethene
PFD	Problem Formulation Document
PID	Photoionization Detector
ppb	Parts Per Billion
ppm	Parts Per Million
PSA	Preliminary Site Assessment
PTE	1-Phenyl-1-[4-methylphenyl]-ethane
PVC	Polyvinyl Chloride
PXE	1-Phenyl-1-[2,4-dimethylphenyl]-ethane
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAGS	Risk Assessment Guidance for Superfund
RAIS	Risk Assessment Information System
RAOs	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
SARA	Superfund Amendments and Reauthorization Act
SB	Site Background
SCO	Soil Cleanup Objectives
SVOC	Semivolatile Organic Compound
TAL	Target Analyte List
TCE	Trichloroethene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leachate Procedure
TDS	Total Dissolved Solids
TIC	Tentatively Identified Compound
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
TOGS	Technical and Operational Guidance Series
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USSCS	United States Soil Conservation Service
UV	Ultraviolet
VOC	Volatile Organic Compound
WEF	Water Environment Federation

EXECUTIVE SUMMARY

The Wastebeds 1 through 8 Site (Site) is a 404-acre property situated along the southwestern shore of Onondaga Lake (**Figure 1**) that is owned by New York State and Onondaga County. Data collected during the Remedial Investigation (RI) and other investigations indicates that the environmental conditions observed at the Site are related to historical industrial activities, as well as former and current land uses, including:

- Solvay waste - The historic use of the site was primarily as a settling basin for Solvay waste, an inert material consisting largely of calcium carbonate, calcium silicate, and magnesium hydroxide. The settling basins were in active operation from approximately 1916 to 1943. In addition over the operating time frame there was periodic co-disposal of former Allied Chemical Main Plant byproducts including benzene, toluene, ethylbenzene, and xylenes (BTEX); naphthalene and other PAHs; and phenol during settling basin operations from approximately 1916 to 1943. These activities resulted in impacts to lakeshore surface soils/fill, subsurface soils/fill, groundwater, and surface water. The impacts to Onondaga Lake and Ninemile Creek are being addressed by the Integrated IRM that has been implemented at the Site.
- Crucible Landfill - The disposal of waste materials containing chromium, nickel and other metals from Crucible Specialty Metals in an on-site Landfill from 1973 until its regulated closure in 1988. This activity resulted in impacts to surface soils/fill, subsurface soils/fill, and groundwater.
- Municipal sewage sludge - The placement of municipal sewage sludge from the City of Syracuse and Onondaga County generally containing metals, PAHs, pesticides, and PCBs in the Biosolids Area from 1925 to 1978. This activity resulted in impacts to surface soils/fill and subsurface soils/fill.
- Other - Portions of the Site are used as parking lots for the New York State Fair and the Site is transected by Interstate-690 and the New York State (NYS) Route 695 interchange. Storm water run-off from the parking areas, Interstate 690 and NYS Route 695, and upstream areas (*i.e.*, Bridge Street and Crucible Parking lots) have resulted in impacts to site surface water and sediment in Ditch A. These impacts include constituents ubiquitous to the environment and general urban run-off such as BTEX, PAHs, pesticides, PCBs, and metals.

Introduction

This document is the RI Report for the Site in Geddes, New York. The RI was performed pursuant to the Administrative Order on Consent (D-7-0002-02-08) between the New York State Department of Environmental Conservation (NYSDEC) and Honeywell International, Inc. (Honeywell) dated January 22, 2004. The RI was performed in accordance with the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988a) and the National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR Part 300.68), and CERCLA as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986.

This document includes discussion of data collected during the Preliminary Site Assessment (PSA), Focused Remedial Investigation (FRI), RI, Chromium Speciation Investigation, Supplemental Remedial Investigation (SRI), and other investigations. It also contains discussion of interim remedial measures (IRMs) being implemented at the 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. Subsequent to the completion of the data collection associated with the RI, these data were used to develop designs for the IRMs.

Site Description

Wastebeds 1 through 8 are located on the southwestern side of Onondaga Lake [Blasland, Bouck & Lee (BBL), 1989]. A Site plan is included as **Figure 2**. The irregularly shaped beds extend roughly 1.5 miles along the shoreline, extend to a maximum width of 0.5 mile, and cover approximately 315 acres. The Site, in its entirety, covers approximately 404 acres. The Site elevation ranges from 363 to 430 ft above mean sea level (**Figure 3**). **Exhibit 1** contains a time series of aerial photographs for the Site between 1926 and 1998.

Project Objectives

The objectives of the RI were to:

- Collect data necessary to evaluate and characterize the nature and extent of Site-related CPOIs
- Evaluate potential CPOI migration pathways
- Evaluate potential risks to human and ecological receptors via performance of risk assessments in accordance with USEPA Risk Assessment Guidance for Superfund (RAGS) and Ecological Risk Assessment Guidelines (ERAGs)
- Identify preliminary remedial action objectives (RAOs)
- Gather sufficient data to support the Feasibility Study (FS)

Conclusions

Based on the investigations conducted, the following detailed conclusions have been developed.

- The Site geology consists of seven distinct layers including fill/Solvay waste, marl/peat, silt and clay, silt and fine-grained sand, basal sand and gravel, basal till, and bedrock.
- The marl layer pinches out to the south, away from the lake, and transitions to alternating layers of marl and peat.
- The Site Hydrogeology consists of two groundwater zones, an Upper Groundwater System and a Lower Groundwater System separated by a confining silt and clay layer.
  - The Upper Groundwater System consists of the anthropogenic fill/waste and the native marl/peat. Localized deltaic deposits were also observed along the former Ninemile Creek channel to Onondaga Lake under Wastebeds 5 and 6.
  - The discontinuous confining or low flow zones are a silt and clay layer between the marl/peat and deep zone, and the basal till lying between the deep and bedrock zones.
  - The Lower Groundwater System consists of the silt and fine grained sand deposits and the basal sand and gravel deposits, and a bedrock zone that consists of the Vernon Shale.
- The silt and clay confining layer was not observed under the central sections of Wastebeds 2, 3, 4, and 5 and portions of Wastebeds 7 and 8.
  - The lack of this confining layer may have allowed for downward migration of CPOIs from the Upper Groundwater System into the Lower Groundwater Zone.
- Shallow groundwater generally flows radically from the wastebeds into Onondaga Lake, Ninemile Creek, and drainage ditches
  - Shallow groundwater also surfaces in areas along the lakeshore and Ninemile Creek as seeps.
- Groundwater flows along the former Ninemile Creek channel deltaic deposits into Onondaga Lake and Ninemile Creek.
- CPOIs at the Site include BTEX, naphthalene and assorted PAHs, phenolic compounds, pesticides, and inorganics. The preliminary CPOIs presented in Section 4 of this report are based on based on conservative screening values and may not be representative of current or future uses of the Site, or calculated risks.

- The eastern lakeshore surface soils/fill including two areas of stained Solvay waste present along the lakeshore located on the eastern side of Lakeview Point and southeastern lakeshore of the Site extending roughly 5 ft bgs are currently being mitigated through cover systems and the collection of shallow and intermediate groundwater by the on-going IRM.
- A layer of stained fill (*i.e.*, Solvay waste) is present at the base of Wastebeds 1 through 4 approximately 60 ft below the surface. This deep layer may be a source of BTEX, naphthalene and other PAHs, and phenol concentrations along the lakeshore and southeastern portion of the Site including deep and bedrock groundwater beneath both the Site and the adjacent Onondaga Lake. It should be noted that a separate Deep Groundwater Investigation (O'Brien & Gere 2007, O'Brien & Gere 2010c) is being conducted to evaluate other potential sources of benzene in deep and bedrock groundwater encountered regionally along the lakeshore and beneath Onondaga Lake.

The nature and extent of CPOIs are defined sufficiently to conduct a FS for the Site, and no further Site characterization is warranted at this time.

Risk Assessment Summary

Potential human and ecological receptors are discussed in the NYSDEC-approved *Wastebeds 1 through 8 Site Human Health Risk Assessment Report* (O'Brien & Gere, 2011d) and the *Wastebeds 1 through 8 Site Baseline Ecological Risk Assessment Report* (O'Brien & Gere, 2011e).

Potential risks related to human exposures to soil/fill material were limited to non-cancer risks driven by inhalation of metals in dust. The estimated risks to human health are similar to those risk levels estimated for typical background concentrations, or were associated with concentrations only detected in a relatively small area proximal to the Crucible Landfill.

Potential risks related to terrestrial ecological receptor exposures to soil/fill material were primarily driven by metals for which detected concentrations do not exceed background concentrations in New York State, are associated with a single outlier, or are associated with the Biosolids Area at the Site. Potential risks to aquatic ecological receptors were related to exposure to soil/fill material substrate in one location at the Site (lower Ditch A).

Preliminary Remedial Action Objectives

Based on the results of the PSA, FRI, RI, Chromium Speciation Investigation, SRI, HHRA, BERA, and previous investigations, the following list of preliminary remedial action objectives (RAOs) has been developed.

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

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

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

- Prevent, or reduce to the extent practicable, the migration of contaminants to groundwater, sediment or surface water 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 material or sediment causing toxicity or impacts from bioaccumulation through the terrestrial food chain.

Groundwater Preliminary 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

- In the event that buildings are constructed at the Site, mitigate impacts to public health resulting from existing, or the potential for, soil vapor intrusion into buildings at a Site.

Future Activities

Two Feasibility Studies will be conducted for the Site, one for the Site soil/fill and a second for Site groundwater.

1. INTRODUCTION

1.1. GENERAL

This document is the Remedial Investigation (RI) Report for the Wastebeds 1 through 8 Site (the Site) in Geddes, New York. A Site location plan is included as **Figure 1**. The RI was performed pursuant to the Administrative Order on Consent (D-7-0002-02-08) between the New York State Department of Environmental Conservation (NYSDEC) and Honeywell International, Inc. (Honeywell) dated January 22, 2004. Honeywell, formerly AlliedSignal Inc., owned the site until 1953 when it deeded the property to the people of New York State.

In accordance with the requirements of the Consent Order, a Preliminary Site Assessment (PSA) was performed between the summer of 2004 and spring of 2005. The PSA was performed in accordance with the NYSDEC-approved PSA Work Plan (O'Brien & Gere, 2004a) and was more extensive than typically included in a PSA. As described in the January 2004 PSA Work Plan, Honeywell and NYSDEC agreed that the data to be generated during the PSA would meet many of the data requirements of a Remedial Investigation/Feasibility Study (RI/FS). A summary of the analytical data collected during the PSA was submitted to the NYSDEC in September 2005 (O'Brien & Gere, 2005a). Based on a review of the data, the NYSDEC determined that a RI/FS should be implemented at the Site. The determination was communicated to Honeywell during a May 18, 2005 meeting and in a letter dated July 5, 2005.

During the May 18, 2005 meeting between Honeywell and the NYSDEC, it was agreed that Honeywell could submit a Focused Remedial Investigation (FRI) Work Plan prior to submittal of the RI/FS Work Plan. A FRI Work Plan was initially submitted to the NYSDEC in July 2005 (O'Brien & Gere, 2005b). The FRI Work Plan was revised in accordance with the August 19, 2005 NYSDEC comments and Honeywell's September 16, 2005 response to comments letter and resubmitted on September 19, 2005. Field work associated with the FRI was performed between October 2005 and June 2006.

The RI Work Plan (O'Brien & Gere, 2005c) was initially submitted to the NYSDEC for review on October 3, 2005. The revised RI Work Plan (O'Brien & Gere, 2006a) was submitted on November 3, 2006 and incorporated revisions based on NYSDEC comments presented in April 24, 2006 and October 4, 2006 comment letters.

The RI Report was submitted to the NYSDEC on April 3, 2008, and the NYSDEC provided comments on this report in a letter dated October 27, 2008. These comments identified additional data gaps, and in order to address these data gaps, the Supplemental Remedial Investigation (SRI) Work Plan was submitted to the NYSDEC on March 5, 2009. The SRI Work Plan was revised based on the NYSDEC April 2, 2009 letter, and resubmitted on May 13, 2009. The SRI Work Plan was approved by the NYSDEC in a letter dated May 14, 2009. The SRI was performed between June 2009 and November 2009.

During implementation of the Human Health Risk Assessment (HHRA) and Baseline Ecological Risk Assessment (BERA), and the USEPA Bike Trail Human Health Risk Assessment (USEPA, 2007a) data gaps regarding chromium speciation in soil samples were identified. To address this data gap, the Chromium Investigation Work Plan was submitted to the NYSDEC on March 11, 2008. This work plan was revised based on NYSDEC comments provided on April 2, 2008, and resubmitted May 6, 2008. The Chromium Speciation Investigation Work Plan was approved in a letter dated May 9, 2008 and the Chromium Speciation Investigation was performed in May 2008.

The results of the Chromium Speciation Investigation were submitted to the NYSDEC on July 31, 2008, and the NYSDEC provided comments on September 29, 2008. Based on these comments a teleconference between Honeywell and the NYSDEC occurred on October 14, 2008, and Honeywell submitted a response to comments letter on October 15, 2008. The NYSDEC approved the October 15, 2008 letter in a letter dated October 29, 2008.

The RI was performed in accordance with the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988a), the National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR Part 300.68), and CERCLA as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986. Health and safety procedures and quality assurance/quality control (QA/QC) for this program were performed in accordance with:

- the *Wastebeds 1 through 8 Health and Safety Plan* (HASP) (O'Brien & Gere, 2003a),
- the *Wastebeds 1 through 8 Quality Assurance Project Plan* (QAPP) (O'Brien & Gere, 2004b), and
- the Revised Wastebeds 1 through 8 Quality Assurance Project Plan included as part of RI Work Plan (O'Brien & Gere, 2006b).

1.2. SITE DESCRIPTION

Wastebeds 1 through 8 are located on the southwestern side of Onondaga Lake [Blasland, Bouck & Lee (BBL), 1989]. A Site plan is included as **Figure 2**. The irregularly shaped beds extend roughly 1.5 miles along the shoreline, extend to a maximum width of 0.5 mile, and cover approximately 315 acres. The Site, in its entirety, covers approximately 404 acres. The Site elevation ranges from 363 to 430 ft above mean sea level (**Figure 3**). **Exhibit 1** contains a time series of aerial photographs for the Site between 1926 and 1998.

1.3. PROJECT OBJECTIVES

The objectives of the RI were to:

- Collect data necessary to evaluate and characterize the nature and extent of Site-related CPOIs
- Evaluate potential CPOI migration pathways
- Evaluate potential risks to human and ecological receptors via performance of risk assessments in accordance with USEPA Risk Assessment Guidance for Superfund (RAGS) and Ecological Risk Assessment Guidelines (ERAGs)
- Identify preliminary remedial action objectives (RAOs)
- Gather sufficient data to support the Feasibility Study (FS)

1.4. SITE BACKGROUND

1.4.1. Use by Honeywell (AlliedSignal Inc.)

The wastebeds were constructed over the Geddes Marsh, which was reclaimed from Onondaga Lake in 1822 when the lake level was lowered to the same level as the Seneca River (BBL, 1989). The wastebed perimeter dikes were constructed of bulkheads or earth depending on location. These dikes were used to contain waste materials (primarily Solvay waste), which consists largely of calcium carbonate, calcium silicate, and magnesium hydroxide with lesser amounts of carbonates, sulfates, salts, and metal oxides. These wastes were generated at the former Main Plant as part of soda ash production using the Solvay Process. Soda ash production began in 1884 and continued until 1986. The Solvay waste was hydraulically placed in the wastebeds in slurry form (90% to 95% water and 5% to 10% solid material). The wastebeds were used on a rotating basis; as a wastebed was filled, additional slurry would be pumped to another wastebed while the first wastebed dewatered by draining and evaporation (BBL, 1989).

Chlorinated benzene production at the Willis Avenue Plant occurred between 1918 and 1977. Additional operations reportedly took place at the Willis Avenue Plant from 1918 to 1977 including production of hydrochloric acid, caustic soda, caustic potash, and chlorine gas (O'Brien & Gere, 1990). The Benzol Plant operated from 1915 to 1970. This plant produced benzene, toluene, xylenes, and naphthalene by the fractional distillation of coke "light oil". The Solvay Process Company operated a coke plant from 1892 through 1923. A phenol production plant operated from 1942 to 1946 (PTI, 1992). Compounds associated with these operations may have been disposed of in Wastebeds 1 through 8 with the Solvay waste slurry or by alternative means, although there are no records or reports to indicate this occurred.

Wastebeds 1 through 6 were in use prior to 1926 and may have been put to use as early as 1916, although no definitive construction date is available. Ninemile Creek was rerouted to the north to permit the construction of

Wastebeds 5 and 6. Wastebeds 7 and 8 were not utilized until after 1939 and remained in use with Wastebeds 1-6 until 1943 (BBL, 1989).

A dike along Wastebed 7 failed, and an area along State Fair Boulevard was flooded with Solvay waste on November 25, 1943. The failure led to the closure of Wastebeds 1 through 8. The location of each wastebed is presented on **Figure 2**.

1.4.2. Use by Others

Crucible Landfill

Subsequent uses of the Site included construction of Interstate 690 (I-690) prior to 1958, construction of the I-690 and NYS Route 695 interchange between 1973 and 1978, and the operation of a landfill on a portion of Wastebed 5 by Crucible Specialty Metals (Crucible) from 1973 to 1988 [Calocerinos & Spina (C&S), 1986].

The Crucible Landfill covers an area of 20 acres and contains an estimated volume of 225,100 yd^3 of non-hazardous and hazardous wastes (C&S, 1986). The landfill was used to contain the following wastes:

Non-hazardous waste materials (217,500 yd^3) (C&S, 1986)

- Slag
- Construction and refractory debris, including absorbents and other miscellaneous materials
- Boiler house ashes
- Coolant swarves
- Mill scale
- Wastewater treatment plant dewatered sludge

Hazardous waste materials (7,600 yd^3) (C&S, 1986)

- Waste caustic solids
- Acid pickling sludges
- Particulate/dust from the electric arc furnace and argon-oxygen decarburization vessel

Crucible submitted an application to the NYSDEC for a permit under 6 NYCRR 364 to transport industrial waste to the landfill. Upon receipt of the permit in 1980, the NYSDEC required Crucible to apply for a Part 360 operating permit for the landfill. The Part 360 permit application was submitted several times between 1980 and 1982 due to additional requests for information by the NYSDEC. The NYSDEC issued the permit for non-hazardous waste operations in 1982.

Crucible submitted a closure plan to the USEPA in 1984 after it failed to obtain the RCRA Part B permit that had been applied for in 1983. This closure plan was determined to be unacceptable and was revised and resubmitted in 1986. The NYSDEC approved the revised Crucible Landfill closure plan in 1986, and the landfill was closed with a cap in 1988.

Biosolids Area

The City of Syracuse and Onondaga County utilized a portion of the wastebeds (Biosolids Area) from 1925 to 1978 for sewage sludge disposal as presented on **Figure 2**. However, the nature, volume, and exact boundaries of the disposal are unknown.

New York State and Onondaga County

The Site was deeded to the people of New York in 1953 with restrictions requiring that the property be used for "park-like" activities and is currently owned by the State of New York and Onondaga County (C&S, 1986). The New York State Fair uses a portion of the Site for parking. While the part used to access the parking is paved, the parking areas are a mix of gravel, crushed stone, and mown grass. The remainder of the Site is largely vegetated. Areas along the shore of Onondaga Lake are being remediated as part of an approved Interim Remedial Measure.

1.5. PREVIOUS AND ONGOING STUDIES AND INTERIM REMEDIAL MEASURES

Several investigations have been previously undertaken at or adjacent to the Site that include:

1) Crucible applications for NYSDEC Part 360 and 364 permits and landfill closure, including supporting documents *Phase II Geotechnical Investigations, Crucible Inc., Solid Waste Management Facilities* and *Phase I Hydrogeological Investigations, Crucible Inc., Solid Waste Management Facilities* (Thomsen, 1982a; Thomsen, 1982b), and the *Revised Landfill Closure Plan Volumes 1 & 2* (C&S, 1986)
2) *Hydrogeologic Assessment of the Allied Waste Beds in the Syracuse Area* (BBL, 1989)
3) *Onondaga Lake Project Waste Beds Investigation Report* performed by TAMS on behalf of the NYSDEC (TAMS, 1995)
4) *Geddes Brook/Ninemile Creek Remedial Investigation* (NYSDEC, 2003a) and *Ninemile Creek Supplemental Sampling Program* (O'Brien & Gere, 2002a)
5) *Onondaga Lake Remedial Investigation Report* (NYSDEC, 2002)
6) *Supplemental Wastebeds 1 through 8 Seeps, Sediment, and Water Sampling* performed by NYSDEC in May 2003
7) *Wastebeds 1 through 8 Preliminary Site Assessment (PSA) Data Summary* (O'Brien & Gere, 2005a).
8) *Environmental Sampling along the Proposed Onondaga Canalways Trail Section 1* (Parsons, 2004a).
9) *Wastebeds 1 through 8 Focused Remedial Investigation (FRI)* (O'Brien & Gere, 2005b).

The results of studies 1 through 5 are discussed in greater detail below. The data collected during studies 6 through 9 are discussed within this document with the date collected for the RI.

1.5.1. Crucible Specialty Metals, 1980 to 1988

Crucible submitted an application to the NYSDEC for a permit under 6 NYCRR 360 and 364 to transport industrial waste and operate an industrial landfill several times between 1980 and 1982. The application was resubmitted due to the NYSDEC's request for additional information. The information included in these applications included analytic results from Crucible's quarterly groundwater program. In 1984, the landfill closure plan was first submitted, and the landfill site was ultimately closed in 1988. Historical sampling locations are presented on **Figure 4**.

In support of the Part 360 application, Thomsen Associates (Thomsen) prepared *Phase II Geotechnical Investigations, Crucible Inc., Solid Waste Management Facilities* (Thomsen, 1982a) and *Phase I Hydrogeological Investigations, Crucible Inc., Solid Waste Management Facilities* (Thomsen, 1982b) in May and June 1982, respectively.

Groundwater quarterly monitoring program results were included in the *Revised Landfill Closure Plan Volumes 1 & 2* for a time period between 1982 and 1985 (C&S, 1986). The groundwater reportedly contained high concentrations of chlorides, calcium, sodium, and TDS and high conductivity potentially due to the presence of Solvay waste. However, concentrations of metals (chromium [total and hexavalent], mercury, and lead) were below analytical detection limits or slightly higher than the detection limit. Phenols were also detected in the groundwater and observed predominantly in the natural deposits underlying the Solvay waste. Concentrations of phenols were highest in Well 18.2, DW101, MS104.1, and MS104.2 (range = 0.76 to 7.22 ppm), with Well 18.2 at the base of the berm to the northeast and the other three situated east of the landfill. Analytic data are included in **Exhibit 2**.

1.5.2. Blasland, Bouck & Lee, 1989

A report by Blasland, Bouck & Lee entitled *Hydrogeologic Assessment of the Allied Waste Beds in the Syracuse Area* was prepared in 1989 for AlliedSignal, Inc. The report was prepared to evaluate, among other things, the potential impact(s) of the Allied wastebeds on local groundwater and surface water resources.

As part of the hydrogeologic assessment, a Site history was prepared, a Site reconnaissance was performed, physical and chemical data for the Solvay waste were reported, surface water and groundwater samples were collected, and chloride loading to Onondaga Lake was estimated. Surface water and groundwater samples were analyzed for groundwater quality parameters (Table 18, **Exhibit 3**). The results of the hydrogeologic assessment that pertain to Wastebeds 1 through 8 are included in **Exhibit 3**.

Results of the hydrogeologic assessment indicated that the groundwater infiltrating the Site was impacted by the Solvay waste and discharged chlorides into Onondaga Lake via shallow groundwater flow. The shoreline of the wastebeds was also reported to have eroded over a thirty-year period, which also contributed to chloride loading to the lake. The estimate of chloride loading from Wastebeds 1 through 8 to Onondaga Lake via groundwater and erosion were 15.85 tons/day and 0.11 tons/day, respectively (BBL, 1989).

1.5.3. TAMS, 1995 and NYSDEC, 2003b

TAMS performed an investigation of Wastebeds 1 through 8 in 1995 on behalf of the NYSDEC. Environmental sample collection and analyses from the Site and selected outfalls was performed to evaluate whether hazardous substances were migrating towards Onondaga Lake from the wastebeds. The media sampled from the wastebeds included groundwater, waste material, surface water/seeps, and outfall and seep sediment (TAMS, 1995).

The primary constituents detected in the media at the Site were BTEX (benzene, toluene, ethylbenzene, and xylene isomers), ketones, phenols, PAHs, and mercury. The distribution of these constituents at the Site is discussed below. Analytic data are included in **Exhibit 4**.

BTEX were detected in groundwater in all ten samples analyzed for VOCs, with the highest concentrations observed at wells 18.2, WP1, and WP2 (**Figure 4**) with concentrations ranging from 1 to 7,100 µg/L for these compounds. Surface water and seep samples contained BTEX compounds at detected concentrations ranging from 1 to 620 µg/L. Sediment from seep locations exhibited concentrations ranging from 2 to 9,400 µg/kg, with the highest concentrations at OUT3.1 and SPGHI. BTEX compounds were also detected in waste samples WST07 and WST08 (**Figure 4**) at concentrations ranging from 3 to 980 µg/kg.

Groundwater samples analyzed for VOCs contained ketones, with concentrations ranging from 21 µg/L at W14.1 to 671 µg/L at W18.2. The majority of the detections were greater than 200 µg/L. Ketones were predominant in surface water/seep samples SP3.16 and SPDEF. Sediment samples from the Site (OUT3.1, SP3.15, SP3.16, SP3.6, and SPGHI) contained concentrations of ketones between 35 and 200 µg/kg, which was predominately acetone (a degradation product of benzene). Waste samples contained ketones at concentrations ranging from 120 to 260 µg/kg.

Phenolic compounds were detected in twelve of thirteen groundwater samples, with maximum concentrations observed at MS301.4, W18.2, and WP1 and a range for total phenols of 14 to 3,173 µg/L. Phenolic compounds were detected in surface water and seep samples OUT3.1, SP3.16, and SPDEF and at sediment locations SPGHI and SP3.15. Phenols were detected in waste material sample WST06 at a concentration of 1,940 µg/L.

Polycyclic aromatic hydrocarbons (PAHs) were detected in eight of thirteen groundwater samples with maximum concentrations observed at W18.2, WP1, and WP2. Naphthalene was the predominant PAH accounting for up to approximately 97% of the total PAHs. Naphthalene was detected at a concentration of 350 µg/L at OUT3.1; PAHs were also detected at SP3.16 and SPDEF. Sediment samples from OUT3.1, SP3.15, SP3.16, SP3.6, SPABC, SPDEF, and SPGHI had detectable concentrations of PAHS, with a maximum at SPGHI (70% naphthalene). PAHs were observed at WST03, WST07, and WST08 with concentrations for total PAHs ranging from 170 µg/kg to 440 µg/kg.

Mercury concentrations in groundwater were detected in twelve of twenty samples, with the highest concentration at WP1 (1.8 µg/L). Mercury was detected in surface water and seep samples locations SG2, SPDEF, and SP3.16. Surface water sample SP3.16 had the highest concentration (0.57 µg/kg) detected in surface water and seep samples. Sediment samples contained less than 2 µg/kg across the Site. Waste material samples contained less than 0.2 mg/kg of mercury, with the exception of WST01 (4.2 mg/kg).

Based on the sampling results, TAMS concluded the "contaminants were present at levels of concern," and a supplemental sampling was conducted on May 19, 2003 by the NYSDEC. The supplemental sampling included seep water and soil/sediment sampling from two locations, one adjacent to Ninemile Creek north of I-690 and one along the lakeshore east of Lakeview Point labeled 101-01 and 101-02, respectively.

Also, two additional seep water samples were collected at the Site. One sample was collected from a discharge pipe protruding from the side of the wastebeds north of the lower State Fair parking area associated with Wastebeds 7 and 8. A second sample was collected from a seep along the banks of the swale known as Outfall 3.1. These samples were designated 101-04 and 101-03, respectively.

Predominant organics detected in the soil/sediment samples included bromoform, bis(2-ethylhexyl)phthalate, dibenzofuran, and assorted PAHs with concentrations ranging from 5 µg/kg to 1,400 µg/kg. Predominant organics detected within surface water samples include acetone, 1,3,5-trimethylbenzene, 1,2,4-trimethylbenzene, xylene, phenol, and assorted PAHs. Concentrations of detected SVOCs ranged from 1 µg/L to 3,700 µg/L. Analytic results are presented within **Exhibit 5**.

1.5.4. Ninemile Creek

The portion of Ninemile Creek that extends along Wastebeds 1 through 8 has been investigated as part of the *Geddes Brook/Ninemile Creek Remedial Investigation/Feasibility Study* (NYSDEC, 2003a) and *Ninemile Creek Supplemental Sampling Program* (O'Brien & Gere, 2002a). A summary of the results for these investigations is presented below. Analytical results are presented within **Exhibit 6**.

Geddes Brook/Ninemile Creek Remedial Investigation.
This remedial investigation was performed in two parts, which included the remedial investigation (NYSDEC, 2003a) and a sediment interim remedial measure (IRM) sampling program by BBL in 2001. The work performed for the RI included surface water chemistry, sediment chemistry, floodplain soil chemistry, fish communities, sediment toxicity testing, and benthic macro invertebrate community analysis. Work performed under the sediment IRM included sediment chemistry and floodplain soil chemistry.

The sampling locations extended along the length of Ninemile Creek and Geddes Brook (Figure 5-2 of the Geddes Brook/Ninemile Creek RI). The locations related to the Site were situated between the 90° bend near the I-690 overpass (NM9) and the mouth of Ninemile Creek (NM10). The RI effort included two single sampling locations within this area: one near the 90° bend near the I-690 overpass and one at the second 90° bend near the outlet. A total of nine transects were sampled in the sediment IRM program, with five being a three-location transect for sediments (TN-1 through TN-5) and four floodplain transects (FN-1 through FN-4) with six sampling locations.

Surface water was sampled at a single location (NM10) during the RI program. Calcium, magnesium, potassium, and sodium, which are associated with Solvay waste, were detected in this sample. Mercury was detected in the unfiltered samples at concentrations ranging from 6.77 ng/L to 26.9 ng/L, and chlorobenzene was also detected at 1.2 µg/L in the sample. No other volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), pesticides, and polychlorinated dibenzo-p-dioxin and dibenzofurans (PCDD/Fs) were detected.

Sediment samples were collected at two transects in the RI and along five transects in the IRM investigation. Predominant VOCs detected in the surface sediment samples were methylene chloride, acetone, carbon disulfide, and 2-butanone. SVOCs were detected at locations NM9 and TN-5, which were located along the 90°

bend near the I-690 overpass. The predominant SVOCs were PAHs and phenolic compounds. Metals present include calcium, magnesium, potassium, sodium, aluminum, and iron. Mercury concentrations were detected at concentrations along the length of the creek between the two 90° bends ranging from 0.01 mg/kg to 13 mg/kg. The majority of PCBs, pesticides, and PCDD/Fs constituents were not detected in the samples.

Floodplain soil samples collected in the investigations from the bank along the Site had similar analytical results to Ninemile Creek sediment. The predominant VOC detected was acetone; no samples were submitted from the IRM investigation floodplain soil samples for VOC analyses. The predominant SVOCs were PAHs and phenolic compounds. Pesticides, PCBs, and PCDD/Fs were detected at trace concentrations. Mercury was detected in most floodplain soil samples along the Site, with concentrations increasing from the immediate upstream reach towards the mouth of Ninemile Creek.

Ninemile Creek Supplemental Sampling Program

The *Ninemile Creek Supplemental Sampling Program* focused on the floodplain soil located along both sides of Ninemile Creek at distances from the creek bank greater than previously investigated (O'Brien & Gere, 2002a). This work was performed as a supplemental investigation to the Geddes Brook/Ninemile Creek Remedial Investigation. The sampling locations included in this discussion focus on those transects between the 90° bend near the I-690 overpass and the outlet of the creek located within the Site boundaries.

Samples were collected from several depth intervals including 0 to 0.5 ft, 0.5 to 1 ft, and 1 to 2 ft with samples at 2 to 3 ft from select locations depending on the substrate. The samples were submitted for laboratory analyses for mercury and total organic carbon (TOC). Samples collected adjacent to the 90° bend near the I-690 overpass were also submitted for SVOC analysis. The focus of the SVOC analysis was on PAHs and hexachlorobenzene.

The predominant SVOCs were PAHs. These were only analyzed for samples from one transect; a horizontal and vertical distribution is presented for this transect only. Floodplain soil concentrations typically decreased with depth (O'Brien & Gere, 2002b). The total PAH concentrations were lower after 5 feet from the creek bank. However, the concentrations increased from 25 ft to 100 ft from the bank. At 100 ft from the bank, the total PAH concentrations decreased only slightly between the surface to the 1 to 2 ft interval.

Mercury was detected at concentrations ranging from 0.06 mg/kg to 76.9 mg/kg (O'Brien & Gere, 2002b). Mercury concentrations were typically higher closer to Ninemile Creek. The lowest concentrations were observed along the transect adjacent to the 90° bend near the I-690 overpass. Concentrations increased downstream, with the highest detected concentrations at the transect located at the mouth of Ninemile Creek. There was no recognizable pattern associated with the vertical distribution of the mercury. However, the maximum concentrations were typically detected at or below the 0.5 to 1 ft interval.

PCDD/Fs were detected at low concentrations along the transect adjacent to the 90° bend near the I-690 overpass along the length of the transect.

1.5.5. Onondaga Lake

The portion of Onondaga Lake adjacent to the Site was investigated in 1992 and 2000 as part of the Onondaga Lake RI/FS (NYSDEC, 2002). Sediment cores were collected from the 30 cm, 2 m, and 8 m depth intervals. The results of the samples collected adjacent to the Site were presented by TAMS on figures presented within **Exhibit 7**. The predominant constituents of concern based on these figures were VOCs and SVOCs including: BTEX, naphthalene, and phenolic compounds. Mercury results are also presented on these figures.

The BTEX concentrations in sediment collected along the shoreline of the Site were compared to New York State *Technical Guidance for Screening Contaminated Sediments* guidance values (NYSDEC, 1999) based on an average lake sediment TOC concentration of 4.5%.

- Benzene was detected at concentrations ranging from 2.0 µg/kg to 8,400 µg/kg. Locations P49, P53, P63, S48, S53, S54, S324, S325, S326, S327, S363, and S364 exceeded the derived human health sediment criteria for benzene of 27 µg/kg (Figure 1 of **Exhibit 7**).
- Toluene was detected at concentrations ranging from 4.1 µg/kg to 8,000 µg/kg. Locations P53, S324, and S363 exceeded the derived sediment quality guidance for toluene of 2,210 µg/kg (Figure 2 of **Exhibit 7**).
- Ethylbenzene was detected at concentrations ranging from 0.7 µg/kg to 1,100 µg/kg. Location S363 exceeded the derived benthic aquatic chronic toxicity sediment quality guidance for ethylbenzene of 1,080 µg/kg (Figure 3 of **Exhibit 7**).
- Xylene was detected at concentrations ranging from 3.0 µg/kg to 28,850 µg/kg. Location S363 exceeded the derived benthic aquatic chronic toxicity sediment quality guidance for xylene of 4,150 µg/kg (Figure 4 of **Exhibit 7**).

The sediment cores that exceeded the sediment guidance values were generally located within 500 ft of the shore. Typical sample depths for samples exceeding guidance values were 0 to 0.2 m, with S324 and S363 extending to 1 m and 2 m, respectively.

Predominant SVOCs included naphthalene and phenolic compounds (phenol and 2-methylphenol) and these compounds were detected at concentrations below New York State *Technical Guidance for Screening Contaminated Sediments* guidance values (NYSDEC, 1999) based on a TOC of 4.5%, with the exceptions discussed below.

- Naphthalene was detected at concentrations ranging from 48 µg/kg to 14,000 µg/kg. Locations S325 and S363 exceeded the derived human health sediment guidance for naphthalene of 1,350 µg/kg (Figure 5 of **Exhibit 7**).
- Phenol was detected at concentrations ranging from 45 µg/kg to 8,700 µg/kg. Locations P53, S53, S324, S325, S326, S327, S362, S363, S364, and S365 exceeded the derived human health sediment guidance for phenol of 23 µg/kg (Figure 6 of **Exhibit 7**).
- 4-Methylphenol concentrations ranged from 71 µg/kg to 930 µg/kg (Figure 7 of **Exhibit 7**).
- Total phenol concentrations ranged from 40 µg/kg to 8,700 µg/kg. Locations P53, S53, S304, S305, S306, S324, S326, S327, S362, S363, S364, and S365 exceeded the derived human health sediment guidance for total unchlorinated phenols of 23 µg/kg (Figure 8 of **Exhibit 7**).

1.5.6 Wastebeds 1 through 8 Focused Feasibility Study

The Wastebeds 1 through 8 Focused Feasibility Study (FFS) was performed to develop and evaluate Interim Remedial Measures (IRM) alternatives to mitigate groundwater flow, seep discharge, and eastern shore and revetment area Solvay waste erosion from the Site to Onondaga Lake, and groundwater and seep discharge from Site to Ninemile Creek. The FFS was conducted pursuant to the ACO (D-7-0002-02-08) between the New York State Department of Environmental Conservation (NYSDEC) and Honeywell dated January 22, 2004 and as described in the *Shallow and Intermediate Groundwater FFS Work Plan* (O'Brien & Gere 2008a). It was conducted to accelerate the development and evaluation of IRM alternatives to provide for continued effectiveness of the NMC OU-2 and Onondaga Lake remedies so that implementation of the preferred IRM could be conducted in alignment with the schedules for remediation of NMC OU-2 and Onondaga Lake. The FFS was submitted to the NYSDEC in June 2010 (O'Brien & Gere 2010a) and accepted by the NYSDEC in a letter dated June 30, 2010.

As part of the FFS, a series of field activities were performed to further assess Site conditions and develop remedial alternatives. The additional field activities included a geotechnical investigation, material compatibility testing, a microcosm study, evaluation of vertical stratification of intermediate groundwater, and groundwater pumping tests.

The geotechnical investigation was performed in 2007 and 2008, and consisted of advancing 70 borings [SB-52 through SB-58, SB-60 through SB-79, and SB-81 through SB-123 (borings SB-59 and SB-80 were not advanced)], and 5 test pits (TP-29 through 33). Soil borings were advanced to evaluate stratigraphy of Wastebeds 1 through 8 along the lakeshore, evaluate the presence and depth of the confining layer (silt and clay layer), obtain field information relative to strength parameters of fill and soil along the lakeshore, evaluate the presence of hydric soils along the lakeshore, and obtain samples for laboratory geotechnical analyses. Test pits were advanced to evaluate physical characteristics of the subsurface such as ease of excavation, stability of excavation, and presence of staining or odors.

The material compatibility testing involved identifying construction materials that could be used during IRM activities. Compatibility testing was performed for three materials, high density polyethylene (HDPE), concrete, and geosynthetic clay liner. These materials were identified for testing because adequate literature from the manufacturer was not available, and they had not been previously tested using similar groundwater. Compatibility of these materials with Site groundwater was assessed by establishing baseline property values, then submersing the material in a site groundwater composite for 30 day increments for a total of 120 days. The geosynthetic clay liner was found to be incompatible with Site groundwater.

The microcosm study was conducted by Bioremediation Consulting, Inc. between November 2008 and September 2009. The study was conducted to examine the biodegradability of benzene, toluene, ethylbenzene toluene, naphthalene, and phenol. For the microcosm study, Site groundwater collected from four monitoring wells (MW-01S, MW-02S, MW-03S, and MW-16S), and soils/fill from immediately adjacent to the monitoring wells were used to create microcosms. Five microbial processes were tested on the microcosms from each well, and included anaerobic, nitrate-reducing, ferric-reducing, methanotrophic, and direct aerobic. It was established during the microcosm study that biodegradation was not effective for conditions on the Wastebeds 1 through 8 Site.

The intermediate groundwater vertical stratification investigation was performed September 2009 and October 2009. The investigation involved collecting 117 samples for pore water characterization from 14 soil boring locations (SB-136 through SB-149). Samples were collected in 4 ft macrocores and shipped to Lancaster Laboratories Inc., where pore water was extracted. The pore water volume extracted varied by sample, and did not always meet the volume required to perform all of the intended analyses. Samples were analyzed using USEPA SW-846 methods and based on the volume of pore water extracted prioritized in the following order; VOCs including naphthalene, cations, chloride and sulfate, conductivity, and pH.

The pumping tests performed as part of the FFS took place between March 30, 2009 and April 11, 2009. The pump tests were designed to provide the basis for evaluating the spacing of wick drains or passive wells used for the effective capture of intermediate groundwater. Two pumping wells (TW-05 and TW-06) were installed along the eastern lakeshore, and associated observations wells OW-08I, OW-09I, and OW-10I were installed for test well TW-05, and observation wells OW-11I, OW-12I, and OW-13I were installed for test well WB18-TW-06. Test wells were installed at 3 ft, 6 ft, and 9 ft intervals from the test wells in order to establish a zone of impact. The TW-05 pumping test was conducted between March 30 and April 2, 2009 and the TW-06 pumping test was conducted between April 7 and April 11, 2009. These pumping tests established a zone of influence for pumping wells on the lakeshore.

Subsequent to completion of field activities, four alternatives were developed:

- Alternative 1 – No Action (required by the National Oil and Hazardous Substances Contingency Plan and serves as a benchmark for the evaluation of action alternatives)
- Alternative 2 – Low Permeability Vegetative Cover with Inland Groundwater Collection
- Alternative 3 – Vegetative Cover with Lakeshore Groundwater Collection
- Alternative 4 – Excavation with Inland Groundwater Collection

The activities and findings of the FFS are discussed in detail within the *Focused Feasibility Study Report* submitted to the NYSDEC in June 2010(O'Brien & Gere 2010a).

1.5.7 Integrated IRM, Mitigation Wetlands, and Remediation Area A Hydraulic Control System 50% Design Report

The *Integrated IRM, Mitigation Wetlands, and Remediation Area A Hydraulic Control System 50% Design Report* was developed to establish a preliminary design to mitigate groundwater and seep discharges from the Site to Ninemile Creek and Onondaga Lake, and mitigate erosion of the Solvay waste, along the Site's Onondaga Lake shoreline. The Pre-Design Investigation completed as part of the 50% Design report was performed to collect data for use in preparing the Integrated IRM Design for the Site. The Remedial Design was performed pursuant to Order on Consent (Index # D7-0002-02-08) between Honeywell and the NYSDEC. The 50% Design Report was performed in accordance with the NYSDEC-approved *Wastebeds 1 through 8 Groundwater Remedial Alternative Work* (O'Brien & Gere 2004a) and the *Pre-Design Investigation Work Plan* (O'Brien & Gere 2009).

The major components of the PDI included geotechnical borings and testing, compatibility testing, hydrogeologic investigation, mitigation wetland water quality evaluation, CCTV inspection, and topographic survey. The activities and findings of the 50% design and PDI are discussed in detail within the *Wastebeds 1 through 8 Integrated IRM, Mitigation Wetlands, and Remediation Area A Hydraulic Control System 50% Design Report* submitted to the NYSDEC in May, 2011 (O'Brien & Gere 2011).

Geotechnical Evaluation

Geotechnical information pertinent to IRM design elements was collected as part of the PDI between December 28, 2009 and March 4, 2010. A total of 65 soil borings were installed, and included:

- Eighteen borings (WB18-SB-179 through WB18-SB-196) along the proposed eastern shoreline groundwater collection system alignment to the silt and clay stratum, terminating between 34 and 58 ft below ground surface (bgs)
- Five borings (WB18-SB-197 through WB18-SB-201) along the center line of the proposed mitigation wetlands to the silt and clay stratum, terminating between 34 and 60 ft bgs
- Eighteen borings (WB18-SB-202 through WB18-SB-219) along the proposed eastern shoreline seep collection system alignment to the marl stratum, terminating at 16 ft bgs
- Five borings (WB18-SB-220 through WB18-SB-224) along the proposed NMC seep collection system alignment to the silt and clay stratum, terminating between 30 and 44 ft bgs
- Three borings (WB18-SB-225 through WB18-SB-227) within the footprints of the pump stations to refusal, terminating between 64 and 140 ft bgs
- Sixteen borings (WB18-SB-228 through WB18-SB-243) along the proposed revetment alignment to the silt and clay or marl stratum, terminating between 54 and 60 ft bgs

Laboratory analyses for these borings included:

- 117 natural moisture content tests
- 96 grain size with hydrometer tests
- 96 Atterberg limits tests
- 33 consolidation tests
- 3 Consolidated Undrained (CU) triaxial tests
- 3 Unconsolidated Undrained (UU) triaxial tests

Compatibility Testing

Potential construction materials were tested to evaluate compatibility with groundwater at the Site. Based on a review of the groundwater and chemical parameters of interest (CPOI) concentrations at the Site, previous compatibility studies, results of the desktop review and vendor testing review, the following potential construction materials were identified for further testing:

- Polypropylene textile/High Density Polyethylene geogrid/Polypropylene geotextile-Triplaner geocomposite gas venting layer (Tenax Tenflow II)
- Polypropylene-Woven geotextile stabilization/separation fabric (Mirafi 600x).

Compatibility of these materials with Site groundwater was assessed by establishing baseline property values, then submersing the material in a site groundwater composite for predetermined lengths of time, and measuring for changes in the overall properties of the materials. It was concluded that Site groundwater did not have an adverse affect on the Tenex Tenflow II or Mirafi 600x materials.

Hydrogeologic Investigation

The objective of the hydrogeologic investigation efforts was to further characterize the hydraulic conductivity, hydraulic head, and the geochemistry of the site along the alignment of the groundwater and seep collection systems and mitigation wetlands.

Hydraulic conductivity was evaluated within the marl. Fourteen piezometers (PZ-09 through PZ-22) were installed to estimate the horizontal hydraulic conductivity of materials surrounding the well screen. To measure hydraulic conductivity in the piezometers, *in situ* rising and falling head measurements were collected from the piezometers except PZ-19 and PZ-22, where the water level precluded the performance of falling tests. The *in situ* hydraulic conductivity tests were completed to correlate measured hydraulic conductivity values with the hydraulic conductivity values estimated using the grain size/hydrometer data. These data were used during the design of the passive wells associated with the collection trench.

Geochemical modeling was conducted to evaluate the mechanisms associated with inorganic precipitate formation. The PHREEQCi version 2 (PH [pH], RE [redox], EQ [equilibrium], C [program written in C], i [interactive]) model developed by USGS. This model was used to simulate chemical reactions and transport processes in aquatic settings, and this information was incorporated into the Integrated IRM design.

To facilitate the PHREEQCi model, groundwater and seep surface water samples were collected. The dataset used in the model included four groundwater samples (MW-04I, MW-08I, MW-18S, and MW-18I) originally collected under the FFS program and nine PDI locations (PZ-05, PZ-07, PZ-09, PZ-10, PZ-13, PZ-14, PZ-16, PZ-17 and TW-06). In addition to groundwater samples, surface water samples were collected from Ninemile Creek (WB18-SW-12 and WB18-SW-14), Ditch A (WB18-SW-09 and WB18-SW-11), Onondaga Lake (WB18-SW-10 and WB18-SW-13), and selected flowing seeps (WB18-SP-15, WB18-SP-24, WB18-SP-78 WB18-SP-155, WB18-SP-158, and WB18-SP-164) for use in the model.

The potential hydraulic head and upward hydraulic pressure in the vicinity of the proposed inland wetlands were evaluated as part of the PDI in order to account for upwelling pressure beneath the proposed liner and cover systems. To evaluate potential upwelling, water levels were monitored at piezometers and monitoring wells within the footprint of the proposed wetlands (PZ-05, PZ-18, PZ-19, PZ-20, PZ-21, PZ-22, MW-02S, MW-02I, MW-03S, and MW-03I). Water levels were collected at these locations every other week between March 9, 2010 and May 7, 2010. These data were used to refine the inland wetland design in the IRM.

Mitigation Wetland Water Quality Evaluation

Available information was reviewed to identify potential limiting factors of surface water quality to sustain wildlife (including amphibians). As part of the review, surface water quality within Onondaga Lake adjacent to the mitigation wetland area along the eastern shoreline was assessed for its suitability to support wildlife and the hydrophytes supportive of wetland habitat. Subsequent to initial review, it was concluded that remedial efforts within and around Onondaga Lake as well as continued lake recovery following Metro improvements will likely change lake water characteristics relative to existing conditions. Further, lake water characteristics will likely change substantially once subject to biogeochemical processes occurring within the inland wetlands (Reddy and DeLaune 2008). Based on these factors, further analyses of lake water was unnecessary for the design.

CCTV Inspection

Closed-circuit television (CCTV) inspection of the Ditch A culvert leading to Ninemile Creek was performed to evaluate potential infiltration and lateral connections. The inspection was performed by Jamko Technical Solutions, Inc., on December 29, 2009. The inspection documented that the total length of the 24 inch culvert was approximately 320 feet in a general southeast to northwest orientation. Major observations included apparent scaling at and above the water level, and possible scaling along one joint in the culvert indicating possible inflow or infiltration. A vault serving as a catch basin was discovered approximately 270 ft from the southeastern most end of the culvert.

Topographic Survey

Topographic surveys of various areas of the Wastebeds 1 through 8 Site have been performed in recent years to support study and design efforts at the site. These surveys included the entire Site (October, 2004), southern Onondaga Lakeshore (January, 2008), Onondaga Lake Shoreline (October, 2009), Ninemile Creek (April, 2009), and the off-site Onondaga Lake shoreline (September 2009). O'Brien & Gere combined these survey maps into one map that represents the existing base map for the site. The contour interval of this map is 1 foot along the Onondaga Lake shoreline area and the Ninemile Creek shoreline area and 2 feet on the upper (*i.e.,* higher elevation) portions of the site.

1.5.8. Wastebeds 1 through 8 SMU-4 Pre-Design Investigation

The Wastebeds 1 through 8 SMU-4 Pre-Design Investigation (SMU-4 PDI) was implemented to fill data gaps created by the addition of a hydraulic control system along Remediation Area A of Onondaga Lake to the Integrated IRM being performed pursuant to Order on Consent (Index # D7-0002-02-08) between Honeywell and the New York State Department of Environmental Conservation (NYSDEC). The SMU-4 PDI was performed in accordance to the August 2010 SMU-4 Pre-Design Investigation (PDI) Addendum Work Plan (O'Brien & Gere, 2010b) In order to address these data gaps geotechnical borings and testing were advanced, and the hydraulic conductivity of the area was evaluated. The activities and findings of the SMU-4 PDI are discussed in detail within the Wastebeds 1 through 8 SMU-4 Pre-Design Investigation Addendum Summary Report submitted to the NYSDEC in June, 2011 (O'Brien & Gere 2011a).

As part of the geotechnical testing, eight borings (WB18-SB-244 through WB18-SB-251) were completed by Parratt-Wolff, Inc. between October 2010 and November 2010. Four of these borings were converted to piezometers (PZ-23 through PZ-26) for use in the hydraulic conductivity evaluation.

Selected split spoon samples from the borings were tested for geotechnical index properties to assist in characterizing the subsurface stratigraphy. Natural moisture content, particle size, and Atterberg limits tests were performed to assist in classifying the soil, and evaluating the consistency of the soil and subsurface materials. Selected Shelby tube samples were tested for soil strength and consolidation parameters. The Consolidated, Undrained (CU) triaxial and Direct Shear testing was performed to establish the strength of the soil. The borings for CU and Direct Shear testing were selected to fill in the data gaps from the previous investigations.

The horizontal hydraulic conductivity of the overburden material along the proposed alignment of the Remediation Area A groundwater hydraulic control system was evaluated. Hydraulic conductivity evaluation activities included collection of soils for grain size and hydrometer analyses, installing of four piezometers in the marl unit, and completing *in situ* hydraulic conductivity tests on the new piezometers.

Data generated during the SMU-4 PDI was incorporated into the Integrated IRM.

1.5.9. Wastebeds 1 through 8 Supplemental Design Investigation

The Wastebeds 1 through 8 Supplemental Design Investigation (SDI) was performed to provide supplemental information for use in the Integrated IRM Remedial Design being performed pursuant to Order on Consent (Index # D7-0002-02-08) between Honeywell and the New York State Department of Environmental Conservation (NYSDEC). The Supplemental Design Investigation was performed in accordance to the Supplemental Design Investigation Work Plan (O'Brien & Gere 2011b). Data generated during the SRI was used in the design of the proposed eastern shore access path, the foundations for three pump stations, and mitigation of groundwater/seep discharges to the middle reach of Ditch A; and to characterize the Biosolids Area. The activities and findings of the SDI are discussed in detail within the Supplemental Design Investigation Summary Report submitted to the NYSDEC in May, 2012 (O'Brien & Gere 2012).

The field investigation of the SDI included two main components, geotechnical testing and a storm drainage network investigation.

Both soil borings and test pits were advanced as part of the geotechnical testing. Four borings (WB18-SB-252 through SB-254 and SB-257) were completed by Lyon Drilling, Inc., in August 2011. Six borings (WB18-SB-255, SB-256, and SB-258 through SB-261) were completed by Parratt-Wolff, Inc., in September 2011. These borings were completed to obtain standard penetration test (SPT) N-values that will were used in conjunction with laboratory test data to develop soil strength parameters. Seven test pits (TP-1, TP-3, TP-4, TP-5, TP-7, TP-9, and TP-11) were advanced using a track-mounted excavator within the estimated footprint of the Biosolids Area. Shelby tube samples were collected, at the ground surface in each of the seven test pits where a discernible layer of biosolids was present, in accordance with ASTM D1587 for subsequent laboratory testing. Five test pits (TP-2, TP-6, TP-8, TP-10, and TP-12) were completed by hand due to accessibility constraints posed by the presence of dense vegetative growth in this area.

Selected split spoon samples were tested for geotechnical index properties to assist in developing and confirming the consistency of the subsurface stratigraphy. Natural moisture content, particle size, and Atterberg limits are index tests to assist in classifying the soil and evaluating the consistency of the soil and subsurface materials. Selected Shelby tube samples were tested for soil strength (CU Triaxial test) and to determine consolidation parameters.

During the storm drainage network investigation, numerous storm drainage features (*e.g*., culverts, swales, and catch basins) located along the I-690 corridor that bisects the Site were identified. Available historical mapping and field observations were used to estimate the locations and routes of underground pipes associated with the storm drainage system. On October 24, 2011, five dye tracer tests were performed to verify the pipe pathways. Between dye testing and visual confirmation, the storm water drainage system was mapped with the exception of one inflow into CB-27. Storm drainage network information gathered during the SDI was incorporated into the Integrated IRM.

1.5.10. Wastebeds 1 through 8 Integrated IRM, Mitigation Wetlands, and Remediation Area A Hydraulic Control System

The Integrated Interim Remedial Measure (IRM), Mitigation Wetlands, and Remediation Area A Hydraulic Control System for the Wastebeds 1 through 8 Site design was performed pursuant to the Order on Consent (Index # D7-0002-02-08) between Honeywell and the NYSDEC. The IRM was developed to mitigate groundwater and seep discharges from the Site to Ninemile Creek (NMC) and Onondaga Lake and mitigate erosion of Solvay waste along the Onondaga Lake Shoreline and also reduce groundwater upwelling velocities for cap effectiveness in adjacent Remediation Area B and a portion of Remediation Areas A and C. The Integrated IRM is documented in the NYSDEC's Response Action Document (RAD) (NYSDEC and United States Environmental Protection Agency [USEPA] 2011). The Integrated IRM design is presented in detail within the Integrated IRM, Mitigation Wetlands, and Remediation Area A Hydraulic Control System 100% Design Report submitted to the NYSDEC in January 2013 (O'Brien & Gere 2013).

This design includes the following remediation activities, as presented in **Figure 5**:

- Shoreline stabilization
- Vegetative cover
- Groundwater and seep collection systems
- Lower Ditch A restoration

- Upper, Middle, and Lower Ditch A Maintenance
- Mitigation wetlands along the Wastebeds 1 though 8 shoreline

Shoreline Stabilization

Erosion of Solvay waste was found to occur along the surf zone of the northern and eastern shorelines of the Site due to wind and wave action. Slope stabilization systems are being installed to minimize this erosion action. Two areas of the site require stabilization: a steep embankment area and a shallow sloped shoreline area located along the northern and eastern shorelines of the Site.

A vegetated on-shore revetment will be used to stabilize approximately 1,700 feet of steep embankment area adjacent to SMUs 3 and 4. The lake design includes the shallow slope stabilization system within the lake and extending up to an elevation of 365 feet in both SMUs 3 and 4 to achieve consistency of stabilization and restoration approaches from the lake shore up to this elevation.

Vegetative Cover

The vegetative cover system was selected for areas of the eastern shoreline not occupied by inland wetlands, the connected wetland, storm water features, berms, area of integration with the shoreline stabilization, and access pathways. The location of this cover was also selected to provide a transitional area for wildlife that may migrate or otherwise inhabit areas between the mitigation wetlands, lake, and upland portions of the Wastebeds 1 through 8 Site. The vegetative cover system is being installed as a means to minimize direct contact with, and ingestion and erosion of exposed Solvay waste along the eastern shoreline of the Site. The vegetative cover system also provides ecological value to the Site by providing habitat diversity complementary to the mitigation wetlands and by introducing locally native species.

Groundwater and Surface Water Collection Systems

Site groundwater and seep water currently flow toward Onondaga Lake and Ninemile Creek. The hydraulic control systems are designed to control the movement of shallow and intermediate groundwater, thus creating a hydraulic barrier that mitigates contaminated groundwater and seep water from entering NMC and Onondaga Lake. Four collection systems are being installed to achieve the goals of the Integrated IRM, and include the eastern shoreline seep collection system, eastern shoreline shallow and intermediate groundwater collection system, Remediation Area A hydraulic control system, and the Ninemile Creek collection system. The eastern shoreline seep collection system intercepts seep discharges via a seep apron to divert flow to a collection trench to mitigate discharge to Onondaga Lake and the mitigation wetlands.

Shallow and intermediate groundwater migrating toward Onondaga Lake is being collected along approximately 6,700 linear feet of the eastern shoreline. The collection trench is a 12-inch slotted high density polyethylene (HDPE) pipe installed at approximately 8 feet below ground surface (bgs) surrounded by sand backfill and conveys water to the Eastern Shoreline Pump Station. While the trench intercepts and collects shallow groundwater, passive wells installed through the trench and intercept and collect intermediate groundwater. Collected groundwater is pumped through a 6-inch HDPE pipe from the Eastern Shoreline Pump Station to the Willis Avenue Groundwater Treatment Plant (GWTP) for treatment.

Site shallow and intermediate groundwater migrating from the site to Onondaga Lake is collected along a 1,050 linear foot collection trench along the northern shoreline. This collection system is to mitigate potentially unacceptable upwelling velocities within cap limits. The trench also controls the seep discharge along the northern shoreline. The trench contains a 6-inch slotted HDPE pipe installed at approximately 8 feet bgs. While the trench intercepts and collects shallow groundwater and seep discharge, passive wells installed through the trench to the top of the silt and clay unit intercept and collect intermediate groundwater. Recovered groundwater from the trench is conveyed to the northern shoreline pump station where it is pumped via force main to the Eastern Shoreline Pump Station and then to the GWTP for treatment.

Hydraulic control of the seeps along Ninemile Creek is being achieved through construction of seep aprons that divert seep flow to an approximately 1,800 linear foot collection trench. The trench comprises a 6-inch slotted

HDPE pipe surrounded by sand backfill, installed at approximately 13.5 feet bgs. While the trench intercepts and collects shallow groundwater and seep discharge, passive wells installed through the trench intercept and collect intermediate groundwater. Recovered water is conveyed to the NMC pump station where it is pumped through a 4-inch HDPE force main to the Eastern Shoreline Pump Station and then to the GWTP for treatment.

Ditch A

Approximately 320 linear feet of the culvert, originating in the upper portion of Ditch A and terminating at NMC, was rehabilitated as part of the Integrated IRM. This culvert was lined with cured-in-place pipe (CIPP) and the existing manhole associated with this system was rehabilitated with Epoxytech liner.

Maintenance of the Middle Reach of Ditch A to mitigate transport of Solvay waste substrate and sediment to Onondaga Lake and to Ninemile Creek is included as part of the IRM. This was accomplished by promoting the controlled settlement of sediment and calcium carbonate precipitate, accompanied by on-going maintenance activities, as necessary, to remove accumulated sediment from the Middle Reach of Ditch A.

The existing substrate of the lower reach of Ditch A, approximately 380 feet spanning from the I-690 culvert to the confluence with Onondaga Lake, consists mostly of Solvay waste and accumulated sediments. Within the existing channel cross section, the existing substrate will be removed as part of the Integrated IRM such that a low permeability habitat cover can be placed subsequent to existing substrate removal. The low permeability habitat cover will form a barrier between Ditch A water and the underlying Solvay waste substrate, mitigate erosion of underlying Solvay waste substrate, and provide a suitable habitat layer area for plants and wildlife. After placement of the liner, the ditch (including the embayment) will be returned to the existing geometry and grade after restoration with a clean stone layer and native species restored on the banks of the area.

Mitigation Wetlands

Wetland mitigation will include the construction of a minimum of 9.5 acres, of which 2.3 acres will be connected wetlands and 7.2 acres will be inland wetlands. These wetlands on the Site will mitigate for wetlands and open water aquatic habitat disturbed by the Willis/Semet IRM (2.3 acres), Wastebed B/Harbor Brook IRM (6.5 acres), and Wastebeds 1 through 8 Integrated IRM (0.7 acres).

The wetland mitigation complex is located within the low-lying eastern shoreline of the Site along the southern shoreline of Onondaga Lake. The wetland mitigation design considered habitat components within the areas adjacent to the wetland, including adjacent upland habitat, to complement the wetland and aquatic habitat while affording water quality protection to the mitigation wetlands.

Schedule

Implementation of the Integrated IRM began in 2012 and is currently ongoing. Substantial completion of the Integrated IRM is anticipated to occur in 2014.

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, 2007g) and the *March 1, 2010 Deep Groundwater Investigation Work Plan* (O'Brien & Gere, 2010c). The *Deep Groundwater Investigation Report* was submitted to the NYSDEC in January 2011 (O'Brien & Gere 2011c).

The objectives of the DGWI 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. Groundwater samples were collected from the Wastebeds 1 through 8 Site during Phase 1 of the DGWI, and included:

- Nine samples from overburden groundwater (comprising the intermediate and deep groundwater zones) for VOCs
- Ten samples from overburden groundwater for anions/cations, alkalinity, and hardness
- Eighteen samples from overburden groundwater for tritium and stable isotopes
- Six samples from the bedrock groundwater zone for VOCs
- Seven samples from bedrock groundwater for anions/cations, alkalinity, and hardness
- Four samples from bedrock groundwater for tritium and stable isotopes

Benzene, toluene, ethylbenzene, and xylenes (BTEX) are the primary VOCs detected in the nine samples collected from the Wastebeds 1 through 8 overburden groundwater. Benzene was detected in seven of the nine samples with a concentration range of 7.64 µg/L (WB18-MW-16D) to 11,400 µg/L (WB18-MW-01D) and mean of 3,316 µg/L. Total BTEX concentrations were calculated for the seven samples with detected BTEX compounds, and the concentration range was 10.2 µg/L (WB18-MW-16D) to 11,400 µg/L (WB18-MW-01D), with benzene contributing 15% to 100% (mean = 84%) of the total BTEX. Exceedances of Class GA standards and guidance values were observed for BTEX and acetone.

The major cations and anions were detected in all ten of these samples. Sodium, chloride, sulfate, and magnesium concentrations exceeded their Class GA standards and guidance values for most samples.

BTEX and acetone are the primary VOCs detected in the six samples collected from the Wastebeds 1 through 8 bedrock groundwater. Benzene was detected in all six samples with a concentration range of 0.24 µg/L (WB18-MW-03BR) to 12,900 µg/L (WB18-MW-13BR). The only exceedances of the Class GA standards and guidance values were for benzene (five).

The results of the DGWI are consistent with the data collected during the completion of the remedial investigation at Wastebeds 1 through 8.

1.6. DOCUMENT ORGANIZATION

The balance of this document contains the following sections:

Section 2 – Remedial Investigation Program: This section describes the field methods used to characterize the Wastebeds 1 through 8 Site.

Section 3 – Study Area Physical Characteristics: This section provides a description of the site topography, drainage, geology, hydrogeology, and groundwater geochemistry.

Section 4 – Nature and Extent of Constituents: This section presents a discussion of the nature and extent of constituents in various media at the Site based on data collected during the PSA (including the Bike Trail surface soil sampling), FRI, RI, Chromium Speciation Investigation, and SRI.

Section 5 – Comparison of Analytical Results to Potentially Applicable Standards and/or Guidance Values: This section presents a comparison of analytical results to potentially applicable standards and/or guidance values.

Section 6 – Constituents Fate, Persistence, and Transport: This section provides a discussion of the fate, persistence, and transport for potential chemical parameters of interest (CPOIs) at the site.

Section 7 – Wetland Delineation: This section provides a summary of the wetland delineation completed at the Site.

Section 8 – Baseline Risk Assessment Summary: This section provides a summary of the Human Health and Baseline Ecological Risk Assessments completed at the Site.

Section 9 – Conceptual Site Model: This section provides the overall conceptual site model for the Site.

Section 10 – Conclusions and Preliminary Remedial Action Objectives: This section provides the conclusions of the remedial investigation and identifies preliminary remedial action objectives to be considered in the Feasibility Study.

2. REMEDIAL INVESTIGATION PROGRAM

This section describes the field methods used to characterize the Wastebeds 1 through 8 Site. As mentioned in Section 1 the RI consisted of the PSA, FRI, RI, Chromium Speciation Investigation and SRI field programs. A photograph log presenting general Site conditions and various work activities discussed below is provided in **Appendix A**.

2.1. SITE CHARACTERIZATION METHODS

The PSA included field activities performed between the summer and winter of 2004, as well as a groundwater sampling event in the summer of 2005. These were conducted in accordance with the PSA Work Plan (O'Brien and Gere, 2004a) and QAPP (O'Brien & Gere, 2004b). The FRI included field activities conducted between the summer of 2005 and the spring of 2006 in accordance with the FRI Work Plan (O'Brien & Gere, 2005b) and QAPP (O'Brien & Gere, 2004b). The RI field activities were performed from January 2007 through August 2007 in accordance with the RI work plan (O'Brien and Gere, 2006) and QAPP (O'Brien and Gere, 2006a). The Chromium Speciation Investigation field work was performed in May 2008 in accordance with the Chromium Speciation Work Plan (O'Brien & Gere 2008d). The SRI included field activities were conducted between June 2009 and November 2009 in accordance with the SRI work plan (O'Brien & Gere, 2009a). All five investigations were performed in accordance with the *Wastebeds 1 through 8 Site HASP* (O'Brien and Gere, 2003a).

The following field activities were performed as part of the PSA, FRI, RI, Chromium Speciation Investigation, and SRI:

- Site reconnaissance, flagging, and utility clearance
- Soil sampling
  - Surface soil sampling (including Onondaga Canalways Trail Section 1 surface soil sampling)
  - Subsurface soil sampling
    - Soil borings
    - Test pit excavations
- Groundwater screening
- Monitoring well installation
- Well development
- Hydraulic conductivity measurements (K-tests)
- Synoptic groundwater measurements
  - Continuous groundwater level monitoring
  - Specific gravity evaluation
- Groundwater sampling
- Aquifer pumping tests
- Packer tests
- Surface water sampling
- Sediment sampling
- Seep reconnaissance and sampling
- Vapor intrusion evaluation
- Wetland delineation and floodplain assessment

- Geophysical survey
- Floodplain survey
- Phase 1A and Phase 1B cultural resource surveys
- Site survey/topographic map

Sample summary matrices are provided for the PSA, FRI, RI, and SRI in **Table 1**.

2.1.1. Site Reconnaissance, Flagging, and Utility Clearance

Prior to the initiation of PSA, FRI, RI, and SRI field activities, sampling locations were staked in concurrence with Honeywell and the NYSDEC. Dig Safely New York (formerly Underground Facilities Protection Organization) was notified prior to intrusive activities at the Site, and underground utilities at the Site were marked by the representatives of those utility owners. Once utilities were marked, sample locations were relocated, as necessary, so the intrusive work would not impact Site utilities.

2.1.2. Soil Sampling

Soil sampling was performed during the PSA, FRI, RI, Chromium Speciation Investigation, and SRI. Site soils were characterized from surface and subsurface soil samples collected from surface soil locations, soil boring locations, and test pit locations. A description of these activities is provided below.

2.1.2.1. Surface Soil Sampling

Surface soils were collected as part of the PSA (including the Canalways Bike Trail surface soil sampling), RI, Chromium Speciation Investigation, and SRI. The RI surface soils were collected to further characterize the areas around SS-02, SS-19, and SS-20. The Chromium Speciation Investigation soils were collected to evaluate hexavalent chromium at the site and to establish ratios of trivalent to hexavalent chromium across the site. The SRI surface soils focused on the eastern shoreline to fill data gaps in this area. Surface soils are considered any sample collected between 0 and 2 ft below ground surface (bgs). A description of the sampling performed during each phase is presented below.

PSA Surface Soils

During the PSA, a total of 35 samples were collected from a depth of 0 to 0.5 ft bgs, and 34 samples were collected from 0.5 to 1 ft bgs from 35 locations (SS-01 through SS-35). A sample was not collected from the 0.5 to 1 ft interval at location WB18-SS-17 (SS-17) due to refusal. Twenty-seven of these locations were located immediately adjacent to test pits. These locations include SS-01 through SS-24 and SS-26 through SS-28. Four surface soil locations were located directly adjacent to direct push borings. Surface soils SS-32, SS-33, SS-34, and SS-35 were located next to GWS-16, GWS-17, GWS-18, and GWS-19, respectively. The remaining surface soil locations were located within the State Fair Parking areas. These include SS-29, SS-30, and SS-31. Location SS-25 was collected between the east and west bound lanes of I-690.

Table 2 lists the sample locations, depth interval, and analyses performed for surface soils collected during the PSA. The sample locations are presented on **Figure 4A**.

Surface soil samples were collected between June 17 and June 22, 2004. Samples were collected using hand augers and transferred to dedicated aluminum pans using dedicated plastic scoops. The samples were homogenized, transferred to sample containers provided by the laboratory, and placed in a cooler on ice. Representative grab samples were collected for VOCs prior to the homogenization. Chain of Custody forms were initiated at the time of sampling and remained with the samples during transport to O'Brien & Gere Laboratories. Chain of Custody forms are included in **Appendix B**.

The samples were analyzed using USEPA SW-846 Methods. Target compound list/target analyte list (TCL/TAL) analyses were performed using Methods 8260B, 8270C, 8081, 8082, 6010B, 7471A, and 9010B/9012A for VOCs, SVOCs, pesticides, PCBs, metals, mercury, and cyanide, respectively. PCB analysis included Aroclor 1268.

Bike Trail Surface Soils

Concurrent with the PSA sampling, ten surface soil samples were collected on the Wastebeds 1 through 8 Site along the proposed bike trail. Nine samples were collected from depths of 0 to 0.5 ft bgs from locations BT-SS-09 through BT-SS-15, BT-SS-21, and BT-SS-22. In addition, one sample was collected from a depth of 1 to 2 ft bgs at location BT-SS-09. **Table 3** presents the sample locations, depth intervals, and analyses performed for surface soils collected along the proposed bike trail. The sample locations are presented on **Figure 4A**.

Surface soil samples were collected between June 24 and June 28, 2004. Samples were collected using hand augers and transferred to dedicated aluminum pans using dedicated plastic scoops. The samples were homogenized, transferred to sample containers provided by the laboratory, and placed in a cooler on ice. Representative grab samples were collected for VOCs prior to the homogenization. Chain of Custody forms were initiated at the time of sampling and remained with the samples during transport to O'Brien & Gere Laboratories. Chain of Custody forms are included in **Appendix B**.

The samples were analyzed using USEPA SW-846 Methods. TCL/TAL analyses were performed using Methods 8260B, 8270C, 8081, 8082, 6010B, 7471A, and 9010B/9012A for VOCs, SVOCs, pesticides, PCBs, metals, mercury, and cyanide, respectively. PCB analysis included Aroclor 1268. Two samples, BT-SS-21 and BT-SS-22, were analyzed for select SVOCs and mercury only using methods 8270C and 7471A, respectively.

Two woody tissue samples were collected in addition to the bike trail surface soil sampling. These samples were collected in conjunction with surface soil samples BT-SS-11 and BT-SS-13 and were collected from the woody tissues of trees located adjacent to the surface soil samples. The purpose of the sampling was to evaluate mercury concentrations in trees and shrubs that are to be removed during bike trail construction and potential disposal options. These data will not be discussed in Section 4.

The tree samples were collected using a tree-coring device that was decontaminated prior to sampling at each location. Approximately 100 grams of sample was collected at each location and avoided vegetation that had come in contact with the underlying soils. The samples were placed in labeled plastic bags, stored in a cooler with ice, and shipped to O'Brien & Gere Laboratories for analysis. Chain of Custody forms were initiated at the time of sampling and remained with the samples during transit to the laboratory. Samples were analyzed for mercury using USEPA SW-846 Method 7471A.

RI Surface Soils

During the RI, a total of 24 samples were collected from 12 locations (12 from 0 to 0.5 ft bgs and 12 from 0.5 to 1 ft bgs). Locations were selected based on surface soils results from the PSA and located in clusters of four around PSA surface soil locations SS-02, SS-19, and SS-20 to further characterize these areas. **Table 4** presents the sample locations, depth intervals, and analyses performed for surface soils collected during the RI. The sample locations are presented on **Figure 4A**.

RI surface soil samples were collected on March 28, 2007 and March 29, 2007. Samples were collected using hand augers and transferred to dedicated aluminum pans using dedicated plastic scoops. The samples were homogenized, transferred to sample containers provided by the laboratory, and placed in a cooler on ice. Representative grab samples were collected for VOCs prior to the homogenization. Chain of Custody forms were initiated at the time of sampling and remained with the samples during transport to Columbia Analytical Services, Inc (CAS). Chain of Custody forms are included in **Appendix B**.

The samples were analyzed using USEPA SW-846 Methods. TCL/TAL analyses were performed using Methods 8260B, 8270C, 8081A, 8082, 6010B, 7471A, and 9010B/9014C for VOCs, SVOCs (including polychlorinated naphthalenes), pesticides, PCBs, metals, mercury, and cyanide, respectively. PCB analysis included Aroclor 1268.

Chromium Speciation Surface Soils

During the Chromium Speciation Investigation, a total of 41 samples (0 to 2 ft bgs) were collected from 41 locations throughout Site. Samples were collected to evaluate hexavalent chromium at the site and to establish ratios of hexavalent chromium to trivalent chromium across the site for use in the risk assessments. Six samples were associated with previous sampling locations (SS-02, SP-07, SP-15, SP-16, SP-24, and SP-62). Twelve samples were co-located with soil borings advanced for this investigation (SB-124 through SB-135), and 23 sample locations were independently located (SS-36 through SS-58). A description of the soil borings is presented below. **Table 5** presents the sample locations, depth intervals, and analyses performed for surface soils collected during this investigation. The sample locations are presented on **Figure 4A**.

The surface soil samples were collected on May 19, 20, and 21, 2008. Samples were collected using hand augers and transferred to dedicated aluminum pans using dedicated plastic scoops. The samples were homogenized, transferred to sample containers provided by the laboratory, and placed in a cooler on ice. Chain of Custody forms were initiated at the time of sampling and remained with the samples during transport to Test America Laboratories, Inc (Test America). Chain of Custody forms are included in **Appendix B**. These samples were analyzed for total chromium and Cr^{+6} using methods 6010B and 3060A/7199, respectively.

SRI Surface Soils

During the SRI, a total of fourteen samples (seven from 0 to 0.5 ft bgs and seven from 0.5 to 1 ft bgs) were collected from seven locations along the eastern shoreline of Onondaga Lake. These samples were collected to address data gaps and further evaluate surface soils on the lakeshore portion of the site. Five sample locations were co-located with soil borings SB-165, SB-172, SB-174, SB-175, and SB-178; the other two surface soil sample locations (SS-59 and SS-60) were independently located. **Table 6** presents the sample locations, depth intervals, and analyses performed for surface soils collected during the SRI. The sample locations are presented on **Figure 4A**.

SRI surface soil samples were collected on June 1 and 2, 2009. Samples were collected using hand augers and transferred to dedicated aluminum pans using dedicated plastic scoops. The samples were homogenized, transferred to sample containers provided by the laboratory, and placed in a cooler on ice. Representative grab samples were collected for VOCs prior to the homogenization. Chain of Custody forms were initiated at the time of sampling and remained with the samples during transport to TestAmerica. Chain of Custody forms are included in **Appendix B**.

The samples were analyzed using USEPA SW-846 Methods. TCL/TAL analyses were performed using Methods 8260B, 8270D, 6010C, 7471A, and 9010B/9014C for VOCs, SVOCs (including PXE and PTE), metals, mercury, and cyanide, respectively. Samples were also analyzed for hexavalent chromium and total organic carbon (TOC) using Method 3060A/7199 and Lloyd Kahn, respectively.

2.1.2.2. Subsurface Soil Sampling

During the PSA, FRI, RI, Chromium Speciation Investigation, and SRI, subsurface soil samples (> 2 ft) were collected from soil borings and test pits. A description of the sampling performed during each phase is presented below.

PSA Soil Borings

During the PSA, soil borings were advanced at 28 locations to characterize subsurface soils and facilitate monitoring well installation. A total of 23 samples were collected from the eight deep borings. **Table 7** presents the sample locations, depth intervals, and analyses performed for subsurface soils collected during the PSA. The boring locations are presented on **Figure 4B**.

Soil borings were advanced between July 6 and October 11, 2004. The soil borings were advanced using direct push drilling techniques, and samples were collected continuously throughout the borings in accordance with ASTM Method D1586-84 using a 140-lb hammer and 2-ft split-barrel samplers.

The drilling was performed by Parratt-Wolff under the supervision of an O'Brien & Gere geologist. The geologist completed a boring log for each boring to document encountered subsurface strata and other pertinent field observations. Each split spoon was screened using a photoionization detector (PID). Pertinent field observations are included in **Table 8**. The boring logs are included in **Appendix C**.

Based on the results of the screening and field observations, samples were submitted for laboratory analyses for each deep boring. Chain of Custody forms were initiated at the time of sampling and remained with the samples during transport to O'Brien & Gere Laboratories. Chain of Custody forms are included in **Appendix B**. The samples were analyzed using USEPA SW-846 Methods. TCL/TAL analyses were performed using methods 8260B, 8270C, 8081, 8082, 6010B, 7471A, and 9010B/9012A for VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, and cyanide, respectively.

In addition, one soil sample was collected from each deep soil boring for Toxicity Characteristic Leachate Procedure (TCLP) analyses, reactivity, and ignitability. TCLP parameter analyses were performed using the methods listed above and extraction Method 1311. Ignitability was analyzed using Method 1030, and reactivity was analyzed using *Test Method to Determine Hydrogen Sulfide Released from Wastes*. A sample collected for TCLP was analyzed if results from the corresponding totals sample was 20 times greater than the regulatory limit or totals results were unavailable within the specified holding times for the TCLP samples. Sample specific TCLP analyses performed on these samples are presented in **Table 7**.

The drill rig, split spoons, and other tools that came into contact with the soils were decontaminated with high pressure steam prior to each boring. In addition, the split spoons were decontaminated between each sample as outlined in the *Wastebeds 1 through 8 Site QAPP* (O'Brien & Gere, 2004b). Equipment blanks were collected by running distilled water through the decontaminated split spoon and collecting it in the appropriate laboratory containers.

FRI Soil Borings

During the FRI, soil borings were advanced for source characterization, former Ninemile Creek sand and gravel channel delineation, monitoring well installation, and subsurface soil evaluation. These soil borings were advanced between October 2005 and March 2006. Samples were collected based on field screening results and visual observations. **Table 9** lists the soil boring locations, sample depth intervals, and analyses performed for subsurface soils collected during the FRI. The boring locations are presented on **Figure 4B**. A brief synopsis for each of the different boring types is provided below.

FRI Source Characterization Soil Borings

Fifteen samples were collected from fourteen soil boring locations (SB-32 through SB-44 and SB-46BR) advanced for source characterization. Soil borings installed for this purpose were advanced 2 ft into the silt and clay or fine sand/silt layers. These borings were advanced, and samples were collected to evaluate subsurface strata and to quantify constituent concentrations in subsurface soil, and to evaluate visible staining in subsurface soils.

Former Ninemile Creek Sand and Gravel Delineation Borings

Six samples were collected from five soil borings (SB-27NM through SB-31NM) advanced to evaluate the extent of the localized alluvial deposits related to the former Ninemile Creek channel. Soil borings installed for the Ninemile Creek bed delineation were advanced to the top of the silt and clay layer. These borings were advanced to quantify constituent concentrations in subsurface soils, evaluate stratigraphy along Ninemile Creek, evaluate the historical Ninemile Creek channel, evaluate the presence and depth of the confining layer, obtain field information relative to strength parameters of fill and soil, and obtain samples for geotechnical analyses.

Soil Borings to Facilitate Monitoring Well Installation

Twenty samples were collected from 27 borings advanced to facilitate monitoring well installation. Seven monitoring well clusters (MW-09, MW-10, MW-13, MW-14, MW-16, MW-17, and MW-18), two single shallow monitoring wells (MW-12S and MW-15S), and two single bedrock wells (MW-19BR and MW-20BR) were installed as part of the FRI. These borings were advanced to quantify constituent concentrations in subsurface soils, evaluate subsurface geologic strata and facilitate the installation of monitoring wells.

Subsurface Soil Evaluation Borings

Twenty-nine samples were collected from twenty-six soil boring locations (SB-01 through SB-26) advanced for subsurface soil evaluation. Soil borings SB-09BR, SB-13BR, SB-16BR, SB-19BR, and SB-24BR were all advanced to the top of bedrock. Borings not advanced to bedrock were advanced approximately 10 ft into the silt and clay confining layer. Samples were collected based on field screening results and visual observations. **Table 9** lists the sample locations, depth intervals, and analyses performed for subsurface soils collected during the FRI. The boring locations are presented on **Figure 4B**. These borings were advanced to quantify constituent concentrations in subsurface soils, evaluate stratigraphy along the lakeshore, evaluate the presence and depth of the confining layer, obtain field information relative to strength parameters of fill and soil, and obtain samples for geotechnical analyses.

FRI Drilling Methods

The drilling was performed by Parratt-Wolff under the supervision of an O'Brien & Gere geologist. The geologist completed a boring log for each boring to document encountered subsurface strata and other pertinent field observations. Each split spoon was screened using a PID and ultraviolet (UV) light. Pertinent field observations are included on **Table 10**. The boring logs are included in **Appendix C**.

Shallow Soil Borings. Soil borings that did not penetrate the silt and clay layer were advanced using conventional hollow stem auger drilling techniques. Samples were collected continuously throughout the borings in accordance with ASTM Method D1586-84 using a 140-lb hammer and 2-ft split-barrel samplers. Soil borings not converted to monitoring wells were grouted to the surface with bentonite upon completion.

Soil Borings penetrating the Silt and Clay Layer. Soil borings that penetrated the silt and clay layer were installed using double cased methods. Double cased installations were conducted by advancing 6¼-inch inside diameter augers from the ground surface to a minimum depth of 5 ft below the top of the silt and clay layer. During advancement of the 6¼-inch augers, soil samples were collected at continuous 2-ft intervals using 2-inch diameter split-barrel samplers in accordance with ASTM Method D1586-84. At locations where borings were previously completed, samples were not collected in duplicate intervals. Upon completion of advancement of the 6¼-inch augers, 4-inch diameter steel casing fitted with a plastic end cap was lowered through the auger string. The annular space between the borehole wall and the 4-inch casing was filled with cement/bentonite grout using a tremie pipe as the auger string is removed. A head of grout was maintained within the auger string until all of the augers were removed from the borehole. The grout was allowed to cure for a minimum of 12 hours prior to further borehole advancement.

Subsequent to curing of the grout, fluid-rotary drilling methods were used to advance the boreholes to the terminal depths. A nominal 3.875-inch diameter roller bit was used to advance the boreholes. Potable water was recirculated through the drill stem to carry soil cuttings to the ground surface. Cuttings that were carried to the ground surface were initially contained in the recirculation tub and transferred to 55-gallon drums as needed. During the fluid-rotary drilling, soil samples were collected at continuous 2-ft intervals in accordance with ASTM Method D1586-84.

FRI Subsurface Soil Evaluation Borings (Geotechnical borings). The borings were installed using a 6-inch hollow stem augers in accordance with ASTM D1452. Continuous split spoon samples were collected for the entire depth for the boring in accordance with ASTM D1586, "Standard Method for Penetration Test and Split Barrel Sampling of Soils." Once the silt and clay layer was encountered, an undisturbed Shelby tube sample was collected in accordance with ASTM D1587 "Standard Practice for Thin-Walled Tube Sampling of Soils" for subsequent laboratory testing. Following the completion of each boring, the borehole was backfilled and sealed with a bentonite grout mixture.

FRI Soil Boring Analytical Summary

Based on the results of the screening and field observations, samples were submitted for laboratory analyses from each boring. Chain of Custody forms were initiated at the time of sampling and remained with the samples during transport to Columbia Analytical Services, Inc. and are included in **Appendix B**.

Samples collected from source characterization, Ninemile Creek sand and gravel channel delineation, monitoring well installation, and subsurface evaluation soil borings were analyzed using USEPA SW-846 Methods. TCL/TAL analyses were performed using methods 8260B, 8270C, 8081, 8082, 6010B, 7471A, and 9010B/9014C for VOCs, SVOCs, pesticides, PCBs, metals, mercury, and cyanide, respectively.

Geotechnical data samples were also collected from the subsurface evaluation borings. A summary of the samples collected, their depths, the analysis performed, and results are presented in **Appendix D**.

The drill rig, split spoons, and other tools that came into contact with the soils were decontaminated with high pressure steam prior to each boring. In addition, the split spoons were decontaminated between each sample outlined in the *Wastebeds 1 through 8 Site QAPP* (O'Brien & Gere, 2004b). Equipment blanks were collected by running distilled water through the decontaminated split spoon and collecting it in the appropriate laboratory containers.

RI Soil Borings

During the RI, soil borings were advanced at 20 locations, and a total of 16 soil samples were collected. Five soil borings were advanced to evaluate subsurface strata (targeting the fill and marl layers), with one sample being collected from each boring location. Seven overburden soil borings were advanced to facilitate monitoring well installation, with two samples collected per well cluster and one sample taken at MW-23I. Six soil borings were advanced to facilitate bedrock monitoring well installations with one soil sample collected at each boring. Two additional borings, MW-13BR2 and MW-22D2, were advanced adjacent to existing holes MW-13BR and MW-22D, respectively. No soil samples were collected at these two locations. MW-13BR2 was advanced to replace the original bedrock boring (MW-13BR) that was abandoned when the hole collapsed and to facilitate installation of a monitoring well. MW-22D2 was advanced to replace well MW-22D that was abandoned due to grout within the screen interval. **Table 11** lists the soil boring sample locations, depth intervals, and analyses performed for subsurface soils collected during the RI. The boring locations are presented on **Figure 4B**.

Soil borings were advanced between January 11 and April 5, 2007. Soil borings that did not penetrate the silt and clay layer were advanced using conventional hollow stem auger drilling techniques. Samples were collected continuously throughout the borings in accordance with ASTM Method D1586-84 using a 140-lb hammer and 2-ft split-barrel samplers. The drilling was performed by Parratt-Wolff under the supervision of an O'Brien & Gere geologist. The geologist completed a boring log for each boring to document encountered subsurface strata and other pertinent field observations. Each split spoon was screened using a PID and UV light. Pertinent field observations are included on **Table 12**. The boring logs are included in **Appendix C**.

Soil borings that penetrated the silt and clay layer were installed using double cased methods. These methods are described above in "**FRI Drilling Methods**".

The drilling was performed by Parratt-Wolff under the supervision of an O'Brien & Gere geologist. The geologist completed a boring log for each boring to document encountered subsurface strata and other pertinent field observations. Each split spoon was screened using a PID. Pertinent field observations are included on **Table 12**. The boring logs are included in **Appendix C**.

Based on the results of the field screening and visual observations, samples were submitted for laboratory analyses from each boring. Chain of Custody forms were initiated as the samples were collected and remained with the samples during transport to Columbia Analytical Services. Chain of Custody forms are included in **Appendix B**.

The samples were analyzed using USEPA SW846 methods. TCL/TAL analyses were performed using methods 8260B, 8270C, 8081A, 8082, 6010B, 7471A, and 9010C/9014C for VOCs, SVOCs, pesticides, PCBs, metals, mercury, and cyanide, respectively. The laboratory also reported 1-phenyl-1-[2,4-dimethylphenyl]-ethane (PXE) and 1-phenyl-1-[4-methylphenyl]-ethane (PTE) under the SVOC analytical results.

The drill rig, split spoons, and other tools that came into contact with the soils were decontaminated with high pressure steam prior to each boring. In addition, the split spoons were decontaminated between each sample outlined in the *Wastebeds 1 through 8 Site QAPP* (O'Brien & Gere, 2004b). Equipment blanks were collected by running distilled water through the decontaminated split spoon and collecting it in the appropriate laboratory containers.

Chromium Speciation Investigation Soil Borings

During the Chromium Speciation Investigation, soil borings were advanced on May 21 and 22, 2008 at the following locations: SB-124 through SB-135. Twelve 2-ft interval subsurface soil samples from these locations were collected between 2 and 10 ft bgs. **Table 13** lists the soil boring locations, sample depth intervals, and analyses performed for subsurface soils collected during this investigation. The boring locations are presented on **Figure 4B**. These borings were advanced, and samples were collected in order to evaluate hexavalent chromium in subsurface soils and to establish ratios of hexavalent chromium to trivalent chromium in across the site.

The drilling was performed by Parratt-Wolff under the supervision of an O'Brien & Gere geologist. The geologist completed a boring log for each boring to document encountered subsurface strata and other pertinent field observations. Each split spoon was screened using a PID. The boring logs are included in **Appendix C**.

The soil borings were advanced using conventional hollow stem auger drilling techniques. Samples were collected continuously throughout the borings in accordance with ASTM Method D1586-84 using a 140-lb hammer and 2-ft split-barrel samplers. Soil borings were grouted to the surface upon completion. This method was described above in "**FRI Drilling Methods**".

Chain of Custody forms were initiated at the time of sampling and remained with the samples during transport to TestAmerica and are included in **Appendix B**. These samples were analyzed for total chromium and Cr^{+6} using methods 6010B and 3060A/7199, respectively.

The drill rig, split spoons, and other tools that came into contact with the soils were decontaminated with high pressure steam prior to each boring. In addition, the split spoons were decontaminated between each sample outlined in the *Wastebeds 1 through 8 Site QAPP* (O'Brien & Gere, 2004b). Equipment blanks were collected by running distilled water through the decontaminated split spoon and collecting it in the appropriate laboratory containers.

Supplemental RI Soil Borings

During the SRI, soil borings were advanced for the eastern shoreline evaluation and the former Ninemile Creek sand and gravel channel. Soil borings were advanced between June 2009 and August 2009. Subsurface soil samples were collected based on field screening results and visual observations, while eastern shoreline surface soils were collected from 0 to 0.5 ft and 0.5 to 1 ft bgs. A brief synopsis for each of the different boring types is provided below. The boring locations are presented on **Figure 4B**.

The drilling was performed by Parratt-Wolff under the supervision of an O'Brien & Gere geologist. The geologist completed a boring log for each boring to document encountered subsurface strata and other pertinent field observations. Each split spoon was screened using a PID. Pertinent field observations are included on **Table 15**. The boring logs are included in **Appendix C**.

The soil borings were advanced using conventional hollow stem auger drilling techniques. Samples were collected continuously throughout the borings in accordance with ASTM Method D1586-84 using a 140-lb hammer and 2-ft split-barrel samplers. Soil borings were grouted to the surface upon completion. This method was described above in "**FRI Drilling Methods**".

The drill rig, split spoons, and other tools that came into contact with the soils were decontaminated with high pressure steam prior to each boring. In addition, the split spoons were decontaminated between each sample outlined in the *Wastebeds 1 through 8 Site QAPP* (O'Brien & Gere, 2004b). Equipment blanks were collected by running distilled water through the decontaminated split spoon and collecting it in the appropriate laboratory containers.

Eastern Shoreline Evaluation Borings

Fifteen soil boring locations (SB-164A through SB-178) were advanced approximately 4 ft into the marl layer for the eastern shoreline evaluation. Two samples per boring were collected from ten borings with one sample from the fill material and one sample from the fill/marl interface. Samples were collected every 2 ft below the 0 to 2 ft interval from SB-165 (three samples), SB-172 (five samples), SB-174 (five samples), SB-175 (three samples), and SB-178 (six samples) until the terminal end of the boring. These borings were advanced and samples were collected to further evaluate the subsurface geologic strata and extent of contamination along the eastern lakeshore.

Former Ninemile Creek Sand and Gravel Channel and Wastebeds 5 and 6 Evaluation Borings

Five soil borings (SB-154, SB-156, SB-160, SB-161, and SB-162) were advanced within the known area of the former Ninemile Creek sand and gravel channel. Six soil borings were advanced outside the delineated channel, with two situated to the east (SB-163 and SB-164) and four situated to the west (SB-155, SB-157, SB-158, and SB-159). The soil borings were advanced to approximately 4 ft into the silt and clay layer. One sample was collected from each soil boring at the fill/marl interface, and additional samples were collected from every boring location except SB-157. A total of 25 subsurface soil samples were collected during this evaluation. These borings were advanced, and samples were collected to evaluate the extent of staining in Wastebeds 5 and 6, refine the extent of the historic Ninemile Creek channel, and to facilitate monitoring well installation within the Ninemile Creek deltaic sand and gravel deposits so groundwater flow within the formation could be further evaluated.

Supplemental RI Soil Boring Analytical Summary

Samples collected from the Ninemile Creek deltaic deposits and Wastebeds 5 and 6 evaluation and eastern shoreline evaluation soil borings were analyzed using USEPA SW-846 Methods. TCL/TAL analyses included 8260B, 8270C, 6010C, 7471A, 9010/9014, and Lloyd Kahn for VOCs, SVOCs (including PXE and PTE), metals, mercury, cyanide, and TOC, respectively.

PSA Test Pits

Test pits were advanced between June 1 and June 22, 2004. A total of 28 test pits were advanced during the PSA using a tracked excavator to evaluate the physical and chemical characteristics of shallow subsurface soils (0 to 10 ft) on the Site. Test pits were approximately 150 ft in length and 3 ft in width, and 10 ft deep. **Table 16** lists the sample locations, depth intervals, and analyses performed for test pit soils collected during the PSA.

The excavated materials were staged adjacent to the pit pending visual inspection and collection of samples. The test pit locations are presented on **Figure 4C**. Test pit logs are presented in **Appendix E.** A PID was used to screen collected samples and monitor the breathing zone during excavation, and a PID and Dustrak air particle monitor were used to monitor an upwind location from the test pits. Pertinent field observations are presented in **Table 17**. The excavator was decontaminated between test pits with a steam cleaner. The waste water derived from decontamination was containerized, tested, and disposed of at an acceptable off-site facility.

A total of 28 samples were collected for TCL/TAL analyses from the 28 test pits. Samples were collected by transferring soil from the backhoe bucket to a dedicated aluminum pan and homogenized using a dedicated plastic scoop. Prior to homogenization, a sample for VOCs analysis was collected and containerized. Subsequent to homogenization, soils were collected for the remainder of analyses. Test pit samples were submitted to O'Brien & Gere Laboratories for TCL/TAL analyses by USEPA SW-846 Methods 8260, 8270C, 8081, 8082, 6010B, 7471, and 9010B/9012A for VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), inorganics, mercury, and cyanide, respectively.

In addition, one soil sample was collected from each test pit for Toxicity Characteristic Leachate Procedure (TCLP) analyses, reactivity, and ignitability. TCLP parameter analyses were performed using the methods listed above and extraction Method 1311. Ignitability was analyzed using Method 1030, and reactivity was analyzed using *Test Method to Determine Hydrogen Sulfide Released from Wastes*. A sample collected for TCLP was analyzed if results from the corresponding totals sample was 20 times greater than the regulatory limit or totals results were unavailable within the specified holding times for the TCLP samples. Sample specific TCLP analyses performed on these samples are presented in **Table 16**.

2.1.3. Overburden Groundwater Screening

PSA Groundwater Screening

During the PSA, 52 groundwater screening samples were collected at 20 locations. Groundwater screening samples were collected from first encountered groundwater, at the bottom of Solvay waste, and in the marl/peat. **Table 18** lists the sample locations, depth interval, and analyses performed for samples collected during the PSA. The groundwater screening locations are presented on **Figure 4D**.

The soil borings were advanced using direct push drilling techniques. Samples were collected continuously throughout the borings in accordance with ASTM Method D1586-84 using a 140-lb hammer and 2-ft split-barrel samplers. The drilling was performed by Parratt-Wolff under the supervision of an O'Brien & Gere geologist. The geologist completed a boring log for each boring to document encountered subsurface strata and other pertinent observations. Each split spoon was screened using a PID. The field screening results are included on the boring logs that are included in **Appendix C**.

Once the desired depth had been reached, a groundwater screening sample was collected. Initially, a geoprobe screen point sampler was attempted for the collection of the groundwater screening samples. The screen point sampler was lowered down the borehole, and the drill rods were retracted to expose the screen point. Due to subsurface conditions, the screen point sampler was unable to produce adequate volumes of water for sample collection. Subsequently a temporary 0.75-inch diameter polyvinyl chloride (PVC) well was installed in the borehole to facilitate groundwater screening sample collection. The groundwater screening sample was collected at first encountered groundwater, the temporary well was removed, and the boring was advanced to the next desired depth (bottom of Solvay waste). The temporary well installation and groundwater screening collection procedure was performed again. Each borehole was terminated approximately 2 ft into the silt and clay layer below the marl/peat layer, and the final groundwater screening sample was collected in the marl/peat layer.

Groundwater screening samples were submitted for laboratory analyses. Chain of Custody forms were initiated at the time of collection and remained with the samples during transport to O'Brien & Gere Laboratories. Chain of Custody forms are included in **Appendix B**.

The samples were submitted to O'Brien & Gere Laboratories for TCL/TAL analyses by USEPA SW846 methods 8260B, 8270C, 8081, 8082, 6010B, 7470A, 9010B/9012A for VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, and cyanide, respectively. Samples were also analyzed for hardness, alkalinity, and major cations (Ca, Mg, Na) and anions (Cl, SO_4, CO_3, HCO_3) using methods 310.1/2320B, 2340B, and 6010/E300/2320B, respectively.

FRI Groundwater Screening

During the FRI, six overburden groundwater screening samples were collected at two bedrock monitoring well locations (MW-19BR, and MW-20BR). **Table 19** lists the sample locations, depth intervals, and analyses performed for samples collected during the FRI. The groundwater screening locations are presented on **Figure 4D**.

The drilling was performed by Parratt-Wolff under the supervision of an O'Brien & Gere geologist. The geologist completed a boring log for each boring to document encountered subsurface strata and other pertinent observations. Each split spoon was screened using a PID and UV light. The field screening results are included on the boring logs that are included in **Appendix C**.

The two borings associated with the FRI groundwater screening penetrated the silt and clay layer and were installed using double cased methods. Double cased installations were conducted by advancing 6¼-inch inside diameter augers from the ground surface to a minimum depth of 5 ft below the top of the silt and clay layer. During advancement of the 6¼-inch augers, soil samples were collected at continuous 2-ft intervals using 2-inch diameter split-barrel samplers in accordance with ASTM Method D1586-84. At locations where borings were previously completed, samples were not collected in duplicate intervals. Upon completion of advancement of the 6¼-inch augers, 5-inch diameter steel casing fitted with a plastic end cap was lowered through the auger string. The annular space between the borehole wall and the 4-inch casing was filled with cement/bentonite grout using a tremie pipe as the auger string is removed. A head of grout was maintained within the auger string until all of the augers were removed from the borehole. The grout was allowed to cure for a minimum of 12 hours prior to further borehole advancement.

Subsequent to curing of the grout, fluid-rotary drilling methods were used to advance the boreholes to the terminal depths. A nominal 3.875-inch diameter roller bit was used to advance the boreholes. Potable water was recirculated through the drill stem to carry soil cuttings to the ground surface. Cuttings carried to the ground surface were initially contained in the recirculation tub and transferred to 55-gallon drums as needed. During the fluid-rotary drilling, soil samples were collected at continuous 2-ft intervals in accordance with ASTM Method D1586-84.

During the fluid rotary drilling, a temporary casing was advanced to facilitate collection of groundwater screening samples. Upon reaching the desired depth, first encountered groundwater below the silt and clay layer, a temporary PVC well was placed inside the temporary casing. The temporary casing was retracted to expose the screen of the temporary PVC well, and the formation was allowed to collapse around the screen. Three well volumes were removed to remove potable water associated with the fluid rotary drilling and ensure that formation water was collected for the sample. Dedicated tubing and a peristaltic pump were used to obtain the sample.

Once the sample was collected, the temporary casing and temporary PVC well were removed from the borehole. Samples were collected from each 10-ft interval after the first encountered groundwater until the boring reached bedrock.

Upon reaching the top of bedrock, a 4-inch steel casing was set 2 to 4 ft into the top of bedrock. The bedrock boreholes and the associated groundwater screening samples and packer testing are discussed below in Section 2.1.4.

Groundwater screening samples were submitted for laboratory analyses. Chain of Custody forms were initiated at the time of collection and remained with the samples during transport to Columbia Analytical Services. Chain of Custody forms are included in **Appendix B**.

The samples were submitted to Columbia Analytical Services, Inc. for TCL/TAL analyses by USEPA SW846 methods 8260B, 8270C, 8081, 8082, 6010B, 7470A, 9010B/9014 for VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, and cyanide, respectively. Samples were also analyzed for hardness, alkalinity, and major cations (Ca, Mg, Na) and anions (Cl, SO_4, CO_3, HCO_3) using methods 310.1/2320B, 2340B, and 6010/E300/2320B, respectively. Specific gravity (density) was measured at the time of sampling using a hydrometer.

RI Groundwater Screening

During the RI, ten overburden groundwater screening samples were collected from five bedrock monitoring well locations (MW-03BR, MW-04BR, MW-06BR, MW-13BR, and MW-14BR). **Table 20** lists the sample locations, depth interval, and analyses performed for samples collected during the RI. The groundwater screening locations are presented on **Figure 4D**.

The drilling was performed by Parratt-Wolff under the supervision of an O'Brien & Gere geologist. The geologist completed a boring log for each boring to document encountered subsurface strata and other pertinent observations. Each split spoon was screened using a PID and UV light. The field screening results are included on the boring logs that are included in **Appendix C**.

The six borings associated with the RI groundwater screening penetrated the silt and clay layer and were installed using double cased methods. Double cased installations were conducted by advancing 6¼-inch inside diameter augers from the ground surface to a minimum depth of 5 ft below the top of the silt and clay layer. During advancement of the 6¼-inch augers, soil samples were collected at continuous 2-ft intervals using 2-inch diameter split-barrel samplers in accordance with ASTM Method D1586-84. At locations where borings were previously completed, samples were not collected in duplicate intervals. Upon completion of advancement of the 6¼-inch augers, 5-inch diameter steel casing fitted with a plastic end cap was lowered through the auger string. The annular space between the borehole wall and the 4-inch casing was filled with cement/bentonite grout using a tremie pipe as the auger string is removed. A head of grout was maintained within the auger string until all of the augers were removed from the borehole. The grout was allowed to cure for a minimum of 12 hours prior to further borehole advancement.

Subsequent to curing of the grout, fluid-rotary drilling methods were used to advance the boreholes to the terminal depths. A nominal 3.875-inch diameter roller bit was used to advance the boreholes. Potable water was recirculated through the drill stem to carry soil cuttings to the ground surface. Cuttings carried to the ground surface were initially contained in the recirculation tub and transferred to 55-gallon drums as needed. During the fluid-rotary drilling, soil samples were collected at continuous 2-ft intervals in accordance with ASTM Method D1586-84.

During the fluid rotary drilling, a temporary casing was advanced to facilitate collection of groundwater screening samples. Upon reaching the desired depth, first encountered groundwater below the silt and clay layer, a temporary PVC well was placed inside the temporary casing. The temporary casing was retracted to expose the screen of the temporary PVC well, and the formation was allowed to collapse around the screen. Three well volumes were removed to remove potable water associated with the fluid rotary drilling and ensure that formation water was collected for the sample. Dedicated tubing and a peristaltic pump were used to obtain the sample.

Once the sample was collected, the temporary casing and temporary PVC well were removed from the borehole. Samples were collected from each 10-ft interval after the first encountered groundwater until the boring reached bedrock.

Upon reaching the top of bedrock, a 4-inch steel casing was set into the top 2 to 4 ft of bedrock. The bedrock boreholes and the associated groundwater screening samples and packer testing are discussed below in Section 2.1.4.

Overburden groundwater screening samples were submitted for laboratory analyses. Chain of Custody forms were initiated at the time of collection and remained with the samples during transport to Columbia Analytical Services. Chain of Custody forms are included in **Appendix B**.

The samples were submitted to Columbia Analytical Services for TCL/TAL analyses by USEPA SW846 methods 8260B and 8270C for VOCs and SVOCs, respectively. Samples were also analyzed for hardness, alkalinity, and major cations (Ca, Mg, Na) and anions (Cl, SO_4, CO_3, HCO_3) using methods 310.1/2320B, 2340B, and 6010/E300/2320B, respectively. Specific gravity (density) was measured at the time of sampling via a hydrometer.

2.1.4. Bedrock Groundwater Screening and Packer Tests

During the FRI and RI, bedrock borings were advanced to facilitate the installation of monitoring wells. Prior to the installation of the bedrock monitoring wells, packer tests were completed in each of the bedrock core holes to provide hydraulic conductivity data, and discrete groundwater screening samples to be collected. This data was used to select the well screen interval of the bedrock wells.

During the FRI, seven packer tests were performed and seven bedrock groundwater screening samples were collected at two bedrock monitoring well locations (MW-19BR, and MW-20BR). **Table 19** lists the sample locations, depth intervals, and analyses performed for samples collected during the FRI. The groundwater screening locations are presented on **Figure 4D**. During the RI, eleven packer tests were performed, and eleven bedrock groundwater screening samples were collected from four bedrock monitoring well locations (MW-03BR, MW-04BR, MW-09BR, and MW-14BR). **Table 20** lists the sample locations, depth interval, and analyses performed for samples collected during the RI. The groundwater screening locations are presented on **Figure 4D**.

The drilling was performed by Parratt-Wolff under the supervision of an O'Brien & Gere geologist. The geologist completed a core log for each boring to document encountered subsurface strata and other pertinent observations.

The overburden drilling for these holes is described above in Section 2.1.3. Once the 4-inch casing was set into the top 2 to 5 ft of bedrock, the borehole was advanced 30 ft into the bedrock using coring drilling methods. Cuttings brought to the surface were managed as described in Section 2.1.3. During coring activities, the volume of drilling water lost to the bedrock formation was recorded. Before installation of the packer test assembly, 150% of the volume of drilling water lost during coring was recovered through pumping in the open core.

Following the recovery of the lost drill water, a dual-inflatable packer test assembly was used to measure the hydraulic conductivity of the isolated packer test intervals. Intervals for the packer tests were selected in concurrence with the NYSDEC and based on the fracture patterns present in the retrieved bedrock cores. Typically, one packer test was conducted isolating fracture zones from the top, middle, and bottom of the coring. Actual packer test intervals were overlapping and adjusted in the field based on observations of the fracture pattern of each 5-foot core run.

Due to the nature of the bedrock formation, packer tests were not conducted at MW-06BR (extremely slow recharge) and MW-13BR2 (overburden formation collapse at MW-13BR). It should be noted that the packer test at MW-14BR was of the entire 30-ft coring due to the bedrock fracture pattern and high volume of water produced during the drill water recovery activities at this location.

The following provides a discussion of the methodology used for completing the hydraulic conductivity tests of the packer test assembly intervals.

The packer test assembly consisted of a packer string that included two inflatable rubber packers mounted to a 1-inch diameter steel pipe that extends to the ground surface. The packer was mounted such that it would seal the top and bottom of the selected 10-ft bedrock core interval. A 10-ft section of the pipe between the packers was perforated to allow the introduction or withdrawal of water from the packed-off section.

The packer string was lowered into the borehole. Upon reaching the test interval, the packer was inflated to isolate the test interval from the borehole. The packer was inflated using an inert gas (nitrogen) to the operating inflation pressure specified by the packer manufacturer. The packer seal was evaluated subsequent to inflation by monitoring the inert gas pressure of the inflated packers and allowing the packer assembly to hang freely in the borehole. The seal was sufficient to continue once the pressure of the inflated packers was stable and able to support the weight of the entire packer assembly.

Once the packer assembly was inflated, a transducer was installed in the 1-inch diameter pipe, and the hydraulic head in the packed-off interval was monitored. To conduct the rising *in-situ* hydraulic conductivity test (slug test), the water was removed from the packer assembly using a pump, and the packed-off interval was monitored until the head had stabilized (**Appendix F**).

Subsequent to the *in situ* hydraulic conductivity test, approximately three volumes of the packed-off bedrock interval was purged, and a groundwater sample was collected. Overburden groundwater screening samples were submitted for laboratory analyses. Chain of Custody forms were initiated at the time of collection and remained with the samples during transport to Columbia Analytical Services. Chain of Custody forms are included in **Appendix B**.

The samples were submitted to Columbia Analytical Services for TCL/TAL analyses by USEPA SW846 methods 8260B and 8270C for VOCs and SVOCs, respectively. Samples were also analyzed for hardness, alkalinity, and major cations (Ca, Mg, Na) and anions (Cl, SO_4, CO_3, HCO_3) using methods 310.1/2320B, 2340B, and 6010/E300/2320B, respectively. Specific gravity (density) was measured at the time of sampling via a hydrometer. Sample summary matrices for the FRI and RI are provided in **Tables 19 and 20**, respectively.

Following the completion of the sampling, the packers were deflated and moved to the next selected interval. No groundwater samples were collected prior to the installation of the monitoring well locations MW-06BR and MW-13BR2 due to extremely slow recharge and overburden formation collapse, respectively.

Following analysis of hydraulic conductivity data from the packer tests, a screen interval was selected in concurrence with the NYSDEC for installation of the permanent monitoring well in the bedrock at each location. Monitoring well installation is discussed below in Section 2.1.5.

A 2-inch diameter PVC well consisting of a 10-ft or 30-ft length of 0.010-inch slot screen flush threaded to riser casing was lowered through the 4-inch casing and into the bedrock borehole (**Appendix C**).

2.1.5. Monitoring Well Installation

Borings were installed using conventional drilling techniques by Parratt-Wolff under the supervision of an O'Brien & Gere geologist for the installation of monitoring wells. For borings advanced to the top of the silt and clay layer, soil samples were collected continuously in accordance with ASTM Method D1586-84 using a 140-lb hammer and 2-ft split-barrel sampler. Each sample was logged by the geologist and boring logs were completed to document encountered subsurface material and other pertinent observations including soil composition, color, consistency, moisture content, recovery, odor, and staining. In addition, each split spoon sample was screened using a PID and UV light. Boring logs are presented as **Appendix C**. Boring locations are presented on **Figure 4B** and are discussed in greater detail below.

Overburden Well Installation

Deep groundwater monitoring wells screened at the top of till were double-cased. The double-cased installations were conducted by advancing 6¼-inch inside diameter augers from the ground surface to a minimum depth of 5 ft below the top of the silt and clay layer. During advancement of the 6¼-inch augers, soil samples were collected at continuous 2-ft intervals using 2-inch diameter split-barrel samplers in accordance with ASTM Method D1586-84. At locations where borings were previously completed, samples were not collected in duplicate intervals.

Upon completion of advancement of the 6¼-inch augers, 4-inch diameter steel casing fitted with a plastic end cap was lowered through the auger string. The annular space between the borehole wall and the 4-inch casing was filled with cement/bentonite grout using a tremie pipe as the auger string is removed. A head of grout was maintained within the auger string until all of the augers were removed from the borehole. The grout was allowed to cure for a minimum of 12 hours prior to further borehole advancement.

Subsequent to curing of the grout, fluid-rotary drilling methods were used to advance the boreholes to the terminal depths. A nominal 3.875-inch diameter roller bit was used to advance the boreholes. Potable water was recirculated through the drill stem to carry soil cuttings to the ground surface. Cuttings carried to the ground surface were initially contained in the recirculation tub and transferred to 55-gallon drums as needed. During the fluid-rotary drilling, soil samples were collected at continuous 2-ft intervals in accordance with ASTM Method D1586-84.

Subsequent to the terminal depth for the borehole, a 2-inch diameter PVC well consisting of a 10-ft length of 0.010- or 0.020-inch slot screen flush-threaded to riser casing was lowered through the 4-inch casing. The screen size was selected based upon the nature of the subsurface material. The riser casing was extended approximately 2 ft above ground surface. A sandpack suitable for use with the screen slot size was installed within the annular space between the borehole and the well. The sandpack generally extended from the bottom of the well to 2 to 5 ft above the top of the well screen. At the least, a 3-ft thick bentonite seal was installed in the annular space above the sand pack to prevent water from moving vertically along the borehole. The remaining annular space was filled with a Portland cement/bentonite grout through a tremie pipe to a maximum depth of 5 ft bgs.

To protect the installed well and prevent unauthorized access, a steel guard pipe with a cover and pad lock were installed around each well. A concrete pad was installed around the guard pipe to direct precipitation away from the borehole.

Shallow and intermediate wells, which are screened in the fill and marl units respectively, were installed in a similar manner to the deep wells. The shallower wells were installed directly through the auger string, with no additional casing necessary.

Bedrock Well Installation

A 5-inch steel casing was installed to at least 5 ft below the top of the silt and clay layer by advancing 6 ¼-inch inside diameter augers to depth. During advancement of the 6 ¼-inch augers, soil samples were collected at 2-ft intervals using 2-inch diameter split barrel samplers in accordance with ASTM Method D1586-84. Drilling was overseen by a geologist, who completed a boring log to document subsurface strata and other pertinent observations. A PID and UV light were used to screen collected soil samples and to monitor the breathing zone during drilling activities. Upon completion of advancement of the 6 ¼-inch augers, the steel casing fitted with a plastic end cap was lowered through the auger string. The annular space between the borehole wall and the 5-inch casing was filled with a cement/bentonite grout using a tremie pipe as the auger string was removed. A head of grout was maintained in the auger string until all the augers were removed from the borehole. The grout was allowed to cure for at least 12-hours prior to borehole advancement.

Following installation of the 5-inch steel casing into the silt and clay layer, fluid-rotary methods were used to advance the borehole to a depth of 2 to 4 ft below the top of rock. A nominal 3.875-inch diameter roller bit was used to advance the boreholes. Potable water was recirculated through the drill stem to carry soil cuttings to the ground surface. Cuttings that were carried to the ground surface were initially contained in the recirculation tub and transferred to a lined roll-off box or 55-gallon drums as needed.

When the borehole was completed to depth, a 4-inch steel casing was set into the till/bedrock interface and grouted in place. The borehole was advanced 30 ft into the bedrock by using coring drilling methods. Fluids and cuttings brought to the surface will be managed as described above. The volume of drilling water lost to the bedrock formation will be recorded.

Depending on bedrock conditions, a 2-inch diameter PVC well consisting of a 10-ft length or 30-ft length of 0.010-inch slot screen flush threaded to riser casing was lowered through the 4-inch casing and into the bedrock borehole. Monitoring wells MW-03BR, MW-04BR, MW-09BR, MW-19BR2, and MW-20BR were constructed with 10-ft length of 0.010-inch slot screen flush threaded to riser casing. At locations MW-03BR, MW-04BR, and MW-19BR2, grout lifts were used to fill in the bottom portion of the coring to allow the monitoring well to be set at the desired interval. Monitoring wells MW-06BR, MW-13BR2, and MW-14BR were constructed with 30-ft length of 0.010-inch slot screen flush threaded to riser casing.

The riser casing was extended to the ground surface. A sand pack suitable for the screen size was installed within the annular space between the borehole and the well. The sand pack extended from the bottom of the well to approximately 2 ft above the top of the screen. At the request of the NYSDEC, an approximately 2-ft thick sand choke consisting of Morie #00 sand was installed above the sand pack due to the potential for a bentonite seal to be compromised by the chloride levels in the groundwater. The remaining annular space was filled with a Portland cement/bentonite grout (mixed sufficiently thick so as to not propagate through fractures that may have been encountered) through a tremie pipe to a maximum depth of 5 ft bgs. To protect the well and prevent unauthorized access, a steel guard pipe with a cover and pad lock were installed around each well. A concrete pad was installed around the guard pipe to direct precipitation away from the borehole. A locking vented cap was added to each well.

PSA Monitoring Wells

Drilling activities for the installation of monitoring wells took place between July 6 and October 11, 2004 at the Site. Twenty-eight monitoring wells were installed as part of the PSA. Shallow monitoring wells were installed at MW-01S, MW-02S, MW-03S, MW-04S, MW-05S, MW-06S, MW-07S, and MW-08S. Intermediate monitoring wells were installed at MW-01I, MW-02I, MW-03I, MW-04I, MW-05I, MW-06I, MW-07I, MW-08I, MW-09I, MW-10I, and MW-11I. Deep monitoring wells were installed at MW-01D, MW-02D, MW-03D, MW-04G, MW-04D, MW-05D, MW-06D, MW-07D, and MW-08D. Monitoring well locations are shown on **Figure 4E.**

WA-MW-100D and WA-MW-100BR

Drilling activities for the installation of monitoring wells WA-MW-100D and MW-100BR took place between February 21 and March 1, 2005. This was done at the request of the NYSDEC in accordance with its Willis/Semet IRM comment letter to Honeywell. The wells are situated near the Onondaga County Department of Water and Environmental Protection (OCDWEP) pump station. Due to their proximity to the Site, groundwater elevations, densities, and samples were collected in conjunction with Wastebeds 1 through 8 programs and are included within this report. Monitoring well locations are presented on **Figure 4E**.

FRI Monitoring Wells

Drilling activities for the installation of FRI monitoring wells took place between October 24, 2005 and March 29, 2006 at the Site. Twenty-four monitoring wells were installed as part of the FRI and are shown on **Figure 4E**. Shallow monitoring wells were installed included MW-09S, MW-10S, MW-12S, MW-13S, MW-14S, MW-15S, MW-16S, MW-17S, and MW-18S. Intermediate monitoring wells were installed at MW-13I, MW-14I, MW-16I, MW-17I, and MW-18I. Deep monitoring wells were installed at MW-09D, MW-10D, MW-13D, MW-14D, MW-16D, MW-17D, MW-18D, and MW-18G. Bedrock monitoring wells were installed at MW-19BR2 and MW-20BR. Monitoring well locations are shown on **Figure 4E**.

FRI Aquifer Pumping Test Wells

Drilling activities for the installation of the FRI aquifer pump test wells were performed in April 2006. Aquifer pumping test wells consisted of test wells and observation wells. The wells were installed using the methods discussed above, with the exception of the test wells that were 4-inch diameter PVC wells. Test wells installed as part of the FRI aquifer pump test include two shallow test wells (TW-01S and TW-02S), one intermediate Ninemile Creek sand and gravel test well (TW-03G), and one deep test well (TW-04). Observation wells installed include four shallow wells (OW-01S, OW-02S, OW-03S, and OW-04S), two intermediate Ninemile Creek sand and gravel wells (OW-05G and OW-06G), and one deep well (OW-07D).

RI Monitoring Wells

Drilling activities for the installation of RI monitoring wells took place between January 11 and April 5, 2007. Thirteen monitoring wells were installed as part of the RI. Shallow monitoring wells were installed at MW-21S and MW-22S. Intermediate monitoring wells were installed at MW-21I, MW-22I, and MW-23I. Deep monitoring wells were installed at MW-21D and MW-22D. Bedrock monitoring wells were installed at MW-03BR, MW-04BR, MW-06BR, MW-09BR, MW-13BR, and MW-14BR.

SRI Monitoring Wells

Drilling activities for the installation of SRI monitoring wells were performed in concurrence with the former Ninemile Creek sand and gravel channel and Wastebeds 5 and 6 evaluations. Seven deltaic deposit monitoring wells were installed at MW-24G (SB-164), MW-25G (SB-156), MW-26G (SB-154), MW-27G (SB-163), MW-28G (SB-161), MW-29G (SB-160), and MW-30G (SB-158).

2.1.6. Well Development

Following installation of the wells and prior to groundwater sampling, each well was developed to remove material that may have settled in and around the well screen. Development consisted of the removal of ten well volumes using either a bailer or centrifugal pump. A 50-NTU goal was established. When this goal could not be achieved, the well was purged until no further improvement in turbidity was observed. Development water was contained in 55-gallon drums or 500-gallon polyethylene tanks for subsequent disposal at an acceptable off-site treatment facility. The well development logs are included in **Appendix G**.

2.1.7. Hydraulic Conductivity Measurements

Horizontal and vertical hydraulic conductivity tests were performed on Site. Horizontal hydraulic conductivity tests were performed for 71 of the 74 monitoring wells installed on site during the PSA, FRI, RI and SRI, to estimate the horizontal hydraulic conductivity of materials surrounding the well screen. Hydraulic conductivity measurements were not collected from locations MW-11I, WA-MW-100BR and WA-MW-100D. Rising and falling head measurements were obtained following both insertion and removal of a PVC slug into the well. The groundwater measurements were recorded using an electronic data logger.

The data were analyzed using the Bouwer and Rice (1976) method with the software AquiferWin®. Graphs of the K-test curves are included in **Appendix F**. **Table 21** presents the interpreted hydraulic conductivity values for the Site monitoring wells including wells installed as part of previous investigations discussed in Section 1.5. The K-test values represent either rising or falling head measurement data. In general, falling head measurement data were used when groundwater level was below or at the top of the screen interval. Rising head measurement data were used when the groundwater level was above the top of the screen interval.

Vertical K-tests were performed on select locations (SB-03, SB-18, SB-19, SB-20, SB-24BR, and MW-20BR) during the FRI, and historically at locations (B1C, MS-105, MS-106, EB-1C, EB-4, MS-105.1, MS-104) installed by Thomsen as part of the Crucible Hydrogeological Investigation (Thomsen, 1982). A summary of vertical K-Test results are presented on **Table 22.**

2.1.8. Synoptic Groundwater Measurements

Synoptic groundwater elevations were collected during the PSA, FRI, RI, and SRI. Groundwater levels were measured using a Solinst™ Model 101 water level probe. Measured groundwater elevations are presented in **Table 23**.

In November 2004 and May 2005, groundwater density was calculated for the PSA wells using total dissolved solids data. **Table 24** presents the groundwater densities calculated from the total dissolved solids (TDS). Specific gravity (density) measurements using a hydrometer were also collected with groundwater elevation measurements in June 2006, September 2006, December 2006, February 2007, and December 2007 using a hydrometer. Additional groundwater and density measurements were collected from wells associated with the former Ninemile Creek channel during September 2009, October 2009, and November 2009. Water level and density measurements from these events are presented on **Table 23.**

Continuous Historic Ninemile Creek Channel Groundwater Level Monitoring

As part of the SRI Former Ninemile Creek Channel evaluation, transducers were placed in monitoring wells MW-04G, MW-18G, MW-25G, MW-26G, MW-28G, and MW-29G on August 12, and 13, 2009. Transducers were installed in order to assess the hydraulic relationship of the former channel deposits and adjacent water bodies (Ninemile Creek and Onondaga Lake).

The transducer remained in the monitoring wells through November 6, 2009 so that data could be collected from events capable of creating measureable groundwater level and surface water stage changes. Measurements were collected on two such events occurring on October 25, 2009 and October 28, 2009. Measurements collected from these events were used to assess the hydraulic relationships in question. A detailed discussion of the continuous groundwater level monitoring can be found in **Appendix H.**

Specific Gravity Evaluation

An evaluation of specific gravity variations within Site groundwater was conducted on June 11 and 12, 2009 in conjunction with the SRI. The evaluation focused on the assessment of three potential sources of deviation in the collection of groundwater specific gravity values from individual wells. The three aspects included density stratification, collection of groundwater stored within the well casing versus the formation, and the effects of suspended solids due to turbid samples. **Appendix I** provides a full discussion of the specific gravity evaluation, including methods and results.

2.1.9. Groundwater Sampling

Groundwater samples were collected using low flow sampling techniques. If the hydrogeologic unit did not produce enough water, a bailer was used to purge three well volumes from the well and sample the well. Low flow purging involved inserting a stainless steel grundfos pump (or similar) and dedicated polyethylene tubing within the screened interval of the well and purging at a maximum rate of 0.5 liters/minute. Groundwater elevations were measured during purging to ensure that drawdown within the well was not occurring. Groundwater quality parameters including pH, conductivity, temperature, eH, turbidity, and dissolved oxygen were monitored continuously during purging using an in-line YSI 600XL or a Horiba U-22 meter. Samples were collected directly from the tubing once groundwater quality parameters stabilized or after removal of three well volumes.

The pump was decontaminated between wells in accordance with procedures set forth in the QAPP (O’Brien & Gere, 2004b; O'Brien & Gere, 2006b). Purge water was contained in 55-gallon drums or 500-gallon polyethylene tanks for subsequent disposal. More specific information regarding the groundwater sampling is included on the groundwater sampling logs included in **Appendix J**.

PSA Groundwater Sampling

Two rounds of groundwater samples were collected during the PSA. Samples were collected in October and November 2004 and May 2005. During the first round, MW-08S was not sampled, because it was dry at the time of sampling. The second round was collected in May 2005 and included groundwater monitoring wells WA-MW-100D and WA-MW-100BR. **Table 25** lists the monitoring well samples from the PSA, screen intervals, and the laboratory analyses performed for these samples. Both rounds were performed during times of high groundwater elevations.

Chain of Custody forms were initiated at the time of sampling and remained with the samples during transport to O’Brien & Gere Laboratories. Chain of Custody forms are included in **Appendix B**. Groundwater sampling logs were completed during both rounds and are included in **Appendix J**.

The samples were submitted to O’Brien & Gere Laboratories for TCL/TAL analyses by USEPA SW846 methods 8260B, 8270C, 8081, 8082, 6010B, 7470A, and 9010B/9012A for VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, and cyanide, respectively. Samples were also analyzed for hardness, alkalinity, and major cations (Ca, Mg, Na) and anions (Cl, SO_4, CO_3, HCO_3) using methods 310.1/2320B, 2340B, and 6010/E300/2320B, respectively.

Additionally, three rounds of synoptic groundwater levels and two rounds of total dissolved solids (TDS) samples were collected during the PSA.

- One round in November 2004 for water levels and TDS
- One round in February 2005 for water levels
- One round in March 2005 for water levels
- One round in May 2005 for TDS

FRI Groundwater Sampling

One round of FRI groundwater samples were collected in March and April 2006. WA-MW-100D and WA-MW-100BR were included in the FRI sampling effort. **Table 26** lists the monitoring well locations sampled during the FRI, screen intervals, and the laboratory analyses performed for these samples. This sampling was performed during a time of high groundwater elevations.

Chain of Custody forms were initiated at the time of sampling and remained with the samples during transport to Columbia Analytical Services. Chain of custody forms are included in **Appendix B**. Groundwater sampling logs were completed for each monitoring well and are included in **Appendix J**.

The samples were submitted for TCL/TAL analyses by USEPA SW846 methods 8260B, 8270C, 8081, 8082, 6010B, 7470A, 9010B for VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, and cyanide, respectively. Samples were also analyzed for hardness, alkalinity, and major cations (Ca, Mg, Na) and anions (Cl, SO_4, CO_3, HCO_3) using methods 310.1/2320B, 2340B, and 6010/E300/2320B, respectively.

In addition to the standard groundwater samples, groundwater dating analyses/brine differentiation samples were collected from the Wastebeds 1 through 8 Site, Willis Avenue Chlorobenzene Site, and Semet Residue Ponds Site. Groundwater samples collected for dating analyses/brine differentiation were submitted to Columbia Analytical Services and the University of Rochester. Laboratory analyses include USEPA SW846 methods 6010B/E300 for major cations (Ca, Mg, Na) and anions (Cl, SO_4, CO_3, HCO_3), bromide, and boron, along with analyses for tritium/helium, stable oxygen isotopes (including O^{18}), and stable hydrogen isotopes (including deuterium). The laboratory analysis methods employed by the University of Rochester for tritium/helium, stable oxygen isotopes (including O^{18}), and stable hydrogen isotopes (including deuterium) are included in **Appendix K**. Monitoring wells sampled consisted of:

- Wastebeds 1 through 8: MW-01I, MW-01D, MW-02I, MW-02D, MW-06I, MW-06D. MW-7I, MW-7D, MW-08I, MW-08D, MW-19BR, and MW-20BR
- Lakeshore: WA-OW-2, WA-OW-4, WA-OW-5, WA-OW-6, WA-OW-7, WA-OW-11, WA-WA-1D, WA-WA-2D, WA-MW-100D, and WA-MW-100BR
- Willis Avenue/Semet Ponds: SP-SP-3B, SP-SP-SP-3C, SP-SP-4B, SP-P-4C, SP-P-5B, SP-SP-5C, SP-SP-7B, SP-SP-7C, SP-SP-8B, SP-SP-8C, WA-WA-6D, and WA-WA-7D.

Sampling results for off-site monitoring wells WA-MW-100D and WA-MW-100BR are presented in this report. Sampling results from the Willis Avenue Chlorobenzene Site, Semet Residue Ponds Site, and lakeshore area associated with these two sites, though sampled under the FRI work plan, will not be presented in this report. Additionally, one round of synoptic groundwater levels was collected during the FRI in April 2006. Specific gravity was measured at each well with a hydrometer during the synoptic groundwater event.

FRI Pumping Tests

As presented in the FRI work plan, pump tests were conducted between May 12, 2006 and June 15, 2006. The purpose of the groundwater pumping tests was to evaluate the hydraulic properties (*e.g.*, transmissivity/hydraulic conductivity and storativity) of the subsurface materials located at the Site along the Onondaga Lake shore and Ninemile Creek channel. Three long-term pumping tests were performed to evaluate the hydraulic properties of the shallow fill materials and the depositional unit associated with the former Ninemile Creek channel. Additionally, a repeated pressure pulse test was performed to characterize the hydraulic properties of the deep aquifer. The pump test report is presented as **Appendix L,** and a summary of pump test hydraulic conductivity values are presented on **Table 27.**

RI Groundwater Sampling

Two rounds of groundwater samples were collected during the RI. The first round of groundwater sampling was collected in May 2007 during a time of high groundwater elevations. The second round of groundwater sampling was collected from July to August 2007 during a time of low groundwater elevations. MW-04S, MW-08S, MW-10S, MW-15S, and MW-21S were not sampled during the July and August 2007 groundwater sampling event because the wells were dry at the time of sampling. Both rounds of groundwater sampling included WA-MW-100D and WA-MW-100BR. **Table 28** lists the monitoring well locations sampled during the RI, screen intervals, and the laboratory analyses performed for these samples.

Chain of Custody forms were initiated at the time of sampling and remained with the samples during transport to Columbia Analytical Services, University of Rochester, Life Science Laboratories, Microbial Insights, and Microseeps. Chain of custody forms are included in **Appendix B**. Groundwater sampling logs were completed during both rounds and are included in **Appendix J**.

Samples were submitted for TCL/TAL parameters using Methods 8260B plus 10 TICs, 8270C plus 20 TICs, 8081A, 8082, 6010B, 7470A, and 9010C/9014, for VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, and cyanide, respectively. The groundwater was also be analyzed for hardness, alkalinity, and major cations and anions (Ca, Mg, Na, K, Cl, SO_4, CO_3, HCO_3), and specific gravity (via hydrometer). PXE and PTE were reported under the SVOC scan.

In addition to the analyses listed above, several groundwater monitoring wells were sampled for additional parameters during the May 2007 sampling event. The additional analyses included methods 350.1, 351.2, SMS210B, and AM20GAX for ammonia, total Kjeldahl nitrogen (TKN), CBOD, and dissolved methane/hydrogen, respectively. Phospholipid fatty acids and bacterial plate counts were also analyzed for during the RI. The ammonia, TKN, CBOD, and the bacterial plate count analyses were performed by Life Science Laboratories. The dissolved hydrogen analyses and phospholipid fatty acid analyses were performed by Microseeps and Microbial Insights, respectively.

Groundwater samples collected for dating analyses/brine differentiation were submitted to Columbia Analytical Services and the University of Rochester. Laboratory analyses include USEPA SW846 methods 6010B/E300 for major cations and anions (Ca, Mg, Na, Cl, SO_4, CO_3, HCO_3), bromide, and boron, along with analyses for tritium/helium, stable oxygen isotopes (including O^{18}), and stable hydrogen isotopes (including deuterium). The laboratory analysis methods employed by the University of Rochester for tritium/helium, stable oxygen isotopes (including O^{18}), and stable hydrogen isotopes (including deuterium) are included in **Appendix K**. These analyses were performed to support the conceptual Site model (CSM) by providing additional groundwater fingerprinting data.

Additionally, three rounds of synoptic groundwater levels were collected during the RI (April, June, and July 2007). Specific gravity was measured at each well with a hydrometer during each of the synoptic groundwater events.

SRI Groundwater Sampling

One round of groundwater samples were collected during the SRI in August 2009. Samples were collected from the seven new wells (MW-24G, MW-25G, MW-26G, MW-27G, MW-28G, MW-29G, MW-30G), MW-04G, and MW-18G. **Table 29** lists the monitoring well locations sampled during the SRI, screen intervals, and the laboratory analyses performed for these samples.

Chain of Custody forms were initiated at the time of sampling and remained with the samples during transport to Test America. Chain of custody forms are included in **Appendix B**. Groundwater sampling logs were completed during both rounds and are included in **Appendix J**.

Samples were submitted for TCL/TAL parameters using Methods 8260B plus 10 TICs, D, 8081A, 8082, 6010C, 7470A, and 9010C/9014, for VOCs, SVOCs (including PXE and PTE), pesticides, PCBs (including Aroclor 1268), metals, mercury, and cyanide, respectively. The groundwater was also be analyzed for total Kjeldahl nitrogen (TKN), hardness, alkalinity, total dissolved solids (TDS), and major cations and anions (Ca, Mg, Na, K, Cl, SO_4, CO_3, HCO_3). Specific gravity was measured in the field using via hydrometer.

2.1.10. Surface Water Sampling

PSA Surface Water Sampling

Two rounds of surface water samples were collected during the PSA. The first round of surface water samples was collected concurrently with sediment samples in June 2004. The second round was collected in December 2004. Surface water samples were collected from six locations at the Site from the following areas:

- One location within the Former Ponded Area (SW-01)
- Five locations within Ditch A (SW-02 through SW-06)

Sample locations are presented on **Figure 4F**.

Samples were collected by immersing a dedicated glass container within the surface water body. The glass container was then used to fill the appropriate laboratory containers. The samples were then placed in a cooler on ice. Chain of Custody forms were initiated as the samples were collected and remained with the samples during transport to O'Brien & Gere Laboratories. Chain of Custody forms are included in **Appendix B**.

Field measurements were collected with a Horiba® U-22 multi-parameter water quality meter during sampling. Measurements were collected for temperature, conductivity, turbidity, and pH and are provided in **Table 30**.

Surface water samples were submitted for TCL/TAL analyses by USEPA SW-846 Methods 8260B, 8270C, 8081, 8082, 6010B, 1631, and 9010B/9012A for VOCs, SVOCs, pesticides, PCBs, metals, high resolution mercury, and cyanide, respectively. **Table 31** lists the surface water locations sampled during the PSA and the laboratory analyses performed for these samples.

RI Surface Water Sampling

Two surface water samples (SW-07 and SW-08) were collected during the RI concurrently with sediment samples in March 2007. Surface water samples were collected from the Former Ponded Area on the Site. Samples locations are presented in **Figure 4F.**

Samples were collected by immersing a dedicated glass container within the surface water body. The glass container was then used to fill the appropriate laboratory containers. The samples were then placed in a cooler on ice. Chain of Custody forms were initiated as the samples were collected and remained with the samples during transport to Columbia Analytical Services, Inc. Chain of Custody forms are included in **Appendix B**.

Field measurements were collected with a Horiba® U-22 multi-parameter water quality meter during sampling and included temperature, conductivity, turbidity, and pH. Field measurements are provided in **Table 30**.

Surface water samples were submitted for TCL/TAL analyses by USEPA SW-846 Methods 8260B, 8270C, 8081A, 8082, 6010B, 1631, and 9010C/9014 for VOCs, SVOCs, pesticides, PCBs, metals, high resolution mercury, and cyanide, respectively. The laboratory was directed to report PXE and PTE under the SVOC scan. **Table 32** lists the surface water locations sampled during the RI and the laboratory analyses performed for these samples.

2.1.11. Sediment Sampling

PSA Sediment Sampling

One round of sediment samples was collected during the PSA. Nine samples were collected from six locations (SED-01 through SED-06) during June 2004. Samples were collected from 0 to 0.5 ft and 0.5 to 1.0 ft. The 0.5 to 1.0 ft samples were not collected at SED-03, SED-05, and SED-06 due to refusal. Sample locations are presented on **Figure 4F**. Samples were collected from the following locations:

- One location within the Former Ponded Area (SED-01)
- Five locations within Ditch A (SED-02 through Sed-06)

Sediment samples were collected using Lexan® tubing and dedicated plastic scoops. Samples were placed in the appropriate laboratory containers and placed in a cooler on ice. Chain of Custody forms were initiated as the samples were collected and remained with the samples during transport to O'Brien & Gere Laboratories, Inc. and are included in **Appendix B**.

Sediment samples were submitted for TCL/TAL analyses by USEPA SW-846 Methods 8260B, 8270C, 8081, 8082, 6010B, 7470A, and 9010B/9012A for VOCs, SVOCs, pesticides, PCBs, metals, mercury, and cyanide, respectively. Samples were also analyzed for TOC and grain size. **Table 33** lists the sediment locations sampled during the PSA, sample depths, and the laboratory analyses performed for these samples.

RI Sediment Sampling

Four sediment samples were collected from two locations (SED-07 and SED-08) during the RI. Samples were collected from 0 to 0.5 ft and 0.5 to 1.0 ft. Samples were collected in March 2007 from the Former Ponded Area on-site. Sample locations are presented on **Figure 4F**.

Sediment samples were collected using Lexan® tubing and dedicated plastic scoops. Samples were placed in the appropriate laboratory containers and placed in a cooler on ice. Chain of Custody forms were initiated as the samples were collected and remained with the samples during transport to Columbia Analytical Services, Inc. Chain of custody forms are included in **Appendix C**.

Sediment samples were submitted for TCL/TAL analyses by USEPA SW-846 Methods 8260B, 8270C, 8081A, 8082, 6010B, 7471A, and 9010C/9014 for VOCs, SVOCs, pesticides, PCBs, inorganics, mercury, and cyanide, respectively. Sediment samples were also analyzed for TOC and grain size, and the laboratory was directed to report PXE and PTE under the SVOC scan. **Table 34** lists the sediment locations sampled during the RI, sample depths, and the laboratory analyses performed for these samples.

2.1.12. Seeps Reconnaissance and Sampling

A seeps reconnaissance and sampling was performed as part of the PSA in June 2004. From the reconnaissance, 104 potential seep locations were observed, staked, and marked using a hand held GPS unit. Seep locations were identified as surface soil with an overland flow path or surface soil and surface water locations separate from Ninemile Creek, drainage swale, or other Site surface water flow. Both seep surface water and seep surface soil samples were collected. Seep locations and seep sample locations are presented on **Figure 4G**. In general, seep surface water and seep surface soil samples were co-located, unless otherwise noted. Additional seeps reconnaissances were performed as part of the PSA on November 30, 2004 and on June 4 and June 5, 2006 as part of the FRI. No flowing seeps were identified during these additional reconnaissances.

Seep Surface Water Samples

Eighteen seep surface water samples were collected from the eighteen active seepage locations. **Table 35** lists the seep locations sampled for seep surface water during the PSA and the laboratory analyses performed for these samples. Seep surface water samples were collected from locations Pipe-07 and SP-89 and no seep surface soils were collected due to a lack of soils at these locations.

Soil samples collected from seeps are considered to be terrestrial surface soils and not sediments for the purpose of this report. Seep soils more closely resemble other surface soils on site in that they have intermittent surface water flow, and lack benthic invertebrates. Seep surface soils are discussed as their own media in this report, but are held to the same considerations of surface soils on Site.

Seep surface water samples were collected by diverting flow into sampling jars via a dedicated piece of Lexan® tubing or by immersing a dedicated glass container into seep surface water based on geomorphic conditions. Samples were placed in the appropriate laboratory containers and placed in a cooler on ice. Chain of Custody forms were initiated as the samples were collected and remained with the samples during transport to O'Brien & Gere Laboratories. Chain of Custody forms are included in **Appendix B**.

Seep surface water samples were submitted for TCL/TAL analyses by USEPA SW-846 Methods 8260B, 8270C, 8081, 8082, 6010B, 1631, and 9010B/9012A for VOCs, SVOCs, pesticides, PCBs, metals, high resolution mercury, and cyanide, respectively.

Seep Surface Soil Samples

Thirty seep surface soil samples were collected from 17 of the 104 potential seep locations identified during the PSA reconnaissance. Samples were collected from 0-6 in. bgs and 6-12 in bgs, except at locations SP-16, SP-18 where samples were collected from 0-6 in. bgs only, and locations SP-06 and 07 where samples were collected from 0-0.3 in. bgs. Surface water was not present at all seep sediment sample locations; however, sample locations were also selected based on evidence of recent surface water flow paths. **Table 36** lists the seep locations sampled for seep sediment during the PSA, sample depths, and the laboratory analyses performed for these samples. Seep surface soil samples were collected and no seep surface water samples were at location SP-59 due to a lack of surface water at this location.

Seep surface soil samples were collected using dedicated plastic scoops. Samples were placed in the appropriate laboratory containers and placed in a cooler on ice. Chain of Custody forms were initiated as the samples were collected and remained with the samples during transport to O'Brien & Gere Laboratories. Chain of Custody forms are included in **Appendix B**.

Seep surface soil samples were submitted for TCL/TAL analyses by USEPA SW-846 Methods 8260B, 8270C, 8081, 8082, 6010B, 7470A, and 9010B/9012A for VOCs, SVOCs, pesticides, PCBs, metals, mercury, and cyanide, respectively. Samples were also analyzed for TOC and grain size.

Seep surface soil samples were also collected from five previously identified locations during the Chromium Speciation Investigation. The locations included SP-07, SP-15, SP-16, SP-24, and SP-62, and sample collection details for these samples are presented with the Chromium Speciation Surface Soils discussed in Section 2.1.2 of this report.

2.1.13. Vapor Intrusion Evaluation

Soil vapor samples were collected between January 16 and January 19, 2007 to evaluate the potential for vapor intrusion to occur in the event that buildings are constructed on the Site at a future date. According to the NYS Department of Health (NYSDOH), soil vapor intrusion refers to the process by which VOCs migrate from a subsurface source into the indoor air of buildings (NYSDOH, 2006). This source may consist of either organic chemical-containing groundwater, soil, or both.

A potential vapor intrusion pathway occurs when a source is combined with a migration route and receptor. Each of these elements must be present to have a "complete" pathway. If no buildings are present on the Site, the pathway remains incomplete. Potential future use (constructed buildings) would add a migration route and receptors and create a "complete" vapor intrusion pathway.

Ten soil vapor samples (VI-01 to VI-10) and six ambient air samples (AA-01 to AA-06) were collected to evaluate the potential vapor intrusion pathway (**Figure 4H**). The soil vapor samples were collected from ten discrete locations on the Site, while the ambient air samples were collected at locations around the Site to evaluate the ambient background conditions. **Table 37** lists the soil vapor and ambient air sample locations, sample depths, and the laboratory analysis performed for these samples.

Sample collection was in accordance with the 2006 NYSDOH Vapor Intrusion Guidance. A direct push drill rig was used to advance drill rods and probe tip to the desired depth at each soil vapor sample location. The lone exception was VI-06, where a slide hammer was used. When using the drill rig, the drill rods were unthreaded from the drive point and removed when the desired depth was reached. A 6-inch stainless steel screen connected to a length of ⅛-inch inert tubing was advanced down the borehole and threaded onto the drive point. The drive point remained in the borehole, which acted as an anchor for the screen and tubing. The screen was then threaded onto the drive point.

After threading the tubing and screen onto the drive point, sand was added around the sampling screen as a porous backfill material to create a 1-foot long sampling zone. Bentonite filled the remainder of the borehole to the ground surface. The bentonite was hydrated and allowed to settle and swell overnight prior to sample collection.

The tubing and screen were purged of one to three volumes of ambient air with a 60-cc syringe to allow for subsurface vapor sample collection. The tubing and screen were purged at a maximum rate of 0.2 L/minute per the NYSDOH 2006 guidance. After purging, the sample tubing was connected to a sampling canister at the ground surface, and the sample was collected over a 4-hour period. Additionally, sample collection began 30 minutes after purging and connecting the sampling canister to allow subsurface conditions to equilibrate.

The integrity of each probe was evaluated using helium tracer gas as a field quality control measure. The helium check began by placing a polycarbonate bucket at the sampling location. The sample tubing was guided through an airtight port in the bucket and secured using a cap or clamp until sampled. The bucket was charged with helium using a second port at the top of the bucket. After charging the bucket, the tubing was connected to a Restek Helium Leak Detector (Catalog #22451) and checked for the presence of helium. If no helium was detected, the integrity of the probe was confirmed, and the tubing was purged as described above and the soil vapor sample was collected. At the conclusion of sample collection, the gas analyzer was again connected to the sample tubing, and a second sample analyzed for helium. No helium was detected at any of the locations before or after sampling. Sampling equipment designated for re-use was decontaminated between each installation.

Six ambient air samples were collected to evaluate ambient air in the vicinity of the Site. The location of the ambient air samples is shown on **Figure 4H**.

Chain of Custody forms were initiated as the samples were collected and remained with the samples during transport to Centek Laboratories, a NYSDOH-approved laboratory. Chain of custody forms are included in **Appendix B**. The samples were analyzed for the full list of VOCs using USEPA Method TO-15. The analytical method was able to achieve a reporting limit of 1 $\mu g/m^3$ or less.

The soil vapor and ambient air data was validated per the 2006 NYSDOH guidance. The results of the validation are included with the RI Data Validation Report under a separate cover.

2.1.14. Wetland Delineation and Floodplain Assessment

A wetland and floodplain evaluation was performed for the Site as part of the FRI field efforts. A review of the available reference literature was conducted as part of this assessment and included the following:

- *Soil Survey of Onondaga County*, New York (USSCS, 1997; **Figure 6**)
- New York State Hydric Soils (USSCS, 1995)
- National Wetland Inventory (NWI) Map for the Syracuse West Quadrangle (USFWS, 1978; **Figure 7**)
- New York State Freshwater Wetlands (NYSFW) Map for the Syracuse West Quadrangle (NYSDEC, 1986; **Figure 8**)
- *Onondaga County Wetlands Inventory, 1976-1978* (Rhodes and Alexander, 1980)
- Flood Insurance Study, Town of Geddes, New York. (FEMA, 1981)

The boundaries associated with the wetland areas identified on the aforementioned maps of the Site were field verified in accordance with the criteria presented in the U.S. Army Corps of Engineers (ACOE) 1987 *Wetlands Delineation Manual* (Manual). Initial field activities for the wetland delineation and floodplain assessment were performed in November 2005 by O'Brien & Gere biologists. A supplemental delineation effort was performed from May to July 2008. In accordance with the Manual, sample plots were established where data concerning soils, vegetation, and hydrology were collected. The wetland boundaries identified were flagged in the field and surveyed using a hand held global positioning system (GPS) unit. The delineated wetlands at the Site are presented on **Figure 9**.

A *Wetland Delineation and Floodplain Assessment Report* (O'Brien & Gere, 2006c) was submitted to the NYSDEC in May 2006. The NYSDEC provided comments on the May 2006 delineation report in its letter of November 7, 2007. In that letter, the NYSDEC requested that an additional field evaluation of portions of the Site be performed. Based on NYSDEC comments, a supplemental delineation effort was performed from May to July 2008. The results of the supplemental efforts were presented in the *Wetland Delineation and Floodplain Assessment Wastebeds 1 through 8 Site Revised Report* (O'Brien & Gere, 2008b. The NYSDEC provided comments to the 2008 revised report in its letter of February 5, 2009. Responses to these comments were incorporated into the Final Report (O'Brien & Gere, 2009b) which was approved by NYSDEC in June 2009. Additional details concerning the wetland and floodplain assessment are presented in Section 7.

2.1.15. Geophysical Survey

Geophysical Applications Inc. performed a geophysical survey in order to evaluate the location and distribution of the historic Ninemile Creek channel deposits. The survey was performed via direct current electrical resistivity and shear wave (S-wave) seismic refraction surveys along two transects (A-A' and B-B'; **Figure H-2** of **Appendix H**). This work was done in association with the SRI, and a detailed discussion of the survey and its findings are included in **Appendix H**.

Surveys were performed across transect A-A' (**Figure H-3** of **Appendix H**) on June 9, 2009 and across transect B-B' (**Figure H-4** of **Appendix H**) on June 10, 2009. A June 30, 2009 conference call between the NYSDEC and O'Brien & Gere discussed the initial geophysical survey results. As a result of this conference call, soil borings SB-154 and SB-162 were advanced to evaluate the variations in the inverted resistivity results. True resistivity and soil moisture measurements were collected during the advancement of the soil borings to better correlate the subsurface materials encountered in the borings to the inverted resistivity results.

2.1.16. Floodplain Survey

The Federal Emergency Management Agency (FEMA) floodplain mapping for the area was utilized to evaluate areas of the Site within the FEMA defined 100-year and 500-year floodplains. The 100- and 500-year flood boundaries in the Site were computed as topographic elevations of 372 and 373.4 feet above mean standard sea level, respectively. The FEMA defined 100-year and 500-year floodplains (flood zones) are presented in **Figure 10**.

2.1.17. Phase 1A and Phase 1B Cultural Resource Surveys (CRS)

A Phase 1A CRS was performed for the Honeywell Sites in the area of Onondaga Lake (Pratt & Pratt, 2003). Due to ground disturbing activities associated with the Integrated IRM and Onondaga Lake remedial action, two Phase 1B CRS were performed. The first Phase 1B was performed for Onondaga lake, and included areas of the lake immediately adjacent to Site (Kane, 2011). The seconded Phase 1B was performed as part of the Integrated IRM in the area of the Ninemile Creek Collection Trench (Homan, 2012).

Two historic Site locations were identified on the Wastebeds 1 through 8 Site as part of the Phase 1A CRS - White City and the Lakeview Hotel. These structures may exist under the deposited Solvay waste. However, according to Pratt & Pratt, the remains of the structures may be difficult to find. Pratt & Pratt (2003) make no reference to cultural resources at the Site.

During the Onondaga Lake Phase 1B, two barges were identified off the shoreline of Wastebeds 1 through 8. It was recommended that shoreline stabilization be designed to avoid adverse impact to these barges. The Wastebeds 1 through 8 Phase 1B performed as part of the Integrated IRM did not identify any cultural resources in the area of the Ninemile Creek area collection trench.

2.1.18. Site Survey/Topographic Map

A Site topographic survey was completed in 2004 by Richard M. Rybinski, a New York State licensed land surveyor (LS). This map is used as the Site base map. The survey included sample locations from the PSA field efforts. The New York State Plane coordinates (NAD 83) were determined for soil borings, groundwater screening locations, monitoring wells, sediment/surface water, seeps, and test pits. Ground surface elevations were surveyed for soil borings and presented in North American Vertical Datum (NAVD88). The ground surface and top of casing elevations were surveyed for each of the new monitoring wells to allow for the calculation of groundwater elevations.

A Site survey was completed by Richard M. Rybinski, LS, subsequent to completion of the FRI field effort in 2005. The New York State Plane coordinates (NAD 83) were determined for soil borings, groundwater screening locations, and monitoring well locations. For soil borings, ground elevation was also surveyed. For monitoring wells, the ground surface elevation and top of casing were surveyed to allow for the calculation of groundwater elevations and development of groundwater flow maps. Pertinent Site features were also surveyed as part of this effort.

A Site survey was completed by Richard M. Rybinski, LS, subsequent to completion of the RI field effort in 2007. The New York State Plane coordinates (NAD 83) were determined for soil borings, groundwater screenings, sediment/surface water, vapor intrusion, and monitoring well locations. For soil borings, ground elevation was also surveyed. For monitoring wells, the ground surface elevation and top of casing were surveyed to allow for the calculation of groundwater elevations. Pertinent Site features were also surveyed as part of this effort.

2.2. BASELINE RISK ASSESSMENT

2.2.1. Human Health Risk Assessment

The Human Health Risk Assessment (HHRA) assessed potential risks to human health associated with the Site-related constituents under current and reasonably foreseeable future land uses and facilitated the evaluation of potential future remedial actions. The HHRA was focused on constituents detected in soil, groundwater, sediment, surface water, and air at the Site. The risk assessment was conducted in accordance with the currently applicable USEPA guidance documents.

RAGS Tables 1 and 4 (O’Brien & Gere, 2007a) were provided to the NYSDEC on February 25, 2007 for review and approval. The NYSDEC provided comments on the HHRA RAGS tables 1 and 4 in a letter dated May 21, 2007. Honeywell responded to these comments in a letter dated June 4, 2007, and a conference call was held on June 12, 2007 to discuss the June 4, 2007 response to comment letter. RAGS Tables 1 through 6 (O’Brien & Gere, 2008c) were submitted to the NYSDEC on February 25, 2008 following additional sample collection and evaluation of the validated data.

In July of 2007, Onondaga County finalized plans for the bike trail. Subsequently, the USEPA initiated a Bike Trail HHRA. The draft Bike Trail HHRA (USEPA, 2007a) was completed on November 26, 2007 and submitted to Onondaga County and the Onondaga Nation for review. The draft Bike Trail HHRA was submitted to Honeywell and O’Brien & Gere on February 1, 2008.

A meeting between Honeywell and Onondaga County was held on February 22, 2008 regarding the path forward for the Bike Trail and Site HHRA Reports. Based on this meeting, a May 2008 chromium (Cr) speciation investigation was performed for the Site to refine the Site risk assessment. The Cr speciation data was presented in an interim deliverable on July 31, 2008. The final *Human Health Risk Assessment, Onondaga Lake Wastebeds 1-8 Site: Bike Trail Report* was issued in January 2009 (USEPA, 2009a).

The NYSDEC provided a comment letter on April 1, 2008 regarding the RAGS Tables 1 through 6 submittal and another comment letter on September 29, 2008 on the Cr speciation data interim deliverable. Honeywell provided a response to the April 1, 2008 on May 1, 2008, and a teleconference was held on October 10, 2008 regarding the implications and path forward for both Honeywell submittals. Honeywell provided a response letter to the September 29, 2008 comment letter and teleconference on October 15, 2009, which the NYSDEC accepted on October 29, 2008.

RAGS Tables 1 through 10 were submitted in a November 20, 2008 deliverable to the NYSDEC. The deliverable included revisions to RAGS Tables 1 through 6, and the addition of Tables 7, 9, and 10. These tables were revised to reflect NYSDEC comments and the HHRA report was submitted on February 10, 2010. The NYSDEC provided comments on this report on June 4, 2010. A revised HHRA was submitted on September 3, 2010. The NYSDEC provided comments on the revised report on November 3, 2010. Additional comments were provided by the NYSDEC on February 15, 2011 for the revised HHRA. A final HHRA report was submitted on April 29, 2011 (O'Brien & Gere, 2011d), and the NYSDEC approved the HHRA in a letter dated June 13, 2011.

2.2.2. Ecological Risk Assessment

The Ecological Risk Assessment (ERA) was performed in accordance with the RI/FS Revised Work Plan (O'Brien & Gere, 2006a) and the guidance co-developed by the NYSDEC and U.S. Environmental Protection Agency (USEPA) for Onondaga Lake Sites (NYSDEC, 1998a). The initial ERA deliverable for the Site was the Problem Formulation Document (O'Brien & Gere, 2007b), which consists of Steps 1, 2, and 3 of the *Ecological Risk Assessment Guidance for Superfund* (USEPA, 1997) and Steps I and IIC of the *Fish and Wildlife Impact Analysis* guidance (NYSDEC, 1994).

The NYSDEC provided comments on the PFD in its April 24, 2007 comment letter. A teleconference was held with the NYSDEC on May 3, 2007 to discuss the comments. Honeywell submitted written responses to the NYSDEC comments on May 30, 2007. On June 22, 2007, a second PFD comment letter was received by Honeywell from the NYSDEC.

On June 28, 2007, Honeywell submitted the Baseline Ecological Risk Assessment (BERA) Work Plan (O'Brien & Gere, 2007c) to the NYSDEC which incorporated responses to the June 22, 2007 NYSDEC letter. The NYSDEC commented on the work plan in a letter dated September 5, 2007, and a revised work plan that incorporated NYSDEC comments was submitted for review on October 10, 2007. Following receipt of NYSDEC comment letters of January 8, 2008 and September 8, 2008, the Final work plan was submitted to the NYSDEC on October 22, 2008. Responses to NYSDEC comments of December 19, 2008 on the Final work plan were incorporated into the BERA Report which was submitted to the NYSDEC on April 26, 2010. The NYSDEC provided comments on the BERA Report in a letter dated June 24, 2010. The final BERA Report was submitted on March 9, 2011 (O'Brien & Gere, 2011e), and was approved by the NYSDEC on March 31, 2011.

2.3. DATA ANALYSIS

2.3.1. Laboratory Methods

Preliminary Site Assessment

The PSA samples were analyzed using the methods and protocols set forth in the approved Wastebeds 1 through 8 QAPP (O'Brien & Gere, 2004b). Samples for all media were analyzed using USEPA SW-846 methods. O'Brien & Gere Laboratories performed the majority of the analyses. TCL/TAL parameter analyses were performed using methods 8260B, 8270C, 8081, 8082, 6010, 7470A, 9010B/9012A for VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, and cyanide, respectively. Groundwater monitoring well samples were also analyzed for hardness, alkalinity, and major cations and anions (Ca, Mg, Na, Cl, SO_4, CO_3, HCO_3) using methods 2340B, 310.1/2320B, and 6010/E300, respectively. Surface water and seep surface water samples were analyzed for high resolution mercury using method 1631. It should be noted that polychlorinated benzenes (1,2-, 1,3-, and 1,4-dichlorobenzenes and 1,2,4-trichlorobenzene) were reported in the 8270 scan during the PSA.

Samples were also collected from test pits and a soil boring for Toxicity Characteristic Leaching Procedure (TCLP) analyses. These samples were selected based on field observation and in concurrence with the NYSDEC. The TCLP samples were extracted and analyzed as per CFR Part 260. TCLP parameter analysis was performed using extraction method 1311 and USEPA SW-846 Methods 8260B, 8270C, 8081A, 8151, 6010B, and 7470A/7471 for VOCs, SVOCs, pesticides, herbicides, metals, and mercury, respectively.

Focused Remedial Investigation

Samples were analyzed using the methods and protocols set forth in the approved Wastebeds 1 through 8 QAPP (O'Brien & Gere, 2004). Samples for all media were analyzed using USEPA SW-846 methods. Columbia Analytical Services performed the majority of the analyses. TCL/TAL parameter analyses were performed using 8260B plus 10 tentatively identified compounds (TICs), 8270C plus 20 TICs, 8081A, 8082, 6010B, 7470A/7471, and 9010B for VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, and cyanide, respectively. Sediment samples were also analyzed for grain size and TOC using ASTM Method D422 and USEPA

Method 9060, respectively. Groundwater was also analyzed for major cations/anions using method 6010B/E300. It should be noted that polychlorinated benzenes (1,2-, 1,3-, and 1,4-dichlorobenzenes; and 1,2,4-trichlorobenzene) were reported in the 8260 scan during the FRI.

Remedial Investigation

Samples were analyzed using the methods and protocols set forth in the approved Wastebeds 1 through 8 QAPP (O'Brien & Gere, 2006b). Samples for all media were analyzed by Columbia Analytical Services, Inc. using SW-846 methods. TCL/TAL parameter analyses were performed using 8260B plus 10 TICs, 8270C plus 20 TICs, 8081A, 8082, 6010B, 7470A/7471A, and 9010C/9014 for VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, and cyanide, respectively. Sediment samples were also analyzed for grain size and TOC using ASTM Method D422 and USEPA Method 9060, respectively. Groundwater was also analyzed for major cations/anions using method 6010/300. Alkalinity was analyzed for using methods 310.1. Hardness was analyzed for using method 130.2. Groundwater was also analyzed for density in the field using a hydrometer. Air samples were analyzed using USEPA method TO-15. It should be noted that polychlorinated benzenes (1,2-, 1,3-, and 1,4-dichlorobenzenes; and 1,2,4-trichlorobenzene) were reported in the 8260 scan during the RI.

Supplemental Remedial Investigation

Samples were analyzed using the methods and protocols set forth in the approved Wastebeds 1 through 8 QAPP (O'Brien & Gere, 2006b). Samples for all media were analyzed by TestAmerica using SW-846 methods. TCL/TAL parameter analyses were performed using 8260B, 8270D, 6010C, 7470A/7471A, and 9010C/9014 for VOCs, SVOCs (including PXE and PTE), metals, mercury, and cyanide, respectively. Surface soil samples were also analyzed for hexavalent chromium and TOC using USEPA Method 3060A/7199 and Lloyd Kahn, respectively. Subsurface soils were also analyzed for TOC using USEPA Method 3060A/7199. Groundwater was also analyzed for TKN, hardness, alkalinity, TDS, and major cations and anions using Method 351.2, 2340B, 310.1/2320B, 2540C, and 6010B/E300, respectively. Groundwater was also analyzed for specific gravity in the field using a hydrometer.

Naphthalene and Chlorinated Benzene Analysis

It should be noted that naphthalene polychlorinated benzenes (1,2-, 1,3-, and 1,4-dichlorobenzenes and 1,2,4-trichlorobenzene) were alternately reported in the 8260 and 8270 scans depending on the Site investigation. The analytical results will be presented in the data tables and statistics tables under the appropriate laboratory scans. Naphthalene was only included in the 8260 and 8270 scan for the NYSDEC surface water and sediment samples (101-01 through 101-04) and was reported under the 8270 scan for all other samples. Therefore, only naphthalene identified as part of the 8270 scan will be discussed for the purposes of the RI and any future documents for this Site. The 8260 and 8270 results for the four polychlorinated benzenes will be discussed as part of this RI and in future documents (as appropriate). However, the polychlorinated benzenes were typically not detected in the samples and may not be included in the discussion. This is consistent with the adjacent Ballfield Site and was requested for the Ballfield Site in a June 7, 2006 telephone conversation between Tracy Smith of the NYSDEC and Thomas Conklin of O'Brien & Gere.

2.3.2. Data Management

Analytical results were received from the respective laboratories in hard copy and electronic formats. Electronic data received as part of the PSA, FRI, RI, Chromium Speciation Investigation, and SRI were uploaded to the Locus Technologies EIM™ environmental data management system. This data management system was used to develop summary reports for this report and used as the comprehensive database for all project deliverables.

2.3.3. Data Validation

The data validation reports for the PSA, FRI, RI Chromium Speciation Investigation, and SRI were issued to the NYSDEC under separate cover (O'Brien & Gere, 2005d; O'Brien & Gere, 2007e; O'Brien & Gere, 2007f; O'Brien & Gere 2008e; and O'Brien & Gere 2010, respectively). The full reports are not presented within this report, and a summary of the data validation reports is provided below.

Preliminary Site Assessment

The analytical data generated for this investigation were evaluated by O'Brien & Gere using the quality assurance/quality control (QA/QC) criteria established in the following documents as guidance.

- USEPA. 1983. Methods for Chemical Analysis of Water and Wastes. Washington, D.C.
- USEPA. 1988b. Determination of Total Organic Carbon in Sediment, Lloyd Kahn Method. Edison, New Jersey.
- USEPA. 1996a. Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW-846), 3rd Edition. Washington, D.C.
- USEPA. 1998. Methyl Mercury in Water by Distillation, Aqueous Ethylation, Purge and Trap, and CVAFS. Washington, D.C.

Data affected by excursions from the QA/QC criteria were qualified based on guidance provided in the following documents (where applicable) and professional judgment.

- USEPA. 1992. *USEPA Region II Evaluation of Metals Data for the CLP 3/90, SOP HW-2.* New York, New York. (applied to metal and inorganic analyses)
- USEPA. 1996b. *USEPA Region II CLP Organics Data Review, SOP HW-6.* New York, New York. (applied to pesticide analyses)
- USEPA. 1999. *USEPA Region II Standard Operating Procedure For the Validation of Organic Data Acquired Using SW-846 Method 8260B, SOP HW-24.* New York, New York.
- USEPA. 2001. *USEPA Region II Validating Semivolatile Organic Compounds by SW-846 Method 8270B, SOP HW-22.* New York, New York.
- USEPA. 2002. *USEPA Region II Validating PCB Compounds by SW-846 Method 8082, SOP HW-23B, Revision 1.* New York, New York.

A discussion of the data quality with regard to the parameters follows below.

- Data usability with respect to precision was 100 percent for organic and inorganic data. None of the data were rejected for precision excursions.
- Sensitivity is established by reported detection limits which represent measurable concentrations of analytes that can be determined with a designated level of confidence. Dilutions were performed in sample preparation, which elevated detection limits reported for target analytes for this project. With the exception of dilutions performed during the analyses, sensitivity requirements were met for the sample data in this project.
- Data usability with respect to accuracy was greater than 90 percent for VOC, SVOC, pesticide, PCB, herbicide, metals and inorganic data (including mercury, hardness, high resolution mercury, cyanide, chloride, sulfate, alkalinity, pH, and ignitability data). Results for VOC, SVOCs, pesticides, metals and inorganics were rejected due to major accuracy excursions. The majority of the results for samples submitted for total releasable cyanide analyses and total releasable sulfide were rejected due to major accuracy excursions.
- Data usability with respect to representativeness was 100 percent for organic data and greater than 90 percent for metal and inorganic data (including mercury, high resolution mercury, hardness, cyanide, chloride, sulfate, alkalinity, pH, and ignitability data). One pesticide result was rejected due to a major representativeness excursion. Results for metals were rejected due to major representativeness 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 QC. These standards are compared to other unknowns to verify their concentrations. The laboratory consistently used standard analytical methods and reporting procedures; therefore, the comparability criteria for the analytical data were met.

Overall, greater than 90% of the VOC, SVOC, pesticide, PCB, herbicide, metal and inorganic data (including mercury, hardness, high resolution mercury, cyanide, chloride, sulfate, alkalinity, pH, and ignitability) were usable for quantitative and qualitative purposes. The PSA data validation results are available in the *Preliminary Site Assessment Validation Report* (O'Brien & Gere, 2005d).

Focused Remedial Investigation

The analytical data generated for this investigation were evaluated by O'Brien & Gere using the QA/QC criteria established in the following documents as guidance.

- American Water Works Association (AWWA), American Public Health Association (APHA) and Water Environment Federation (WEF). 1992. *Standard Methods for the Examination of Water and Wastewater*, 18th Edition. Washington, D.C.
- USEPA. 1983. *Methods for Chemical Analysis of Water and Wastes.* Cincinnati, Ohio.
- USEPA. 1993. *Methods for the Determination of Inorganic Substances in Environmental Samples*, EPA-600/R-93/100. Washington, D.C.
- USEPA. 2004. *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846,* 3rd Edition, Update IIIB. Washington D.C.

Data affected by excursions from the QA/QC criteria were qualified based on guidance provided in the following documents (where applicable) and professional judgment.

- USEPA. 1995. USEPA Region II Validation Organochlorine Pesticide/PCB Analysis by Method 8080A, SOP HW-23. Revision 0. New York, New York.
- USEPA. 1999. USEPA Region II Standard Operating Procedure For the Validation of Organic Data Acquired Using SW-846 Method 8260B, SOP HW-24. Revision 1. New York, New York.
- USEPA. 2001b. USEPA Region II Validating Semivolatile Organic Compounds by SW-846 Method 8270B, SOP HW-22. Revision 2. New York, New York.
- USEPA. 2002. USEPA Region II Validating PCB Compounds by SW-846 Method 8082, SOP HW-23B, Revision 1. New York, New York.
- USEPA. 2005. USEPA Region II Evaluation of Metals Data for the CLP 3/90, SOP HW-2, Revision 13. New York, New York.

A discussion of the data quality with regard to the parameters follows below.

- Data usability with respect to precision is 100 percent for organic and inorganic data. None of the data were rejected for precision excursions.
- Sensitivity is established by reported detection limits that represent measurable concentrations of analytes which can be determined with a designated level of confidence. Dilutions were performed in sample preparation, which elevated detection limits reported for target analytes for this project. With the exception of dilutions performed during the analyses, sensitivity requirements were met for the sample data in this project.
- Data usability with respect to accuracy was greater than 90 percent for the complete data set. None of the VOC, pesticide, PCB, metals, mercury, and inorganic analyses were rejected due to accuracy excursions. Inorganics include total cyanide, chloride, sulfate, alkalinity (total, bicarbonate, and carbonate), hardness, TDS, TSS, total phosphorus, ammonia, and bromide. Less than 10% of the SVOC results were rejected due to major accuracy excursions.
- Data usability with respect to representativeness was 100 percent for the organic and inorganic data. None of the results were rejected due to major representativeness 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 QC. These standards are compared to other unknowns to verify their concentrations. The laboratory consistently used standard analytical methods and reporting procedures; therefore, the comparability criteria for the analytical data were met.

The samples collected from the Site were evaluated based on QA/QC criteria established by the methods listed above. Data validation qualifiers were applied utilizing the USEPA data validation guidance as listed above. Major deficiencies in the data generation process resulted in data being rejected, which indicates that the data are considered unusable for either quantitative or qualitative purposes. Minor deficiencies in the data generation process resulted in 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.

Considering the complete data set, greater than 90% of the VOC, SVOC pesticide, PCB, metals, mercury, and inorganics analyses were usable for quantitative and qualitative purposes. The FRI data validation results are available in the *Focused Remedial Investigation Validation Report* (O'Brien & Gere, 2007e).

Remedial Investigation

The following document was used as guidance in the validation approach utilized for evaluation of the data collected for this investigation.

- O'Brien & Gere. 2006. Wastebeds 1 through 8 Sites Remedial Investigation/Feasibility Study Work Plan, Appendix A: Quality Assurance Project Plan (QAPP). Syracuse, New York.

The analytical data generated for this investigation were evaluated by O'Brien & Gere using the quality assurance/quality control (QA/QC) criteria established in the following documents as guidance.

- American Water Works Association (AWWA), American Public Health Association (APHA) and Water Environment Federation (WEF). 1992. *Standard Methods for the Examination of Water and Wastewater*, 18th Edition. Washington, D.C.
- Columbia Analytical Services (CAS). 2004. *Standard Operating Procedure for Analysis of Water Samples for Metabolic Acids by HPLC.* SOP HPLC-METACIDS. Rochester, New York.
- Kampbell, D.H., J.T. Wilson, and S.A. Vandegrift. 1991*. Dissolved Oxygen and Methane in Water by a GC Headspace Equilibration Technique.* International Journal of Environmental Analytical Chemistry, Volume 36, pp 249-257.
- Microseeps. 2004. *Standard Operating Procedure for the Analysis of Biodegradation Indicator Gases*. SOP AM20GA4. Pittsburgh, PA.
- USEPA. 1983. *Methods for Chemical Analysis of Water and Wastes.* Cincinnati, Ohio.
- USEPA. 1988b. *Determination of Total Organic Carbon in Sediment.* Region II, Environmental Services Division, Monitoring Management Branch, Edison, New Jersey.
- USEPA. 1993. Methods *for the Determination of Inorganic Substances in Environmental Samples*, EPA-600/R-93/100. Washington, D.C.
- USEPA. 2004. *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846,* 3rd Edition, Update IIIB. Washington D.C.

Data affected by excursions from the QA/QC criteria were qualified based on guidance provided in the following documents (where applicable) and professional judgment.

- USEPA. 1995. USEPA Region II Validation Organochlorine Pesticide/PCB Analysis by Method 8080A, SOP HW-23. Revision 0. New York, New York.

- USEPA. 1999. USEPA Region II Standard Operating Procedure For the Validation of Organic Data Acquired Using SW-846 Method 8260B, SOP HW-24, Revision 1. New York, New York.
- USEPA. 2001. USEPA Region II Validating Semivolatile Organic Compounds by SW-846 Method 8270B, SOP HW-22, Revision II. New York, New York.
- USEPA. 2002. USEPA Region II Validating PCB Compounds by SW-846 Method 8082, SOP HW-23B, Revision 1. New York, New York.
- USEPA. 2005. USEPA Region II Evaluation of Metals Data for the CLP Program, SOP HW-2, Revision 13. New York, New York.

A discussion of the overall data quality with regard to the parameters follows below.

- Data usability with respect to precision was 100 percent for organic and inorganic data. None of the data were rejected for precision excursions.
- Sensitivity is established by reporting detection limits, which represent measurable concentrations of analytes, which can be determined with a designated level of confidence that are less than the project action limits. Dilutions were performed in sample preparation, which elevated detection limits reported for target analytes for this project. Sensitivity requirements could not be evaluated for this project, since a current QAPP was not provided for comparison of detection limits to project limits.
- Data usability with respect to accuracy was greater than 90 percent for organic and inorganic data. Results for VOCs, SVOCs, pesticides, CBOD, mercury, aluminum, and TKN were rejected due to major accuracy excursions.
- Data usability with respect to representativeness was 100 percent for organic data and inorganic data. Results for VOCs were rejected for representativeness 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 QC. These standards are compared to other unknowns to verify their concentrations. The comparability criteria for the analytical data were met, since the laboratory consistently used standard analytical methods and reporting procedures.

The samples collected from the Site were evaluated based on QA/QC criteria established by the methods listed above. Data validation qualifiers were applied utilizing the USEPA data validation guidance as listed above. Major deficiencies in the data generation process resulted in data being rejected, indicating that the data are considered unusable for either quantitative or qualitative purposes. Minor deficiencies in the data generation process resulted in 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.

In considering the complete data set, greater than 90% of the organic and inorganic data were usable for quantitative and qualitative purposes. The RI data validation results are available in the *Remedial Investigation/Feasibility Study Validation Report* (O'Brien & Gere, 2007f).

Chromium Speciation Investigation

The analytical data generated for this investigation were evaluated by O'Brien & Gere using the QA/QC criteria established in the following documents as guidance:

- American Society for Testing and Materials (ASTM). 2000. Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method. West Conshohocken, PA.
- American Water Works Association (AWWA), American Public Health Association (APHA) and Water Environment Federation (WEF). 1998. Standard Methods for the Examination of Water and Wastewater, 20th Edition. Washington, D.C.

- United States Environmental Protection Agency (USEPA). 1983. Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020. Cincinnati, Ohio.
- United States Environmental Protection Agency (USEPA). 1988. Determination of Total Organic Carbon in Sediment, Region II, Environmental Services Division, Monitoring Management Branch, Edison, New Jersey.
- United States Environmental Protection Agency (USEPA). 2004. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, 3rd Edition, Update IIIB. Washington, D.C.

In addition, the following document was used as guidance in the data validation approach:

O'Brien & Gere Engineers, Inc. 2008. *Wastebeds 1 through 8 Sites Remedial Investigation/Feasibility Study Work Plan Appendix A: Quality Assurance Project Plan*

Data affected by excursions from the QA/QC criteria were qualified based on guidance provided in the following document (where applicable) and professional judgment:

- United States Environmental Protection Agency (USEPA). 2006a. *USEPA Region II Evaluation of Metals Data for the CLP Program, SOP HW-2* Revision 13. New York, NY.

A discussion of the data quality with regard to the parameters follows below:

- Data usability with respect to precision was 100 percent for the inorganic data. Data were not rejected for precision excursions.
- Sensitivity is established by QLs, which represent measurable concentrations of analytes that can be quantified with a designated level of confidence and are less than the project action limits established in a QAPP. Dilutions were performed in sample preparation, which elevated QLs reported for target analytes for this project.
- Data usability with respect to accuracy was 100 percent for the inorganic data. Data were not rejected for accuracy excursions.
- Data usability with respect to representativeness was 100 percent for the inorganic data. Data were not rejected for representativeness 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 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, considering the complete data set, 100 percent of the inorganic data were usable for quantitative and qualitative purposes based on the data validation performed.

The samples collected as part of the Chromium Speciation Investigation for the Wastebeds 1 through 8 Site were evaluated based on QA/QC criteria established by the methods listed above. Data validation qualifiers were applied utilizing the USEPA data validation guidance as listed above. Major deficiencies in the data generation process were not identified and data were not rejected for this sampling event. The Chromium Speciation Investigation data validation results are available in the *Chromium Speciation Investigation Validation Report* (O'Brien & Gere, 2008e).

Supplemental Remedial Investigation

The analytical data generated for this investigation were evaluated by O'Brien & Gere using as guidance the QA/QC criteria established in methods listed in the following documents:

- American Water Works Association (AWWA), American Public Health Association (APHA) and Water Environment Federation (WEF). 1998. *Standard Methods for the Examination of Water and Wastewater*, 20th Edition. Washington, D.C.

- United States Environmental Protection Agency (USEPA). 1983. *Methods for Chemical Analysis of Water and Wastes*, EPA-600/4-79-020. Cincinnati, Ohio.
- USEPA. 1996. *Determination of Total Organic Carbon in Sediment (Lloyd Kahn Method). USEPA* Region II, Environmental Services Division, Monitoring Management Branch, Edison, New Jersey.
- USEPA. 2004. *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846,* 3rd Edition, Update IIIB. Washington D.C.

In addition, the following document was also used as general guidance in the data validation approach:

- O'Brien & Gere Engineers, Inc. 2008. Wastebeds 1 through 8 Sites Remedial Investigation/Feasibility Study Work Plan Appendix A: Quality Assurance Project Plan.

Data affected by excursions from the QA/QC criteria previously described were qualified based on guidance provided in the following documents (where applicable) and professional judgment:

- USEPA. 2006a. USEPA Region II Evaluation of Metals Data for the CLP Program, SOP HW-2 Revision 13. New York, NY.
- USEPA. 2006b. USEPA Region II Validating Semivolatile Organic Compounds by SW-846 Method 8270, SOP HW-22 Revision 3. New York, NY.
- USEPA. 2006c. USEPA Region II Validating Volatile Organic Compounds by SW-846 Method 8260B, SOP HW-24 Revision 2. New York, New York.

A discussion of the data quality with regard to the parameters follows below.

- Data usability with respect to precision is 100 percent for organic and inorganic data.
- Sensitivity is established by QLs, which represent measurable concentrations of analytes that can be quantified with a designated level of confidence and are less than the project action limits established for the project. Dilutions were performed in sample preparation, which elevated QLs reported for target analytes for this project.
- Data usability with respect to accuracy is greater than 95 percent for organic and inorganic data.
- Data usability with respect to representativeness is 100 percent for organic and inorganic 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 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.

The samples collected as part of the SRI for the Wastebeds 1 through 8 Site were evaluated based on QA/QC criteria established by the methods listed above. Data validation qualifiers were applied utilizing the USEPA data validation guidance as listed above. Major deficiencies in the data generation process resulted in results being rejected, indicating that the data is considered unusable for either quantitative or qualitative purposes. Minor deficiencies in the data generation process resulted in sample data being characterized as approximate or non-detected. Identification of a data point as approximate indicates uncertainty in the reported concentration of the chemical but not its assigned identity.

In considering the complete data set, greater than 95% of the organic and inorganic data were usable for quantitative and qualitative purposes. The RI data validation results are available in the *Supplemental Remedial Investigation Validation Report* (O'Brien & Gere, 2010).

3. STUDY AREA PHYSICAL CHARACTERISTICS

3.1. CLIMATE

Onondaga County has a humid, continental climate with an annual precipitation averaging about 39 inches. The mean annual temperature is 48°F, with a mean July temperature of 71°F and a mean January temperature of 23°F. Record temperatures range from 102°F in July to -26°F in January and February. The frost-free season lasts between 150 to 180 days per year. The National Weather Service Station at Hancock International Airport collects weather data for the area (NOAA, 2002).

3.2. WASTEBEDS 1 THROUGH 8 SITE TOPOGRAPHY AND DRAINAGE

A Site topographic contour map is included as **Figure 3**. In general, the Site consists of variable terrain with numerous topographic highs and lows that range from about 363 ft above mean sea level (MSL) at the shore of Onondaga Lake to 430 ft above MSL at the highest point. Transportation features bisect the Site and include I-690 (which runs between the lakeshore and State Fair Boulevard), access roads for the New York State Fairgrounds parking lots, and foot bridges.

Ninemile Creek and Ditch A (Outfall 3.1) that drain into Onondaga Lake are the two primary flowing surface water bodies on the Site. Both of these features collect surface water runoff from roadways, topographic highs, and drainage ditches. Ninemile Creek also collects surface water from upgradient off-site sources and has perennial flow.

Drainage patterns and surface water bodies are presented on **Figure 11**. Surface drainage from Wastebeds 1 through 8 generally flows outward in a radial direction from the vegetated upland areas and the upper parking lot for the New York State Fair grounds, which consists of asphalt and gravel. Where transportation features are present, runoff is collected in several drainage swales and ditches and channeled from the central portion of the property to Ninemile Creek, Ditch A, the lakeshore, and low-lying areas. Runoff associated the Crucible Landfill is collected in drainage ditches surrounding the landfill and discharges to Ninemile Creek.

3.3. REGIONAL AND SITE GEOLOGY/HYDROGEOLOGY

3.3.1. Regional Geology

Wastebeds 1 through 8 are located at the base of the Onondaga Escarpment, which marks the boundary between the Ontario Lowlands and Allegheny Plateau physiographic provinces. Ground elevation of the escarpment ranges from about 363 ft MSL at the surface of Onondaga Lake to 1,000 ft above MSL near the top of the cuesta forming the escarpment.

The lowlands are characterized by low relief and unconsolidated glaciolacustrine and glaciofluvial 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 in the vicinity of the Site.

The uplands feature higher relief and unconsolidated deposits of predominant glacial drift or valley train deposits. Bedrock 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 one to two degrees (Kantrowitz, 1970). **Figure 6** provides the Onondaga County Soils Map.

3.3.2. Site Geology

Four geologic cross-sections have been developed to present the Site geology. The cross-section locations are shown on **Figure 12**. **Figures 13, 14, 15, and 16** present cross sections A-A’, B-B’, C-C’, and D-D’, respectively. **Figure 13** presents a cross-section traversing west to east along the lakeshore from Ninemile Creek to Tributary 5A. **Figures 14 and 15** present north-south (perpendicular to lakeshore) cross-sections on the eastern and western perimeters of the Site, respectively. **Figure 16** presents a west to east transect from Ninemile Creek to Tributary 5A traversing along the inland side of Wastebeds 1 through 8.

Overburden at Wastebeds 1 through 8 is similar to other Onondaga Lake sub-sites. Up to 250 ft of both anthropogenic and natural unconsolidated deposits overlie the Silurian Age Vernon Shale.
The overburden deposits in the central portion of the Ninemile Creek Valley, which is southwest of the Site, occupy a bedrock channel scoured by glacial meltwater. This channel intersects with the Onondaga Lake bedrock channel in the area of Wastebeds 1 through 8. While regional bedrock stratigraphy dips to the south, the scoured bedrock surface elevation increases from the Onondaga Lake trough to the Onondaga Escarpment. The till/bedrock surface under the Site slopes downward toward the north and northeast (**Figure 17**). Typically, the upper portion of the bedrock consists of 2 to 20 ft of greenish gray to moderate red, thinly bedded weathered Vernon Shale, which lies above more competent greenish gray to moderate red, thinly bedded Vernon Shale. In some areas, a layer of greenish gray, medium bedded sandstone is observed between layers of the Vernon Shale. Bedrock coring across the Site indicates that much of the upper portion of the bedrock is fractured; however, most fractures have been in-filled with gypsum.

A compacted, red, basal till, which is composed of a clay and silt matrix with varying amounts of sand and gravel, overlies the bedrock in most areas. The till grades downward from a sandy, reworked till to a denser silt and clay till in some areas. The till ranges in thickness from less than 1 ft to 35 ft, and it is not continuous across the entire Site. Till thicknesses are presented on **Figure 18** for the borings and wells which fully penetrated the glacial till unit and had confirmed bedrock cores. An isopach map presenting the thickness of till unit across the Site was not generated due to the sparseness of data points fully penetrating the till.

A gray, basal sand and gravel unit with a thickness of up to 25 feet was observed in some deep borings advanced on the Site. The basal sand and gravel unit is not continuous across the Site and exhibits variable textures and thicknesses typical of adjacent lakeshore sites. This unit typically overlies the basal till unit, but some deep borings indicate that there are locations where the sand and gravel unit is in contact with bedrock. The unit typically coarsens downward from fine to coarse-grained sand to coarse-grained sand and gravel at the base. Basal sand and gravel thicknesses are presented on **Figure 19** for the borings and wells where basal sand and gravel were present. An isopach map presenting the thickness of this unit was not generated given that the unit is not continuous across the Site and the due to sparseness of data points.

Brown glaciolacustrine silts and fine-grained sands overlie the basal sand and gravel or the till unit where the basal sand and gravel are absent. The thickness of the silt and fine-grained sand ranges from 15 to 45 ft across the Site. The silt and fine sand unit is typically massive, shows considerable variation in texture, and grades into the gray basal sand and gravel unit. An isopach figure representing this unit was not generated due to the variability in grain size of this unit and the gradational changes that occur both vertically in each borehole as well as spatially across the Site from borehole to borehole.

The silt and fine-grained sand unit grades upward into the glaciolacustrine silt and clay-confining unit, which occurs across most of the Site. This unit acts as a confining layer between the deep and bedrock groundwater zones and the shallow and intermediate groundwater zones. In general, the glaciolacustrine clay and silt unit is thickest towards the axis of Onondaga Lake and thinnest where bedrock and till elevations increase to the south. This silt and clay layer was not encountered under the middle portion of Wastebeds 2, 3, 4, and portions of 7 and 8 at the Site (**Figure 20**). The silt and fine sand is present where the silt and clay layer is absent.

Olive gray to light olive gray fresh water marl and peat were deposited above the glaciolacustrine units. The marl is characterized by varying amounts of silt, sand, shells, and carbonate deposition. Where present, the unit ranges from 3 to 40 ft thick and forms the native base for the wastebeds. The marl unit thins towards the south moving out of the lake basin. In the south, the marl transitions to a dark brown to black organic rich silt and clay with peaty material. In some areas across the Site, the marl and peat are observed in alternating layers. The presence and thickness of the marl/peat layer is presented on **Figure 21**.

Along the northwestern portion of the Wastebeds 1 through 8 Site, a series of fine to coarse grained sand and gravel deposits were identified during the Preliminary Site Assessment (PSA). The extent and hydraulic connection of these deposits were further delineated and investigated during the Focused Remedial Investigation (FRI) field activities (O'Brien & Gere 2008) and Supplemental Remedial Investigation (SRI) activities (O'Brien & Gere, 2009). These deposits are atypical of the shallow and intermediate geologic units found elsewhere on the lakeshore. The proximity of the deposits to Ninemile Creek indicates that they are likely deltaic deposits related to glacial and post glacial fluvial discharges from the prehistoric melt waters of the Ninemile Creek Valley.

The Ninemile Creek related deltaic deposits represent two classes of deposits: coarse grained sand and gravel deposits and fine grained sand and silt deposits. The coarse grained sand and gravel deposits represent creek bed deposits, and are typically described as loose, dark gray to gray, fine to coarse grained sand with fine to coarse grained sub-rounded gravel. The fine grained sand and silt deposits are described in boring logs as brownish gray to gray, firm, silt and fine sand with trace to little shell material or wood fragments. The fine grained sands and silts represent deltaic deposition adjacent to a contemporaneous active distribution channel.

Ninemile Creek was rerouted to its current location in 1926 to accommodate the installation of Wastebed 5. The former Ninemile Creek channel was reportedly filled with native material from the surrounding marsh prior to placement of the beds (Blasland, Bouck and Lee, 1989).

These deltaic deposits and more recent stream features were investigated during the Wastebeds 1 through 8 RI and the Supplemental RI. These field investigations were implemented to characterize both the extent and nature of the historic deltaic facies, to attempt to locate former channel(s) associated with the recent historical features of Ninemile Creek, and to assess the hydraulic connection of the deltaic deposits with Onondaga Lake and Ninemile Creek. The extent of the deltaic deposit as well as the inferred locations of these channels, depicted in historic maps and drawings, are overlain on the Site map in **Figure 22**. A description of the hydraulic connection of the deltaic deposits to Onondaga Lake is summarized in Section 3.3.4 below, and a more complete description of the observations and conclusions of the Ninemile Creek Investigation for the SRI is found in **Appendix H**.

Wastebeds 1 through 8 form a tiered, fill layer above the natural sediments throughout the entire Site. The upper levels of the wastebeds are up to 65 ft above lake level with a maximum thickness of approximately 78 ft and a typical thickness ranging between 60 and 70 ft. The fill is thinner between the toe of the wastebeds to the lake, where the fill is outside the original wastebed containment.

The exact nature of the material used to construct the perimeter berms is unknown and is expected to be variable depending on location. It is believed that containment on the northern shore of the wastebeds consisted of perimeter dikes constructed of piles, sheeting, and/or earth. Earthen dams possibly consisted of a mixture of urban fill consisting of slag, bricks, gravel, sand, and silt. Field activities also uncovered hardened, concrete-like berms on the perimeter of Wastebed 5 adjacent to Ninemile Creek. This berm configuration suggests that Solvay waste was mixed with lime (CaO) containing fly ash and/or high hydroxide slurry to form a cement like mixture which was used to construct or reinforce the perimeter structures. Relic bulkhead woodpiles are evident along the lakeshore, which probably supported the wooden sheeting along the lakeshore between toe of the wastebeds and Onondaga Lake.

The bottom-of-fill elevations are presented on **Figure 23**. The fill within the wastebeds is composed primarily of hydraulically-placed Solvay waste consisting of silt-sized particles of insoluble residues, hydroxides, and various salts derived from the Solvay soda ash process. Hydraulic placement has resulted in interbedded layers of waste and thin fly-ash stringers with several 2 to 4 ft layers of dense, cemented waste. The fly ash and bottom ash from the coal-fired power plant associated with the Solvay Process were reportedly removed mechanically from the boiler house and sent to the wastebeds for disposal.

Solvay waste is also found outside of the perimeter of the berms, between the toe of the berm and the remnant wooden bulkheads on the lakeshore, and in Ninemile Creek and Onondaga Lake. These deposits of waste may have been transported to native surfaces via berm overtopping/overflows, seepage through the berms and/or bulkheads, berm failures, and redistribution by surface water bodies like Ninemile Creek and Onondaga Lake.

3.3.3. Regional Hydrogeology

In general, regional surface water and groundwater flows from Otisco Lake and the Onondaga Escarpment northwards towards the Lake Ontario Basin. The regional hydrogeologic system upgradient of the Site reflects the glacial and fluvial processes that formed the overburden of the Ninemile Creek Valley.

Regional groundwater flow is toward the Ninemile Creek Valley and Onondaga Lake. Groundwater in the Ninemile Creek Valley flows northeast toward Onondaga Lake. Groundwater flow to Onondaga Lake is influenced by a naturally occurring halite brine pool that resides in the unconsolidated sediments under Onondaga Lake (Yager *et al.*, 2007). Groundwater in the northeastern end of the Ninemile Creek Valley, near Onondaga Lake, is also influenced by a calcium rich, anthropogenic brine from another series of Solvay waste wastebeds (Wastebeds 9 through 15), which are hydraulically upgradient of the Site (Wastebeds 9 through 15 Closure Investigation Report, O'Brien and Gere 2013). Wastebeds 9 though 15 began receiving Solvay waste in 1944.

This naturally occurring halite brine pool has been the subject of research by the United States Geologic Survey (USGS). "Halite brine occurs in glacial-drift sediments at the northern end of the Onondaga Trough, covering an area of about 26 square kilometers (km^2) and extending 10 km south of Onondaga Lake" (Yager *et al.*, 2007). Research by the USGS suggests that a potential mechanism for the formation of the natural brine pool was a relatively quick dissolution of halite from the Syracuse and Salina formation salt beds during deglaciation. The USGS research indicates that this pool has remained relatively unchanged since its formation and initial transportation 16,000 years ago. The native brine discharges to the surface where upwardly moving fresh groundwater migrating through the upper native overburden overrides and mixes with the native brine pool (Yager *et al.*, 2007). This brine pool is the source of the historic brine springs that occurred around the lake and the brine wells. The presence of this brine pool, as well as the current presence of anthropogenic calcium rich brine from the wastebeds affects the movement of groundwater in the vicinity of Onondaga Lake.

3.3.4. Site Hydrogeology

Groundwater Setting

Hydrogeologic investigations have identified two groundwater systems comprising six hydrogeologic units at the Site. These two systems and each of the six units are presented on **Table 38**, and are described as follows:

Upper Groundwater System

- A shallow zone composed of Solvay waste and anthropogenic fill within the upland portions of the beds
- An intermediate zone composed largely of marl, with some peat and Solvay waste
- The Ninemile Creek deltaic deposits

Lower Groundwater System

- A confining layer composed of the silt and clay
- A deep zone consisting of the silt and fine grained sand unit and the basal sand and gravel unit
- A shallow bedrock zone

The description of these hydrogeologic units in terms of their geologic characteristics and hydraulic properties are discussed in the following subsections. The inorganic geochemistry of the Site groundwater and native groundwater are also briefly discussed following the unit descriptions. Lastly, these individual units comprise two larger groundwater flow systems, the Upper flow system and the Lower flow system. A brief description of these two groundwater flow systems, the relationship of these hydrogeologic units within these flow systems, and the overall relationship between the Upper and Lower flow systems is discussed in Section 3.5.

Shallow Hydrogeologic Unit

The shallow groundwater unit consists of the Solvay waste and anthropogenic fill. The shallow wells ("S" wells) in this unit screen the water table in the heterogeneous Solvay waste/fill in the upland areas of Wastebeds 1 through 8 (**Table 21**). The horizontal hydraulic conductivity estimated for the shallow zone from field permeability tests ranges from 0.03 to 6.55 ft/day (9.0x10^{-6} to 2.3x10^{-3} cm/sec), with a geometric mean of 0.22 ft/day (7.85x10^{-5} cm/sec; **Table 21**). Horizontal hydraulic conductivity values estimated from pumping tests range from 0.44 to 9.03 ft/day (1.5x10^{-4} to 3.2x10^{-3} cm/sec) with a geometric mean of 1.74 ft/day (6.1x10^{-4} cm/sec; **Table 27**). Vertical hydraulic conductivities estimated from laboratory permeability tests of the shallow zone range from 5.7x10^{-3} to 1.4x10^{-2} ft/day (2.00x10^{-6} to 5.00x10^{-6} cm/sec), with a geometric mean vertical hydraulic conductivity of 2.2x10^{-2} ft/day (7.82x10^{-6} cm/sec; **Table 22**). The low vertical hydraulic conductivity observed in the Solvay waste is due to the layered nature of the hydraulically placed waste.

Groundwater elevation maps presenting measured heads and specific gravity measurements were developed using data from a low water event in June 2007and a high water event in December 2007; **Figures 24 and 25**, respectively). The water table is typically 20 to 35 ft bgs on top of the upper wastebed tiers, and 10 to 18 ft bgs on the lower wastebed tiers adjacent to Ninemile Creek. The water table fluctuates across the Site depending on season and location of the monitoring well. Monitoring wells located on lower tiers of the wastebeds typically have 10-ft seasonal fluctuations; monitoring wells located on the upper tiers of the wastebeds show typical seasonal fluctuations of 20 feet (**Table 23**). Generally, the hydraulic head potential is highest in the Shallow Hydrogeologic Unit compared to any of the other units on the Site except along the shoreline of Onondaga Lake and Ninemile Creek where hydraulic potentials generally increase with depth.

Intermediate Hydrogeologic Unit

The intermediate zone consists mainly of olive gray to light olive gray fresh water marl. Groundwater wells (perimeter "S" wells and "I" wells) in the Intermediate hydrogeologic unit screen the fine-grained marl/peat immediately underlying the shallow Solvay waste hydrogeologic zone, the thin waste layer and marl outside the perimeter of the toe of the beds, and deeper "I" wells are screened at the base of the fine-grained marl around the perimeter of the beds.

The Intermediate Hydrogeologic Unit contains both "S" (Shallow/ Water table) wells and "I" (Intermediate) wells. In general, the wells in this unit screen the upper marl, at approximately the same elevation as Onondaga Lake (~365 to ~355 amsl) both within the perimeter of the wastebeds and at the lakeshore. However, due to the elevation difference between the mounded Solvay waste and native ground surface at the perimeter of the beds, S (shallow) wells along the lakeshore are included in the Intermediate Hydrogeologic Unit (**Table 38**). Also included in this unit are three Intermediate wells on the lakeshore, which are WB18-MW-01I, WB18-MW-02I, and WB18-MW-03I. These wells screen the base of the marl unit, and the top of the silt and clay.

Horizontal hydraulic conductivity values estimated for the intermediate zone from field permeability tests had a geometric mean of 0.087 ft/day (3.07x10^{-5} cm/sec) and a range from 0.003 to 2.5 ft/day (1.0x10^{-6} to 9.0x10^{-4} cm/sec) **(Table 21)**. Horizontal hydraulic conductivity values estimated from pumping tests ranged from 1.21 to 13.16 ft/day (4.2x10^{-4} to 4.6x10^{-3} cm/sec) with a geometric mean of 7.73 ft/day (2.7x10^{-3} cm/sec; **Table 27).** Vertical hydraulic conductivity values estimated from laboratory permeability tests had a geometric mean of 1.6x10^{-3} ft/day (5.8x10^{-7} cm/sec), with a range from 2.0x10^{-4} to 2.9x10^{-2} ft/day (7.0x10^{-8} to 1.0x10^{-5} cm/sec; **Table 22**). The hydraulic conductivity of the marl varies depending upon the proportion of silt, sand, and clay.

Groundwater elevation maps presenting measured heads and specific gravity measurements were developed using data from a low water event in June 2007and a high water event in December 2007; **Figures 26 and 27,** respectively). Hydraulic head potential is higher in the marl wells in the central portion of the beds (I wells) compared to the hydraulic heads at the perimeter of the Site (S and I wells). This indicates that some portion of groundwater is moving from the elevated portion of the wastebeds outward toward Onondaga Lake, Ninemile Creek, and other surface water discharge features. Hydraulic head potential is also higher in the marl under the wastebeds (I wells) compared to the wells screening the sand and gravel unit below the beds (D wells) indicating hydraulic potential for downward migration. Along the Shore of Onondaga Lake there is an upward vertical hydraulic gradient between the deep zone and the intermediate zone.

Deltaic Deposits (former Ninemile Creek Sand and Gravel)

As described above in Section 3.3.2, Ninemile Creek Valley deltaic deposits are found in the marl unit beneath Wastebeds 5 and 6. While these deposits are part of the Intermediate Hydrogeologic Unit, they have unique hydrogeologic characteristics which required separate consideration and discussion.

The alluvial and deltaic deposits range in thickness from 5 to 18 ft, increasing in thickness in the area where the former creek channel entered Onondaga Lake. Horizontal hydraulic conductivity values for the deltaic deposit wells estimated from field permeability tests had a geometric mean of 1.3 ft/day ($4.7x10^{-4}$ cm/sec) and a range from 0.51 to 10 ft/day ($1.8x10^{-4}$ to $3.6x10^{-3}$ cm/sec) (**Table 21**). The variability in horizontal hydraulic conductivity reflects the variability in the relative proportions of silt, sand and gravel occurring within the screened intervals of the wells. These hydraulic conductivities of the Ninemile Creek deltaic deposits are higher than the mean hydraulic conductivity of the Wastebeds 1 through 8 marl deposits (0.09 ft/day or $3.1x10^{-5}$ cm/sec). Therefore, the deltaic deposits potentially represent a preferential groundwater flow pathway within the intermediate hydrogeologic unit. As noted above in the geologic description of the Ninemile Creek alluvial deposits, this depositional sequence within the Intermediate Hydrogeologic Unit has been the subject of several focused studies.

Intermediate and deltaic groundwater elevation maps presenting measured heads were developed from water levels collected in September 11, 2009 during SRI activities (**Figure 28**). The water levels were presented in the 100% Design Report to assess the potential for focused groundwater discharge to Onondaga Lake and Ninemile Creek. The data show a potential for groundwater flow from the center of the deltaic deposits toward the surface water bodies. However, the groundwater elevation data also suggest that groundwater elevations within the deltaic deposits are generally lower than groundwater elevations in the surrounding intermediate zone materials. Low groundwater elevations in the deltaic deposits are consistent with the deltaic deposits having a higher hydraulic conductivity than the surrounding intermediate zone materials. The results of the focused studies and a more in depth description of the hydraulics of this sub-unit are contained in **Appendix H**.

Silt and Clay Confining Layer

Beneath the intermediate groundwater zone is the glaciolacustrine silt and clay confining layer. The silt and clay confining layer consists mainly of thinly laminated silt and clay beneath the intermediate marl and above the glacio-lacustrine silt and sand layer. Vertical hydraulic conductivities estimated from laboratory permeability tests have a geometric mean of $2.8x10^{-4}$ ft/day ($9.8x10^{-8}$ cm/sec), with a range from $1.4x10^{-4}$ to $4.7x10^{-4}$ ft/day ($5.0x10^{-8}$ to $1.7x10^{-7}$ cm/sec; **Table 22**). This low permeability unit acts as a confining layer separating the shallow and intermediate groundwater units and the deep groundwater unit, where present. This confining layer is absent along the upland portion of Wastebeds 1, 2, 3, 4, and 7 (**Figure 20**).

Under the wastebeds there is a downward vertical hydraulic gradient between the intermediate zone and the deep zone. Along the shore of Onondaga Lake there is an upward vertical hydraulic gradient between the deep zone and the intermediate zone. Where the confining layer is present it limits vertical groundwater flow.

Deep Hydrogeologic Unit

The deep hydrogeologic unit consists of the basal sand and gravel layer and the glacio-lacustrine silt and sand layer. Deep monitoring wells in this hydrogeologic unit were placed at the top of till, with the intent of targeting the basal sand and gravel. If the sand and gravel was not present at the top of till interface, then the deep well screens were placed in the glacio-lacustrine silt and sand layer.

Field permeability tests of the deep sand and gravel yielded a geometric mean horizontal hydraulic conductivity value of 200 ft/day ($6.9x10^{-2}$ cm/sec) and a range of 8.5 x 10^{-1} to 29 ft/day ($3.0x10^{-4}$ to $1.0x10^{-2}$ cm/sec; **Table 22**). Field permeability tests of the glacio-lacustrine silt and sand reported a geometric mean horizontal hydraulic conductivity value of 42 ft/day ($1.5x10^{-2}$ cm/sec) and a range of $1.6x10^{-2}$ to 61 ft/day ($5.7x10^{-6}$ to $2.2x10^{-2}$; **Table 22**). The hydraulic conductivity of the deep hydrogeologic unit varies depending upon proportion of silt, sand, and gravel.

Groundwater elevations in the deep zone and measured densities in June 2007 and December 2007 are depicted on **Figures 29 and 30**. The deep zone wells along the lakeshore (MW-01D, MW-02D, MW-03D, and MW-09D) have water elevations above the lake elevation, which indicates an upward hydraulic gradient (**Table 23**). However, the low hydraulic conductivity of the silt and clay-confining layer above the deep hydrogeologic unit suggests there is little groundwater movement vertically through the confining layer.

Basal Till Layer

The basal till unit consists mainly of varying amounts of silt, clay, sand, and gravel in a dense compacted layer above the bedrock unit. This unit is not considered a zone of significant groundwater flow. Therefore, no monitoring wells have been installed in this unit on the Site. Field permeability tests from subsurface investigations in the area report horizontal hydraulic conductivity values of the basal till unit ranging from 0.055 to 8.8 ft/day (O'Brien & Gere, 2002c; Winkley, 1989; Parsons, 2003; BBL, 1995). This range reflects the varying composition of the till. In general, the till is expected to act as a confining layer between the deep groundwater zone and the bedrock where present. The basal till slopes downward along the bedrock face towards the lake.

Bedrock Hydrogeologic Unit

Typically, the bedrock zone consists of 2 to 20 ft of weathered fine-grained, finely-bedded Vernon Shale above more competent shale bedrock with fractures in-filled with gypsum. The bedrock surface slopes to the north towards the lake; however, the bedrock bedding planes have a southerly dip away from the lake. During coring activities, clay lenses and gypsum-healed fractures were observed with no obvious pattern.

Field permeability test results provide a geometric mean horizontal hydraulic conductivity value of 0.35 ft/day ($1.2x10^{-4}$ cm/sec) with a range of $6.6x10^{-4}$ to 5.4 ft/day ($2.3x10^{-7}$ to $1.9x10^{-3}$ cm/sec; **Table 22**). The hydraulic conductivity of this unit varies depending upon the weathering, fracture size, and secondary mineral content of the zone being tested. Permeability of individual fractures and the competency of the bedrock have an effect on the values.

Figures 31 and 32 present the June 2007 and December 2007 groundwater elevations in the bedrock zone, as well as measured density.

3.4. GROUNDWATER GEOCHEMISTRY

Geochemical data collected in May 2007 during the Remedial Investigation were used to plot geochemical signatures on Stiff diagrams. Based on the diagrams, the patterns illustrate the groundwater types observed at the Wastebeds 1 through 8 Site. These groundwater water types are summarized below:

- Leachate from the wastebeds
- Dilute leachate
- Chloride depleted dilute leachate
- Native halite brine
- Native halite brine and leachate mix
- Unknown water types

Stiff diagrams comparing major anion and cation (magnesium, calcium, sodium, potassium, sulfate, bicarbonate, carbonate, and chloride) concentrations from the May 2007 sampling event are presented in **Appendix M**. Each of these patterns is displayed on the figures, and each pattern has been color coded to illustrate similar water types. The distribution of the different groundwater types distinguished by the Stiff diagrams is depicted with the same color coding on **Figures 33 through 37**. The data used to create the Stiff diagrams include the key geochemical parameters of sodium, calcium, magnesium, potassium, chloride, carbonate/bicarbonate alkalinity, and sulfate. These data are presented on **Table 39**. Additional geochemical parameters were used to classify the water types at the Site. These additional parameters include pH, calculated dissolved solids (calculated using major ions in solution) and water type. These are also presented on **Table 39**.

3.4.1. Leachate

A typical leachate signature for the Site is depicted by the Stiff diagrams and ordered by water type on **Figures M-1 through M-4**. The pattern displayed in these figures compares milliequivalent (meq) concentrations of sodium plus potassium, calcium, magnesium, chloride, carbonate plus bicarbonate, and sulfate. The most notable comparison in the leachate type water is between chloride, calcium, and sodium. Leachate characteristically contains approximately twice as much calcium as sodium and typically twice as much chloride as calcium in miliequivalents per liter. These ratios vary slightly depending on the geochemical conditions, but overall, the pattern of the Stiff diagram is distinct. Calcium, sodium, and chloride are the major ions in solution, and concentrations of potassium, magnesium, sulfate, and carbonate/bicarbonate are minor in comparison. A representative sample of wastebed leachate was included using the chemistry reported in the *Hydrogeologic Assessment of the Allied Waste Beds in the Syracuse Area* (BBL, 1989).

The high dissolved concentrations of calcium, chloride, and sodium are representative of the Solvay process where some of the sodium in the native sodium chloride (NaCl) brine was precipitated as soda ash through a series of intricate chemical steps. Calcium from lime (CaO) was used to elevate the solution to a high pH allowing for soda ash precipitation. The chloride from the halite brine remained in solution through the process. The residual waste product had high calcium, chloride, and sodium. The pH of the residual product was generally elevated (usually above 10 and sometimes above 12), and is representative of the leachate slurry that was placed in the wastebeds. A summary of the geochemical conditions within the Site monitoring wells is presented above in **Table 39**. The distribution of the leachate is depicted with yellow dots on **Figures 34 through 37**. Leachate is found in the Intermediate, Ninemile Creek Deltaic deposits, Deep, and Bedrock hydrogeologic units, and its distribution illustrates, in part, historical groundwater flow paths at the Site.

3.4.2. Dilute Leachate

The Site dilute leachate water type typically has low concentrations of the major ions represented in the Stiff diagram compared to other leachate impacted groundwater. In addition, the pH for this water type is between 6 and 9. A typical dilute leachate groundwater signature for the Site is depicted on the Stiff diagrams presented on **Figures M-5**. The Stiff diagram is similar in shape, due to the similar ratios of ions compared with the leachate type; however, the concentrations of these ions are typically an order of magnitude less than leachate type waters. Calculated dissolved solids (**Table 39**) are also an order of magnitude less than those for leachate type waters. The distribution of dilute leachate water types is indicated in green on **Figure 33**. Dilute leachate is only found in the wells in the Intermediate hydrogeologic unit. Wells with diluted leachate signatures are located at the perimeter of the beds, or under the wastebeds near the gap in the confining silt and clay unit.

3.4.3. Chloride Depleted Leachate

A typical signature for chloride depleted leachate is presented on **Figures M-6 and M-7**. Overall the concentrations and dissolved species are similar to dilute leachate, however the diagrams display a unique pattern in terms of relationships due to the low chloride concentrations. With respect to leachate type waters and dilute leachate type waters, the chloride concentrations for leachate waters are approximately balanced by half the calcium concentrations (*e.g.,* chloride ~100 meq to calcium ~50 meq). However, with the chloride depleted groundwater type, the concentrations of chloride are not balanced by half the calcium concentrations. The calcium concentrations are balanced by hydroxide (OH^-). As a result, chloride depleted leachate also has a characteristically high pH similar to leachate type waters with pH > 12 (**Table 39**). The distribution of chloride depleted leachate water types are indicated in blue on **Figures 33 and 34**.

3.4.4. Native Halite Brine

A typical native halite brine signature for the area is depicted by the Stiff diagrams on **Figure M-8**. The typical halite brine has similar sodium and chloride concentrations (miliequivalents per liter) and typically the relative concentrations of all the other major cations and anions are significantly lower. Brines produced by the dissolution of halite consist almost entirely of sodium and chloride and have low concentrations of calcium (Kappel and Miller, 2005). As a result, the Stiff diagram visually displays a very characteristic "T" pattern. Furthermore, halite brines are distinguished from leachate by the significantly lower calcium concentrations compared with higher concentrations of sodium and a pH generally in the neutral range (6 to 8 S.U.). The distribution of native halite brine water types in intermediate and bedrock hydrogeologic unit wells are indicated in orange on **Figures 34 and 37**. A summary of the geochemical conditions within the bedrock formation is presented in **Table 39**. The wells in the intermediate unit are WB18-MW-01I, WB18-MW-02I and WB18-MW-03I. These wells are located at the base of the intermediate unit on the lakeshore in the fine grained marl. Bedrock wells with native halite brine signatures are WB18-MW-03BR, WB18-MW-04BR and WB18-MW-14BR. These are located on the western half of the Site.

3.4.5. Mix of Leachate and Native Brine

A typical signature for a mix of leachate and native brine for the Site is depicted by the Stiff diagrams on **Figure M-9**. The diagrams display a similar to both the leachate Stiff diagrams and the halite brine diagrams. The concentrations of sodium are high due to the presence of the halite brine, dissolved calcium concentrations are also high due to the calcium rich leachate, and chloride is high due to both leachate and brine. Typically the sum of the calcium, potassium and sodium concentrations (meq) roughly equals the total chloride concentration (meq). The key characteristic that distinguishes the mixture of native halite brine and leachate from solely leachate is the higher milliequivalent concentration of sodium compared to calcium. The distributions of mixed native halite brine and leachate signatures for the Site are depicted as red dots on **Figures 35 through 37**. Native halite brine and leachate mix type waters are located in one G well in the Ninemile Creek Deltaic deposits at Lakeview Point (WB18-MW-24G), in several screening the deep sediments underlying the deltaic deposit (WB18-MW-03D, WB18-MW-04D, WB18-MW-16D, and WB18-MW-17D). The native halite brine and leachate mix water type is also found in three bedrock wells WB18-MW-06BR, WB18-MW-19BR2 and WB18-MW-09BR.

3.4.6. Unknown Water Type

Three wells display unknown signatures as depicted by the Stiff diagrams in **Figure M-10**. The Stiff diagrams for WB18-MW-13D and WB18-MW-09I have a similar shape to leachate and native halite brine mix, however they appear to be considerably more dilute than other leachate and native brine mixtures. The Stiff shapes for these wells also appear similar to a water type collected from Gale Springs by the USGS (OD-1812) on the north side of Onondaga Lake. Gale springs represents weak, native brine naturally discharging to the land surface.

The third well with an unknown water type is WB18-MW-06D. This well appears to be a leachate type without the chloride concentrations. The high calculated dissolved solids are similar to other leachate type waters. While the low chloride concentrations are distinct, it is worth noting that the chloride concentration for other sampling dates in this well is more representative of leachate type water.

The distribution of these unknown water types are indicated as purple diamonds (WB18-MW-13D and WB18-MW-09I) and a yellow diamond for WB18-MW-06D) on **Figure 34 and Figure 36**. A summary of the geochemical conditions for these wells is presented in **Table 39**.

3.5. GROUNDWATER FLOW

3.5.1. Upper Groundwater System

As described above, the groundwater at the Site is divided into two flow zones, the upper flow system and the lower flow system. These two zones are separated by a silt and clay confining layer, where it exists. The upper flow system comprises the anthropogenic fill/wastebed hydrogeologic unit and the native marl hydrogeologic unit, and includes the Ninemile Creek deltaic deposits on the western side of the site. The lower flow system is comprises the fine sand, a basal sand and gravel, and bedrock.

As illustrated in **Figure 3**, the wastebeds are a topographic high; therefore, recharge from precipitation is the source of the groundwater in the upper flow system. Groundwater is not expected to flow into the Site from offsite due to the hydraulic mounding observed in the wastebeds. Site groundwater (infiltration) flows outward from the wastebeds toward Onondaga Lake, NMC, and drainage ditches. Groundwater flow along the northern and eastern shores is towards Onondaga Lake.

The geochemical signatures and densities are generally consistent with these flow patterns. Leachate signature or diluted leachate signatures are found in the marl under the wastebeds and along the perimeter of the beds. The native brine signatures observed in the deeper portions of the native marl along the lakeshore suggest that there is an interface between the native halite brine and the leachate along the eastern lakeshore. Some portion of the groundwater in the upper flow system potentially flows vertically downward to the Lower Groundwater System.

3.5.2. Lower Groundwater System

The Lower Groundwater System at the Wastebed 1 through 8 Site is potentially recharged in part from the overlying Upper Groundwater System through the gap in the silt and clay. This system is also likely a part of a more substantial, regional groundwater system which includes the Ninemile Creek Valley and areas adjacent to the Site. The distribution of the leachate type groundwater and proximity of the Wastebed 1 through 8 Site to the Lower Groundwater System suggest that the Wastebed 1through 8 Site may be a source for leachate. However, there are other wastebeds in the area with leachate impacted groundwater. These Sites may also contribute to the impact to the Lower Groundwater System.

4. NATURE AND EXTENT OF CONSTITUENTS

This section presents a discussion of the nature and extent of constituents at the Site based on data collected during the PSA (including the Bike Trail surface soil sampling), FRI, RI, Chromium Speciation Investigation, and SRI. The nature and extent of constituents are presented for the various media sampled. A sample summary for all media is presented on **Table 1**.

In accordance with the NCP and CERCLA, data collected from various media were compared to conservative guidance values to develop a list of preliminary chemical parameters of interest (CPOIs). These preliminary CPOIs are based on based on conservative screening values and may not be representative of current or future uses of the Site, or calculated risks. Summary statistics for each environmental medium are provided below. As part of these summary statistic tables preliminary CPOIs are provided. For each environmental medium the Site constituents were considered to be preliminary CPOIs if one of the following criteria was exceeded:

- 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 is known to bioaccumulate
- The constituent has no screening criterion

The preliminary CPOI screening is documented in Section 5 of this report.

4.1. SURFACE SOILS CHARACTERIZATION

For the purposes of this report, a surface soil is a sample collected from within the 0 to 2 ft bgs interval. These samples were collected in conjunction with surface soil or subsurface soil locations. For purposes of discussion the Site was separated into three subsections for surface soils: Parking Lot Area, Upland Area, and Lakeshore Area. The Parking Lot Area includes the NYS Fairgrounds parking lots (**Figure 2**), while the Lakeshore Area encompasses the Onondaga Lake shoreline. The remaining vegetated area is considered the Upland Area.

Volatile organic compound (VOC) CPOIs detected in Site surface soils include acetone, benzene, toluene, ethylbenzene, xylene, and methylene chloride. Total BTEX concentrations are presented on **Figure 38**.

SVOC CPOIs detected at the Site include naphthalene, assorted PAHs, and assorted phenols. The naphthalene exceedances to NYSDEC Part 375.6 Unrestricted Use Soil Cleanup Objectives and total PAH concentrations in Site surface soils are presented on **Figures 39 and 40**, respectively. The total PAH concentrations were derived by calculating the sum of the following detected chemical parameters in the USEPA SW-846 Method 8270 scan.

- 2-methylnaphthalene
- acenaphthene
- acenaphthylene
- anthracene
- benzo[a]anthracene
- benzo[a]pyrene
- benzo[b]fluoranthene
- benzo[g,h,i]perylene
- benzo[k]fluoranthene
- chrysene
- dibenzo[a,h]anthracene
- fluoranthene
- fluorene
- indeno[1,2,3-cd]pyrene
- naphthalene
- phenanthrene
- pyrene

The concentrations of total phenols observed in surface soils are presented on **Figure 41**. The total phenol concentrations were derived by calculating the sum of the following detected chemical parameters in the USEPA SW-846 Method 8270 scan.

- 2,4,5-trichlorophenol
- 2,4,6-trichlorophenol
- 2,4-dichlorophenol
- 2,4-dimethylphenol
- 2,4-dinitrophenol
- 2-chlorophenol
- 2-methylphenol
- 3+4-methylphenol or 4-methylphenol
- 2-nitrophenol
- 4,6-dinitro-2-methylphenol
- 4-chloro-3-methylphenol
- 4-nitrophenol
- pentachlorophenol
- phenol

Exceedances to NYSDEC Part 375.6 Unrestricted Use Soil Cleanup Objectives for selected inorganic CPOIs in Site surface soils, including aluminum, arsenic, barium, chromium, hexavalent chromium, mercury, nickel, and selenium, are presented on **Figures 42, 43, 44, 45, 46, 47, 48, and 49**, respectively.

Exposed surface soils, especially within the top 0 to 0.5 ft bgs, are largely variable across the site and include soils, fill, Solvay waste, detritus, or mixture of these materials. In March 2014, samples were collected from 0 to 0.17 ft bgs and 0 to 0.5 ft bgs at 11 surface soil locations across the site. These samples were analyzed for pH by O'Brien & Gere using USEPA Method 9045D, and a summary of the data and sample location figure are presented in **Appendix N.** Surface soil pH in the March 2014 event ranged from 7.71 to 8.46 standard pH units. The pH of exposed surface soils is influenced by the presence of Solvay waste, but is on the lower end of the observed Solvay waste range which is typically alkaline and can be greater than 12. It has also been demonstrated that Solvay waste to 1 ft bgs weathers to pH's between 8 and 9 within 10 years following placement, and within 50 years after placement, Solvay waste pH in this depth range tends to be closer to neutral, less than 8 (Hewlett, 1956). According to Hewlett (1956), reductions in Solvay waste pH result from weathering and other internal chemical reactions. These reactions may include the following that are typical soil acidifiers in natural systems (Brady & Weil, 2002):

- Accumulation of organic matter
- Root and microbe respiration leading to the formation of carbonic acid in the soil
- Nitrogen mineralization leading to acidic byproducts
- Acid deposition
- Cation uptake by plants

The pH of Solvay waste was measured during the PSA at 16 subsurface soil locations (presented in section 4.2), and had a range of 7.9 to 12.4 standard pH units (**Table 84)**. Ten samples were collected between 2 and 10 ft bgs and had a pH range of 7.9 to 12.4 standard pH units, three samples were collected between 14 and 24 ft bgs and had a pH range of 12.3 to 12.4 standard pH units, and two samples were collected from 50 to 64 ft bgs and had a pH range of 12 to 12.2 standard pH units. One sample was collected from the silt and sand layer below the wastebeds at 58-60 ft bgs and had a pH of 8.1 standard pH units. The large variation in pH range may reflect the weathering process discussed above, or is likely caused by Solvay waste mixing with other materials. The lower pH readings were generally from areas where Solvay waste makes up a lesser percentage of the soil, whereas the more elevated pH levels were generally from unmixed Solvay waste.

4.1.1. Parking Lot Area Surface Soils

Surface soil samples were collected in the Parking Lot Area during the PSA, RI, and Chromium Speciation Investigation from the gravel fill that comprises the Parking Lot Area. PSA samples were collected from 13 locations at depths of 0 to 0.5 ft bgs, and 0.5 to 1 ft bgs. The samples were co-located with six test pits (SS-21, SS-22, SS-23, SS-26, SS-27, and SS-28) and four direct push borings (SS-29 through 32) and from three surface soil sample locations (SS-33, SS-34, and SS-35) within the Parking Lot Area. In addition to the samples co-located with test pits, one sample was collected for VOCs only from test pit TP-28 from a depth of 1 to 2 ft bgs. One RI surface soil sample was collected from one location (SS-20C) within the Parking Lot Area. Chromium Speciation

Investigation samples were collected from 10 locations (SS-38, SS-56, SS-57, SS-58, SB-125, SB-126, and SB-132 through SB-135) Summaries of PSA, RI, and Chromium Speciation Investigation surface soil locations and laboratory analyses are included in **Tables 2, 4, and 5**.

Analytical results for the PSA surface soils are presented on **Tables 40 through 45** for VOCs, SVOC, pesticides, PCBs, inorganics, and percent solids, respectively. The RI surface soil analytical results are presented on **Tables 46 through 51** for VOCs, SVOCs, pesticides, PCBs, inorganics, and percent solids, respectively. Chromium Speciation Investigation data are presented on **Table 52**. Sample locations are presented on **Figure 4A**.

Summary statistics are provided on **Table 53** for surface soil chemical parameters detected in the Parking Lot Area. Detected CPOIs are listed below in **Table 4.1**.

Table 4.1 Detected Parking Lot Area Surface Soil CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Part 375.6 Unrestricted Use Soil Cleanup Objectives
Volatile Organic Compounds (µg/kg)						
Acetone	29	2	48.8	95.0	1	50
Semivolatile Organic Compounds (µg/kg)						
Benzo(B)fluoranthene	28	18	768	3,900	4	1,000
Benzo(A)pyrene	28	16	898	4,100	4	1,000
Benzo(K)fluoranthene	28	15	783	3,300	4	800
Indeno(1,2,3-CD)pyrene	28	12	530	1,700	4	500
Chrysene	28	19	749	3,700	3	1,000
Benzo(A)anthracene	28	17	759	3,600	3	1,000
Dibenzo(A,H)anthracene	28	9	310	1,100	3	330
Fluoranthene	28	22	979	5,000	0	100,000
Phenanthrene	28	20	617	3,000	0	100,000
Pyrene	28	20	1,277	7,500	0	100,000
Benzo(G,H,I)perylene	28	13	581	2,000	0	100,000
Anthracene	28	11	332	970	0	100,000
Acenaphthylene	28	10	285	1,100	0	100,000
Fluorene	28	7	166	370	0	30,000
Naphthalene	28	7	210	540	0	12,000
2-Methylnaphthalene	28	10	137	380	NA	NC
Bis(2-	28	9	107	340	NA	NC

Table 4.1 Detected Parking Lot Area Surface Soil CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Part 375.6 Unrestricted Use Soil Cleanup Objectives
ethylhexyl)phthalate						
Pesticides (μg/kg)						
Dieldrin	28	14	195	900	9	5
4,4'-DDT	28	11	9.38	34.0	7	3.3
4,4'-DDD	28	1	6.10	6.10	1	3.3
PCBs (μg/kg)						
Aroclor-1268	28	8	21.7	79.0	0	100
Aroclor-1254	28	6	16.4	21.0	0	100
Aroclor-1260	28	5	10.4	25.0	0	100
Inorganics (mg/kg)						
Calcium	28	28	143,725	280,000	28	100(a)
Magnesium	28	28	38,839	96,000	28	600(a)
Potassium	28	27	1272	3,390	26	400(a)
Chromium	38	38	660	14,000	23	30
Aluminum	28	28	5714	17,200	15	4,800(c)
Nickel	28	28	609	9,800	15	30
Hexavalent Chromium	10	6	5.08	6.60	6	1
Antimony	28	22	1.19	16.0	4	0.6(a)
Copper	28	28	60.0	750	3	50
Lead	28	28	32.5	160	3	63
Manganese	28	28	674	5,100	3	1,600
Selenium	28	19	3.95	35.0	3	3.9
Thallium	28	3	3.17	3.90	3	0.1(a)
Zinc	28	28	47.3	120	2	109
Arsenic	28	28	5.08	19.0	1	13
Mercury	28	28	0.06	0.19	1	0.18

Table 4.1 Detected Parking Lot Area Surface Soil CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Part 375.6 Unrestricted Use Soil Cleanup Objectives
Barium	28	28	84.3	200	0	350
Beryllium	28	28	0.33	0.87	0	7.2
Sodium	28	27	123	260	0	750(a)
Cyanide	28	6	0.66	1.00	0	27
Cadmium	28	5	0.17	0.51	0	2.5
Silver	28	1	0.51	0.51	0	2
Cobalt	28	28	50.9	780	NA	NC
Iron	28	28	23,311	180,000	NA	NC
Vanadium	28	28	63.2	830	NA	NC

Notes:
1 – Exceeds NYSDEC (2006) Part 375.6 Table 6.8(a) Unrestricted Use Soil Cleanup Objectives.
2 – Mean concentration values have been rounded.
NA = not applicable as no criterion is available. NC = no criterion (SCO).
(a) - Background values established by McGovern, 1988.; (c) Typical concentrations in Solvay Waste, Calocerinos & Spina, 1980.

For the nature and extent discussion, the surface soil samples collected from the Parking Lot Area during the PSA, RI, and Chromium Speciation are discussed together below.

Organic CPOIs for surface soils included VOCs, SVOCs, and pesticides. VOC CPOIs were detected in only some of the Parking Lot Area surface soils, with only one exceedance of acetone at SS-31. Locations with detectable total BTEX concentrations in Site surface soils are presented on **Figure 38**. Assorted PAHs were detected throughout the Parking Lot Area surface soils, with no evident pattern of the distribution for assorted PAHs. The highest concentration of total PAHs was detected at SS-32 (**Figure 40**). The VOC and SVOC CPOIs in the Parking Lot Area are likely associated with general parking lot activities.

Pesticides were detected in surface soils at the Parking Lot Area. Pesticides were detected in exceedance of NYSDEC Part 375.6 Unrestricted Soil Cleanup Objectives (SCOs) for dieldrin, 4,4'-DDT, and 4,4'-DDD. Pesticide exceedances for site surface soils are presented on **Figure 50.** The source of the pesticides is unknown. The highest pesticide concentrations were detected at SS-34.

PCBs were detected in surface soils at the Parking Lot Area; however, none were observed above the Part 375 Unrestricted SCOs.

Figures 42, 43, 44, 45, 46, 47, 48, and 49 present Site surface soils of NYSDEC Part 375.6 Unrestricted Soil Cleanup Objectives for aluminum, arsenic, barium, chromium, hexavalent chromium, mercury, nickel, and selenium, respectively. There is no distribution pattern of inorganic constituents within the Parking Lot Area surface soils, with two exceptions including chromium and nickel. Both chromium and nickel were generally detected at higher concentrations on the western half of the upper parking lot area adjacent to the Crucible Landfill. Selenium also had the highest detected concentrations in the western half of the upper parking lot area southeast of the Crucible landfill. The concentrations of calcium and magnesium are likely related to the presence of Solvay waste; mercury concentrations are likely related to operations at the Willis Avenue Chlorobenzene Site.

4.1.2. Upland Area Surface Soils

A total of 82 surface soil samples were collected from the Upland Area during the PSA, Bike Trail, RI, and Chromium Speciation Investigation sampling programs. Thirteen samples from 15 locations were collected from a depth of 0 to 0.5 ft bgs, and 14 samples were collected from 0.5 to 1 ft bgs from 14 locations during the PSA. PSA samples were co-located with twelve test pits locations (27 samples) or from designated surface soil sample locations (two samples) within the Upland Area. During the Bike Trail Investigation, ten samples were collected from nine locations between 0 to 0.5 ft bgs, and one sample was collected from 1 to 2 ft bgs. During the RI, twenty-two samples were collected from eleven locations from 0 to 0.5 ft bgs (11 samples) and 0.5 to 1 ft bgs (11 samples), and twenty-one samples were collected as part of the Chromium Speciation Investigation from 0 to 0.5 ft bgs within the Upland Area.

Summaries of PSA, Bike Trail, RI, and Chromium Speciation Investigation surface soil locations and laboratory analyses are included in **Tables 2, 3, 4, and 5**, respectively. Analytical results for the PSA surface soils are presented on **Tables 40 through 45** for VOCs, SVOC, pesticides, PCBs, inorganics, and percent solids, respectively. The Bike Trail surface soil analytical results are presented on **Tables 54 through 59** for VOCs, SVOCs, pesticides, PCBs, inorganics, and percent solids, respectively. Bike Trail woody Tissue samples for mercury are presented on **Table 60.** The RI surface soil analytical results are presented on **Tables 46 through 51** for VOCs, SVOCs, pesticides, PCBs, inorganics, and percent solids, respectively. Chromium Speciation Investigation data (total chromium, hexavalent chromium) are presented on **Table 52** and sample locations are presented on **Figure 4A**

Summary statistics are provided on **Table 61** for surface soil (0 to 2 ft) chemical parameters detected in the Upland Area. Detected CPOIs are listed below in **Table 4.2**.

Table 4.2 Detected Upland Area Surface Soil CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Part 375.6 Unrestricted Use Soil Cleanup Objectives
Volatile Organic Compounds (µg/kg)						
Methylene chloride	59	6	34.7	80.0	1	50
Semivolatile Organic Compounds (µg/kg)						
Indeno(1,2,3-CD)pyrene	59	36	1,078	5,400	25	500
Chrysene	59	46	1,906	18,000	24	1,000
Benzo(A)pyrene	59	42	1,875	17,000	23	1,000
Benzo(A)anthracene	59	42	2,009	19,000	21	1,000
Benzo(B)fluoranthene	59	42	1820	18,000	21	1,000
Benzo(K)fluoranthene	59	40	1,633	15,000	21	800
Dibenzofuran	59	18	346	2,900	7	7,000
Hexachlorobenzene	61	5	1,562	2,700	5	330

Table 4.2 Detected Upland Area Surface Soil CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Part 375.6 Unrestricted Use Soil Cleanup Objectives
Fluoranthene	59	51	3,199	30,000	0	100,000
Pyrene	59	50	3,016	33,000	0	100,000
Phenanthrene	59	42	2,686	32,000	0	100,000
Benzo(G,H,I)perylene	59	36	1,241	4,400	0	100,000
Acenaphthylene	59	30	690	6,300	0	100,000
Anthracene	59	30	1,015	7,700	0	100,000
Naphthalene	59	18	516	3,800	0	12,000
Acenaphthene	59	16	418	2,700	0	20,000
Fluorene	59	16	899	8,600	0	30,000
Dibenzo(A,H)anthracene	59	21	536	2,300	NA	330
Carbazole	59	19	322	2,000	NA	NC
Bis(2-ethylhexyl)phthalate	59	21	781	2,300	NA	NC
2-Methylnaphthalene	59	17	465	4,000	NA	NC
1-Phenyl-1-(2,4-Dimethylphenyl)ethane	22	13	563	2,100	NA	NC
4-Chloroaniline	59	12	5,625	16,000	NA	NC
Pesticides (µg/kg)						
Dieldrin	59	17	378	1,600	17	5
4,4'-DDT	59	15	20.2	120	6	3.3
Alpha-chlordane	59	8	111	290	4	94
4,4'-DDE	59	2	84	160	2	3.3
PCBs (µg/kg)						
Aroclor-1260	59	21	4,637	33,000	13	100
Aroclor-1254	59	14	88.7	250	4	100
Aroclor-1268	59	4	24.7	44	0	100
Aroclor-1248	59	1	19.0	19.0	0	100

Table 4.2 Detected Upland Area Surface Soil CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Part 375.6 Unrestricted Use Soil Cleanup Objectives
Inorganics (mg/kg)						
Aluminum	59	59	8538	20,100	59	4,800(c)
Calcium	59	59	176092	370,000	59	100(a)
Magnesium	59	59	18261	33,500	59	600(a)
Chromium	80	80	280	2,150	39	30
Potassium	59	44	1,351	3,430	35	400(a)
Nickel	59	59	74.5	281	30	30
Sodium	59	53	1,310	3,300	28	750(a)
Mercury	61	61	1.89	11.5	24	0.18
Lead	59	59	293	1,670	22	63
Copper	59	59	284	1,980	18	50
Zinc	59	59	978	8,880	16	109
Cadmium	59	27	57.5	203	15	2.5
Silver	59	15	48.8	80.2	15	2
Arsenic	59	59	12.8	74.3	14	13
Barium	59	59	184	817	13	350
Thallium	59	13	1.28	2.20	13	0.1(a)
Antimony	59	32	2.03	16.5	9	0.6(a)
Hexavalent Chromium	21	6	37.7	124	6	1
Selenium	59	36	1.71	4.00	1	3.9
Manganese	59	59	431	784	0	1600
Beryllium	59	46	0.86	5.40	0	7.2
Cyanide	51	41	7.91	20.0	0	27
Iron	59	59	15,026	35,400	NA	NC
Vanadium	59	58	25.2	83.0	NA	NC
Cobalt	59	50	11.5	65.6	NA	NC

Table 4.2 Detected Upland Area Surface Soil CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Part 375.6 Unrestricted Use Soil Cleanup Objectives

Notes:
1 – Exceeds NYSDEC (2006) Part 375.6 Table 6.8(a) Unrestricted Use Soil Cleanup Objectives.
2 – Mean concentration values have been rounded.
NA = not applicable as no criterion is available. NC = no criterion (SCO).
(a) - Background values established by McGovern, 1988.; (c) Typical concentrations in Solvay Waste, Calocerinos & Spina, 1980.

For the nature and extent discussion, the surface soil samples collected from the Upland Area during the PSA, Bike Trail Investigation, RI, and Chromium Speciation Investigation are discussed together.

VOC CPOIs were detected at only some of the Upland Area surface soil locations. One VOC (methylene chloride) was detected above NYSDEC Part 375.6 Unrestricted Soil Cleanup Objectives. The source of the methylene chloride is unknown. SS-18 and SS-15 had detected concentrations for BTEX. Total BTEX detected concentrations for Site surface soils are presented on **Figure 38**.

Assorted PAHs were detected throughout the Upland Area surface soils (**Figure 40**). There is no evident pattern of distribution for the PAHs. Total PAH concentrations were the highest in the Upland Area of Wastebeds 1-4.

Phenols were detected at five locations within the Upland Area surface soils. Total phenol concentrations in surface soils are presented in **Figure 41.** The highest total phenol concentration was detected at SS-02 located within the Biosolids Area.

VOC and SVOC CPOIs in Upland Area surface soils are potentially associated with the historic co-disposal of material with Solvay waste during operation of the wastebeds, historic disposal of biosolids by Onondaga County, and potentially from adjacent parking lot activities.

Pesticides were detected in Upland Area surface soils. Pesticides were detected above NYSDEC Part 375.6 Unrestricted Soil Cleanup Objectives for dieldrin, 4,4'-DDT, alpha-chlordane, and 4,4'-DDE. The highest pesticide concentrations were detected at SS-02D (dieldrin) located in the Biosolids Area. Pesticide SCO exceedances in Site surface soils are presented on **Figure 50**.

PCBs, Aroclors 1254 and 1260, were detected above NYSDEC Part 375.6 Unrestricted Soil Cleanup Objectives. Aroclor 1260 was detected at SS-02, SS-02A, SS-02B, SS-02C, SS-02D, and SS-04. The highest total PCB concentration was detected at SS-02D. PCBs present in the Upland Area surface soils generally correspond with the extent of the Biosolids Area.

Figures 42, 43, 44, 45, 46, 47, 48, and 49 present Site surface soils of NYSDEC Part 375.6 Unrestricted Soil Cleanup Objectives for aluminum, arsenic, barium, chromium, hexavalent chromium, mercury, nickel, and selenium, respectively. There is no evident distribution pattern of inorganic constituents within the Upland Area surface soils with the exception of the samples with the highest concentrations were generally detected in the Biosolids Area.

4.1.3. Lakeshore Area Surface Soils

Surface soil samples were collected from the Lakeshore Area during the PSA, Chromium Speciation Investigation, and SRI. PSA samples were collected at seven locations from depths of 0 to 0.5 ft bgs and 0.5 to 1 ft bgs. The samples were co-located with test pits within the Lakeshore Area. A summary of PSA surface soil locations and laboratory analyses is included in **Table 2**. During the Chromium Speciation Investigation, five samples were collected from 0 to 0.5 ft bgs. A summary of Chromium Speciation Investigation surface soil locations and analyses performed is presented on **Table 5.** SRI samples were collected at seven locations from depths of 0 to 0.5 ft bgs and 0.5 to 1 ft bgs. Five of the SRI surface soil locations were co-located with soil borings. A summary of SRI surface soil locations and laboratory analyses is included as **Table 6.** Analytical results for the PSA surface soils are presented on **Tables 40 through 45** for VOCs, SVOC, pesticides, PCBs, inorganics, and percent solids, respectively. Chromium Speciation Investigation data are presented on **Table 52**. Analytical results for SRI surface soils are presented on **Tables 62 through 65** for VOCs, SVOCs, Inorganics, and Other data, respectively. Sample locations are presented on **Figure 4A**.

As part of the Integrated IRM discussed in Section 1.5.10 of this report, surface soils on the Lakeshore Area will be covered by a combination of mitigation wetland and vegetative cover. One purpose for these covers is to minimize direct contact with, and ingestion and erosion of exposed Solvay waste along the eastern shoreline of the Site. Surface soil conditions that existed prior to the integrated IRM are discussed below.

Summary statistics are provided on **Table 66** for surface soil (0 to 2 ft) chemical parameters detected in the Lakeshore Area. Detected CPOIs are listed below in **Table 4.3**.

Table 4.3 Detected Lakeshore Area Surface Soil CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Part 375.6 Unrestricted Use Soil Cleanup Objectives
Volatile Organic Compounds (µg/kg)						
Xylenes, total	28	8	104	400	1	260
Acetone	28	2	60.5	100	1	50
Toluene	28	16	14.1	45.0	0	700
Benzene	27	7	10.8	33.0	0	60
2-Butanone	27	6	4.75	6.20	0	120
Semivolatile Organic Compounds (µg/kg)						
Naphthalene	28	20	1674	25,000	1	12,000
Fluoranthene	28	23	115	300	0	100,000
Pyrene	28	22	83.1	270	0	100,000
Chrysene	28	17	56.2	170	0	1,000
Phenanthrene	28	17	167	1,800	0	100,000
Benzo(A)anthracene	28	15	39.3	100	0	1,000
Benzo(B)fluoranthene	28	15	57.7	160	0	1,000
Benzo(A)pyrene	28	14	36.9	110	0	1,000
Benzo(G,H,I)perylene	28	14	29.9	75.0	0	100,000
Indeno(1,2,3-CD)pyrene	28	14	27.3	68.0	0	500
Dibenzofuran	28	13	78.1	870	0	7,000

Table 4.3 Detected Lakeshore Area Surface Soil CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Part 375.6 Unrestricted Use Soil Cleanup Objectives
Anthracene	28	12	12.4	34.0	0	100,000
Acenaphthylene	28	11	14.4	36.0	0	100,000
Acenaphthene	28	9	3.22	6.60	0	20,000
Dibenzo(A,H)anthracene	28	9	7.50	23.0	0	330
1-Phenyl-1-(2,4-Dimethylphenyl)ethane	14	14	882	5,000	NA	NC
1-Phenyl-1-(4-Methylphenyl)ethane	14	14	147	1,000	NA	NC
Di-N-butyl phthalate	28	13	7.10	14.0	NA	NC
2-Methylnaphthalene	28	12	522	5,300	NA	NC
Benzaldehyde	14	11	78.2	220	NA	NC
Caprolactam	14	11	24.4	50	NA	NC
Carbazole	28	8	4.91	11.0	NA	NC
1,1'-Biphenyl	14	6	99.7	530	NA	NC
Acetophenone	14	3	154	390	NA	NC
Pesticides (µg/kg)						
4,4'-DDD	14	1	3.70	3.70	1	3.3
4,4'-DDE	14	1	5.90	5.90	1	3.3
Delta-bhc	14	4	3.28	7.30	0	40
4,4'-DDT	14	3	1.18	2.50	0	3.3
PCBs (µg/kg)						
Aroclor-1260	14	8	41.4	250	1	100
Inorganics (mg/kg)						
Calcium	28	28	315,893	420,000	28	100(a)
Magnesium	28	28	13,389	36,000	28	600(a)
Sodium	28	28	1,455	5,700	24	750(a)
Mercury	28	28	0.28	2.20	14	0.18

Table 4.3 Detected Lakeshore Area Surface Soil CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Part 375.6 Unrestricted Use Soil Cleanup Objectives
Aluminum	28	28	4,718	9,600	13	4,800(c)
Thallium	28	8	1.82	3.10	8	0.1(a)
Chromium	33	33	29.1	340	7	30
Potassium	28	22	343	1290	7	400(a)
Barium	28	28	361	2350	5	350
Nickel	28	28	16.0	47.0	3	30
Copper	28	28	16.6	190	1	50
Lead	28	28	23.9	260	1	63
Zinc	28	28	60.2	1,000	1	109
Cadmium	28	20	1.20	16.0	1	2.5
Silver	28	15	0.93	10.0	1	2
Hexavalent Chromium	5	1	3.6	3.6	1	30
Arsenic	28	28	7.43	13.0	0	13
Cyanide	28	28	3.53	20.0	0	27
Manganese	28	28	203	520	0	1,600
Beryllium	28	23	0.44	1.10	0	7.2
Antimony	28	9	0.42	0.58	0	0.6(a)
Selenium	28	7	0.49	0.65	0	3.9
Iron	28	28	4,858	9,600	NA	NC
Vanadium	28	28	11.5	27.3	NA	NC
Cobalt	28	25	2.38	8.10	NA	NC

Notes:
1 – Exceeds NYSDEC (2006) Part 375.6 Table 6.8(a) Unrestricted Use Soil Cleanup Objectives.
2 – Mean concentration values have been rounded.
NA = not applicable as no criterion is available. NC = no criterion (SCO).
(a) - Background values established by McGovern, 1988.; (c) Typical concentrations in Solvay Waste, Calocerinos & Spina, 1980.

For the nature and extent discussion, the surface soil samples collected from the Lakeshore Area during the PSA, Chromium Speciation Investigation, and SRI are discussed together.

VOC CPOIs detected in Lakeshore Area surface soils included BTEX parameters, 2-butanone, and acetone. One NYSDEC Part 375.6 Unrestricted Soil Cleanup Objective exceedance of acetone was detected at SS-08. Total BTEX concentrations for Site surface soils are presented on **Figure 38**. Location SS-08 had the highest detected total BTEX concentration in the Lakeshore Area surface soils.

Assorted PAHs and naphthalene were the most commonly detected SVOC CPOIs in the Lakeshore Area surface soils. The highest concentration of total PAHs was detected at SB-178 (**Figure 40**) and naphthalene makes up the majority of the total PAH concentration at this location. This detection represents the only naphthalene NYSDEC Part 375.6 Unrestricted Soil Cleanup Objective exceedance in surface soils (**Figure 39)**.

VOC and SVOC CPOIs detected in surface soils along the Lakeshore Area, such as the PAHs at SS-03, are potentially associated with the stained materials identified in this area.

Pesticides were detected in surface soils at the Lakeshore Area. Pesticides were detected above the NYSDEC Part 375.6 Unrestricted Soil Cleanup Objectives for 4,4'-DDE and 4,4'-DDD. The highest pesticide concentrations were detected at SS-08. The source of the pesticides is unknown; however, these compounds are ubiquitous in the environment. Pesticide exceedances in Site surface soils are presented on **Table 50**.

One PCB (Aroclor 1260) had a detected concentration above NYSDEC Part 375.6 Unrestricted Soil Cleanup Objectives at location SS-03. This location is downgradient of the Biosolids Area, which contained detected PCBs in surface soils.

Figures 42, 43, 44, 45, 46, 47, 48, and 49 present Site surface soils of NYSDEC Part 375.6 Unrestricted Soil Cleanup Objectives for aluminum, arsenic, barium, chromium, hexavalent chromium, mercury, nickel, and selenium, respectively. There is no evident distribution pattern of inorganic constituents within the Lakeshore Area surface soils.

4.2. SUBSURFACE SOILS CHARACTERIZATION

Subsurface soils are considered soil samples collected from a depth greater than 2 ft bgs. Samples included any soil sample with a terminal depth greater than 2 ft bgs (*i.e.*, 1 to 3 ft or 1 to 10 ft). PSA subsurface soil samples were collected from test pits and soil borings. The FRI and RI subsurface soil samples were collected from soil borings. Sample locations are presented in **Figure 4B**.

A summary of PSA test pit locations and laboratory analyses is included in **Table 16.** Analytical results for the PSA test pits are included in **Tables 67 through 72** for VOCs, SVOCs, pesticides, PCBs, inorganics, and percent solids. The composite sample from TP-28 (0 to 10 ft) was classified as a subsurface soil since the terminal depth was greater than 2 ft bgs. However, the VOC grab sample from this location was collected from 1 to 2 ft bgs and is included in the Parking Lot Area surface soil discussion and corresponding summary statistics. A summary of PSA soil boring locations and laboratory analyses is included in **Table 7.** Analytical results for the PSA soil borings are included in **Tables 73 through 78** for VOCs, SVOCs, pesticides, PCBs, inorganics, and percent solids. Subsurface soils collected during the PSA and analyzed using TCLP analyses are included in **Tables 79 through 84** for VOCs, SVOCs, pesticides, herbicides, inorganics, and ignitability and reactivity.

A summary of FRI, RI, Chromium Speciation Investigation, and SRI soil boring locations and laboratory analyses are included in **Tables 9, 11**, **13, and 14** respectively**.** Analytical results for the FRI and RI soil borings are included in **Tables 85 through 90 and Tables 91 through 96**, respectively, for VOCs, SVOCs, pesticides, PCBs, inorganics, and percent solids. Analytical results for Chromium Speciation Investigation soil borings are presented on **Table 97.** Analytical subsurface soil data collected during the SRI are included in **Tables 98 through 101** for VOCs, SVOCs, inorganics, and Other data, respectively.

Summary statistics are provided on **Table 102** for subsurface soils. Detected CPOIs are listed below in **Table 4.4**.

Table 4.4 Detected Subsurface Soil CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Part 375.6 Unrestricted Use Soil Cleanup Objectives
Volatile Organic Compounds (µg/kg)						
Benzene	203	105	6,099	210,000	79	60
Toluene	203	90	18,003	420,000	52	700
Acetone	202	67	330	3,300	48	50
Xylenes, total	117	55	8,132	120,000	46	260
2-Butanone	20	95	167	1,400	38	120
Xylenes, m & p	86	43	57,749	500,000	31	260
o-Xylene	86	41	18,852	180,000	26	260
Ethylbenzene	203	74	2,178	26,000	18	1,000
Methylene chloride	202	54	54.9	260	17	50
Carbon disulfide	202	43	16.8	130	NA	NC
Isopropylbenzene	152	33	4,343	24,000	NA	NC
Methylcyclohexane	152	32	889	5,800	NA	NC
Semivolatile Organic Compounds (µg/kg)						
Naphthalene	203	111	104,183	1,700,000	37	12,000
Phenol	175	88	526	3,400	37	330
4-Methylphenol	175	82	611	5,200	29	330
2-Methylphenol	171	67	173	930	9	330
Chrysene	203	36	372	6,800	3	1,000
Benzo(A)pyrene	203	26	369	4,500	3	1,000
Benzo(K)fluoranthene	203	11	722	4,100	3	800
Benzo(B)fluoranthene	203	34	283	4,400	2	1,000
Indeno(1,2,3-CD)pyrene	203	19	261	2,400	2	500
Dibenzofuran	203	61	944	7,800	1	7,000
Benzo(A)anthracene	203	29	361	5,200	1	1,000
Fluorene	203	23	4,020	34,000	1	30,000

Table 4.4 Detected Subsurface Soil CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Part 375.6 Unrestricted Use Soil Cleanup Objectives
Dibenzo(A,H)anthracene	203	5	330	1,400	1	330
1,2-Dichlorobenzene	51	1	1,500	1,500	1	1,100
Phenanthrene	203	91	1,161	21,000	0	100,000
Fluoranthene	203	72	433	14,000	0	100,000
Pyrene	203	58	503	16,000	0	100,000
2-Methylnaphthalene	203	80	12,769	120,000	NA	NC
Bis(2-ethylhexyl)phthalate	203	59	614	21,000	NA	NC
1,1'-Biphenyl	150	47	1,240	8,500	NA	NC
1-Phenyl-1-(2,4-Dimethylphenyl)ethane	82	44	19,755	620,000	NA	NC
Acetophenone	150	43	124	1,800	NA	NC
1-Phenyl-1-(4-Methylphenyl)ethane	82	42	14,616	310,000	NA	NC
Benzaldehyde	146	33	135	560	NA	NC
Pesticides (µg/kg)						
Dieldrin	136	5	80.1	240	3	5
4,4'-DDD	136	2	74.5	130	2	3.3
Alpha-chlordane	136	5	40.1	110	1	94
PCBs (µg/kg)						
Aroclor-1260	136	10	1,299	3,600	7	100
Aroclor-1248	136	2	2,215	4,300	2	100
Aroclor-1254	136	1	20.0	20.0	0	100
Aroclor-1268	136	1	7.90	7.90	0	100
Inorganics (mg/kg)						
Calcium	203	203	239,382	429,000	203	100(a)
Magnesium	203	203	20,319	57,000	203	600(a)
Sodium	203	203	4,832	31,400	193	750(a)

Table 4.4 Detected Subsurface Soil CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Part 375.6 Unrestricted Use Soil Cleanup Objectives
Potassium	203	154	990	4,390	130	400(a)
Aluminum	203	203	5,322	23,400	126	4,800(c)
Barium	203	203	268	7,110	25	350
Thallium	203	19	1.06	3.30	19	0.1(a)
Mercury	203	109	0.26	7.70	13	0.18
Chromium	215	213	22.6	1330	12	30
Arsenic	203	192	6.47	77.3	12	13
Copper	203	200	20.7	600	8	50
Cyanide	203	140	8.90	53.0	7	27
Nickel	203	161	12.2	87.0	6	30
Antimony	203	25	0.63	2.70	6	0.6(a)
Lead	203	162	23.6	1,000	5	63
Cadmium	203	57	2.96	56.0	5	2.5
Zinc	203	184	38.4	980	4	109
Silver	203	36	3.03	38.0	4	2
Hexavlent Chromium	12	3	32.3	72.6	3	30
Selenium	203	48	1.07	5.80	2	3.9
Manganese	203	203	321	2,530	1	1,600
Beryllium	203	89	0.34	0.94	0	7.2
Iron	203	203	8,126	32,000	NA	NC
Vanadium	203	161	11.1	44.6	NA	NC
Cobalt	203	110	3.88	39.0	NA	NC

Notes:
1 – Exceeds NYSDEC (2006) Part 375.6 Table 6.8(a) Unrestricted Use Soil Cleanup Objectives.
2 – Mean concentration values have been rounded.
NA = not applicable as no criterion is available. NC = no criterion (SCO).
(a) - Background values established by McGovern, 1988.; (c) Typical concentrations in Solvay Waste, Calocerinos & Spina, 1980.

For the nature and extent discussion, subsurface soil samples (soil borings and test pits) collected during the PSA, FRI, RI, Chromium Speciation Investigation and SRI are discussed together.

VOC CPOIs detected in Site subsurface soils include BTEX, acetone, methylene chloride, and 2-Butanone. Benzene exceedances and total BTEX concentrations in subsurface soils are presented in **Figure 51 and 52** for samples collected between 2 to 10 ft bgs and **Figure 53 and 54,** for samples collected from depths greater than 10 ft. The highest detected benzene concentration was collected from MW-10D at 58 to 62 ft bgs. The maximum concentration total BTEX concentration was from SB-36 at 70 to 72 ft bgs.

Predominant SVOCs detected in subsurface soils at the Site include naphthalene, assorted PAHs, dibenzofuran, and assorted phenols. Naphthalene exceedances, total PAH, and total phenol concentrations in subsurface soils from 2 to 10 ft are presented on **Figures 55, 57, and 59**, respectively. **Figures 56, 58, and 60**, present naphthalene exceedances, total PAH, and total phenol concentrations for samples from depths greater than 10 ft bgs, respectively. The highest naphthalene concentration was from SB-34 (46 to 48 ft). The maximum total PAH concentration was at location SB-34 (46 to 48 ft). The highest phenol concentration was from SB-155 (64 to 66 ft). The highest total phenol concentration was from SB-41 (6 to 8 ft).

Organic CPOIs were detected more frequently and at the highest concentrations between the central and southeastern portions of the Site. This extent is consistent with the stained materials present at the base of Wastebeds 1 through 4 discussed below in Section 4.8.1.

PCBs were detected in eleven subsurface soil samples, with the highest concentrations detected at TP-02 for Aroclor 1248 and Aroclor 1260. The majority of PCBs detected in subsurface soils were located in or adjacent to the Biosolids Area.

Figures 61 through 69 present NYSDEC Part 375.6 Unrestricted Soil Cleanup Objectives exceedances in samples collected from depths of 2 to 10 ft bgs for aluminum, arsenic, barium, chromium, cyanide, hexavalent chromium, mercury, nickel, and selenium. **Figures 70 though 74** present NYSDEC Part 375.6 Unrestricted Soil Cleanup Objectives exceedances in samples collected from depths greater than 10 ft bgs for aluminum, arsenic, barium, cyanide, and mercury. There were no chromium, nickel, or selenium exceedances at depths greater than 10 ft bgs, and hexavalent chromium samples were not collected at depths greater than 10 ft bgs. There is no evident distribution pattern within the subsurface soils.

4.3. GROUNDWATER CHARACTERIZATION

Groundwater samples were collected during the PSA, FRI, RI, and SRI. Groundwater samples were collected from groundwater screening locations and monitoring wells; sample locations are presented on **Figure 4D and 4E**, respectively. Two rounds of PSA groundwater samples were collected, one round of FRI groundwater samples was collected, two rounds of RI groundwater samples were collected, and one round of SRI groundwater samples were collected.

As part of the Integrated IRM being implemented on the Wastebeds 1 through 8 Site, shallow and intermediate groundwater from several areas of the site will be collected and pumped to the Willis Avenue Groundwater Treatment Plant for treatment. Further discussion of the Integrated IRM and how it relates to shallow and intermediate groundwater can be found in Section 1.5.10 and in the Groundwater Nature and Extent Summary in Section 4.3.5 below.

Fifty-two PSA groundwater screening samples were collected in June 2004 from 20 locations (GWS-01 through GWS-20) and were analyzed for VOCs, SVOCs, pesticides, PCBs, inorganics, and other parameters. A summary table presenting sample locations depths and analyses is included as **Table 18**. The PSA groundwater screening data are presented on **Tables 103 through 108**.

Twenty eight monitoring wells were installed during the PSA. Twenty seven wells were sampled during the first round of PSA groundwater samples. MW-08S was not sampled, because it was dry during this round. WA-MW-

100D and WA-MW-100BR were installed between the first and second rounds. Thirty wells were sampled during the second round. A summary of PSA groundwater sampling locations and laboratory analyses is included as **Table 25**. Analytical results for the PSA groundwater samples are included in **Tables 109 through 114** for VOCs, SVOCs, pesticides, PCBs, inorganics (including major cations and anions), and other parameters.

The FRI included groundwater screening locations. Thirteen groundwater screening samples were collected from bedrock borings in February and March 2006 and were analyzed for VOCs, SVOCs, pesticides, PCBs, inorganics, and other parameters including total alkalinity, carbonate alkalinity, bicarbonate alkalinity, chloride, and sulfate. The FRI groundwater screening data are presented in **Tables 115 through 120**.

Twenty four monitoring wells were installed as part of the FRI field program. These 24 wells and 30 PSA monitoring wells were sampled in March and April of 2006. A summary of FRI groundwater sampling locations and laboratory analyses is included in **Table 26.** Analytical results for the FRI groundwater samples are included in **Tables 121 through 126** for VOCs, SVOCs, pesticides, PCBs, inorganics (including major cations and anions), and other parameters, including carbonate alkalinity, bicarbonate alkalinity, bromide, chloride, hardness, sulfate, and total alkalinity.

The RI groundwater samples were collected from groundwater screening locations and monitoring wells. Groundwater screening samples were collected between January and April 2007 and were analyzed for VOCs, SVOCs, inorganics and other parameters including carbonate alkalinity, bicarbonate alkalinity, chloride, hardness, sulfate, and total alkalinity. A summary of RI groundwater screening sampling locations and laboratory analyses is included in **Table 20**. RI groundwater screening data are presented in **Tables 127 through 130**.

Thirteen monitoring wells were installed as part of the RI. The first round of monitoring well sampling was performed in May 2007. The sampling included the 13 RI wells and the 54 previously installed monitoring wells. The second round was performed July and August 2007, and 62 of the 67 Site wells were sampled. MW-04S, MW-08S, MW-10S, MW-15S, and MW-21S were not sampled, because they were dry at the time of sampling. A summary of RI groundwater monitoring well locations and laboratory analyses is included in **Table 28.** Analytical results for the RI groundwater monitoring well samples are included in **Tables 131 through 137** for VOCs, SVOCs, pesticides, PCBs, inorganics (including major cations and anions), other parameters, and microbial data. Other parameters included phospholipid fatty acids, methane, bacterial plate counts, TKN, CBOD, ammonia, carbonate alkalinity, bicarbonate alkalinity, chloride, hardness, sulfate, and total alkalinity.

The SRI groundwater samples were from monitoring wells installed within the Ninemile Creek deltaic deposits unit, including the seven wells installed during the SRI, MW-04G, and MW-18G. Monitoring well samples were collected in August 2009. A summary of SRI groundwater monitoring well locations and laboratory analyses is included in **Table 29**. Analytical results for the SRI groundwater monitoring well samples are included in **Tables 138 through 141** for VOCs, SVOCs (including PXE and PTE), inorganics (including cyanide, mercury, and major cations and anions), and other parameters. Other parameters include TKN, hardness, alkalinity, and TDS.

Wastebeds 1 through 8 are characterized as having two main groundwater systems, the upper system and lower system. The upper system consists of shallow and intermediate groundwater zones, and the lower flow system consists of deep and bedrock groundwater zones. **Table 38** presents the breakdown of groundwater zones and the wells screened within these zones. For the purpose of nature and extent, wells screened within the intermediate groundwater zone are further partitioned into two groups, those screened within the stained and unstained marl/peat layer stained material and those screened within the Ninemile Creek deltaic deposits.

4.3.1. Shallow Groundwater

The shallow groundwater component of the upper groundwater system consists of wells screened within Solvay Waste. Summary statistics are provided in **Table 142** for shallow groundwater chemical parameters detected on site. Shallow groundwater monitoring wells include MW-04S, MW-05S, MW-06S, MW-07S, MW-08S, MW-10S, MW-15S, MW-16S, MW-17S, MW-18S, MW-21S, and MW-22S. The shallow groundwater statistics were developed using data from these shallow monitoring wells, but not data from the groundwater screening samples. Detected CPOIs are listed below in **Table 4.5**.

Table 4.5 Detected Shallow Groundwater CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Class GA Standards and Guidance
Volatile Organic Compounds (μg/L)						
Acetone	38	37	182	870	25	50(S)
Benzene	38	23	67.7	1,400	15	1(S)
Toluene	37	19	33.4	390	9	5(S)
Xylenes, m & p	29	14	10.1	50.0	5	5(S)
o-Xylene	29	12	4.70	19.0	4	5(S)
Xylenes, total	9	4	36.6	70.0	3	5(S)
2-Butanone	38	35	17.2	60.0	1	50(G)
2-Hexanone	37	28	6.67	17.0	0	50(G)
Ethylbenzene	37	10	1.19	2.90	0	5(S)
4-Methyl-2-pentanone	37	15	2.99	13.0	NA	NC
Methylcyclohexane	29	6	0.76	1.20	NA	NC
Semivolatile Organic Compounds (μg/L)						
Phenol	38	31	8.84	41.0	30	1(S)
4-Methylphenol	37	20	7.61	33.0	20	1(S)
2-Methylphenol	37	12	3.64	14.0	11	1(S)
Naphthalene	38	23	19.9	100	8	10(G)
2-Nitrophenol	38	2	3.25	5.40	2	1(S)
4-Nitrophenol	37	2	3.85	4.90	2	1(S)
Bis(2-ethylhexyl)phthalate	38	15	1.72	7.50	1	5(S)
Chrysene	38	1	0.50	0.50	1	0.002(G)
Phenanthrene	38	34	1.93	5.00	0	50(G)
Fluoranthene	38	7	0.86	1.40	0	50(G)
2-Methylnaphthalene	38	24	2.27	4.30	NA	NC
Acetophenone	34	13	4.54	8.00	NA	NC

Table 4.5 Detected Shallow Groundwater CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Class GA Standards and Guidance
Carbazole	38	9	0.78	1.60	NA	NC
Benzaldehyde	34	7	2.90	7.30	NA	NC
Inorganics (mg/L)						
Sodium	38	38	219	752	38	20(S)
Chloride	38	38	1,366	18,000	35	250
Iron	38	29	4.66	28.7	23	0.3(S)
Barium	38	38	0.83	7.20	7	1(S)
Manganese	38	27	0.23	1.33	7	0.3(S)
Magnesium	38	26	20.7	111	6	35(G)
Chromium	37	19	0.05	0.28	4	0.05(S)
Lead	38	14	0.02	0.05	3	0.025(S)
Selenium	38	3	0.05	0.06	3	0.01(S)
Nickel	38	16	0.04	0.17	1	0.1(S)
Mercury	38	12	0.0002	0.001	1	0.0007(S)
Thallium	38	1	0.12	0.12	1	0.0005(G)
Sulfate	38	38	24.9	220	0	250
Cyanide	38	15	0.02	0.04	0	0.2(S)
Zinc	38	14	0.07	0.27	0	2(G)
Copper	35	13	0.05	0.15	0	0.2(S)
Cadmium	38	9	0.001	0.002	0	0.005(S)
Calcium	38	38	1,363	3,460	NA	NC
Potassium	38	38	42.2	160	NA	NC
Aluminum	36	30	5.14	37.4	NA	NC
Vanadium	38	8	0.02	0.06	NA	NC
Ammonia	7	7	9.51	50.0	NA	NC

Notes:
1 – Exceeds NYSDEC Class GA groundwater standards (S) and guidance values (G).
2 – Mean concentration values have been rounded.
NA = not applicable as no criterion is available. NC = no criterion.

For the nature and extent discussion, shallow monitoring well groundwater samples during the PSA, FRI, and RI are discussed together.

VOC CPOIs in shallow groundwater include BTEX parameters and acetone. Benzene and total BTEX concentrations in shallow groundwater are presented on **Figures 75 and 76,** respectively. Benzene and BTEX concentrations in shallow wells were highest in the southwestern portion of the uplands area of the site, with the maximum BTEX concentration detected at MW-22S during the May 2007 sampling event. The lowest benzene and BTEX concentrations were typically detected in samples from the northwestern portion of the Site and the highest concentrations were observed at MW-22S and MW-07S.

Naphthalene, assorted PAHs (predominantly phenanthrene and 2-methylnaphthalene), and assorted phenols represent the majority of detected SVOC CPOIs. The distribution of naphthalene and assorted PAHs is similar to the distribution of VOCs in groundwater. The highest concentrations of naphthalene and total PAHs were detected at MW-07S. The lowest concentrations were detected in samples from the northwestern portion of the Site. Phenols were more widely distributed in the shallow groundwater, with the highest concentrations of total phenols at MW-22S. Concentrations of naphthalene, total PAHs, and total phenols are presented on **Figures 77, 78, and 79**, respectively.

Figures 80 through 87 present concentrations of aluminum, arsenic, barium, chromium, mercury, nickel, selenium, and zinc in shallow groundwater. Inorganics CPOIs associated with Solvay waste or native brines, such as chloride, and sodium, exceeded NYS Class GA groundwater standards. However, the distribution varies across the Site.

4.3.2. Intermediate Groundwater

The intermediate groundwater component of the upper groundwater system consists of wells screened at the Solvay waste and native material interfaces, or within the Ninemile Creek deltaic deposits below the beds. For the purpose of the nature and extent discussion, the intermediate groundwater zone has been divided into two groups:

- Intermediate wells screened within and outside the stained material (not including those screened in the historic Ninemile Creek channel)
- Intermediate wells screened within the Ninemile Creek deltaic deposits.

Intermediate Groundwater within the Stained Material and Unstained Material

Summary statistics are provided on **Table 143** for intermediate groundwater chemical parameters detected on-site within and outside the stained material. These monitoring wells include MW-01I, MW-01S, MW-02I, MW-02S, MW-03I, MW-03S, MW-04I, MW-05I, MW-06I, MW-07I, MW-08I, MW-09I, MW-09S, MW-10I, MW-11I, MW-12S, MW-13I, MW-13S, MW-14I, MW-14S, MW-16I, MW-17I, MW-18G, MW-18I, MW-21I, MW-22I, and MW-23I. Monitoring wells MW-06I, MW-07I, MW-16I, MW-21I, MW-22I, and MW-23I were screened within the observed stained material at the base of Wastebeds 1-4, while the remaining intermediate monitoring wells were screened outside of the stained material area. The groundwater statistics were developed using data from the intermediate monitoring wells (but not data from the groundwater screening samples). Detected CPOIs are presented below in **Table 4.6**.

Table 4.6 Detected Intermediate Groundwater CPOIs Within the Stained and Unstained Material

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Class GA Standards and Guidance
Volatile Organic Compounds (μg/L)						
Benzene	103	82	6,822	56,000	74	1(S)
Toluene	103	63	5,458	37,000	48	5(S)
Ethylbenzene	103	48	72.2	260	37	5(S)
Acetone	103	45	253	810	37	50(S)
Xylenes, total	75	56	913	7,500	36	5(S)
o-Xylene	75	46	276	1,200	34	5(S)
Xylenes, m & p	75	43	940	4,500	31	5(S)
2-Butanone	103	56	52.6	170	21	50(G)
Styrene	103	22	148	300	21	5(S)
Isopropylbenzene	75	12	26.9	75	10	5(S)
Vinyl chloride	103	8	1.42	2.8	2	5(S)
Carbon disulfide	103	25	11.1	110	1	60(G)
2-Hexanone	103	32	9.43	36	0	50(G)
4-Methyl-2-pentanone	103	23	5.45	21	NA	NC
Semivolatile Organic Compounds (μg/L)						
Phenol	103	86	215	2,400	86	1(S)
4-Methylphenol	103	71	530	3,700	71	1(S)
2-Methylphenol	103	63	125	520	63	1(S)
Naphthalene	103	75	1,340	7,700	47	10(G)
2-Chlorophenol	101	8	2.74	7.3	7	1(S)
Bis(2-ethylhexyl)phthalate	101	10	2.09	6.1	2	5(S)
4-Chloroaniline	101	1	1,000	1,000	1	5(S)
4-Nitrophenol	101	1	1.90	1.9	1	1(S)
2,4-Dimethylphenol	101	20	5.18	17	0	50(G)

Table 4.6 Detected Intermediate Groundwater CPOIs Within the Stained and Unstained Material

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Class GA Standards and Guidance
2-Methylnaphthalene	103	45	29.8	140	NA	NC
Acetophenone	75	26	37.0	90	NA	NC
Pesticides (µg/L)						
Heptachlor	103	3	0.25	0.48	3	0.04(S)
4,4'-DDT	103	2	0.37	0.73	1	0.2(S)
Dieldrin	99	1	0.05	0.052	1	0.004(S)
Inorganics (mg/L)						
Chloride	103	103	26,048	99,900	103	250
Sodium	103	103	10,154	71,260	103	20(S)
Iron	93	74	8.70	100	57	0.3(S)
Sulfate	103	102	572	4,540	37	250
Barium	103	103	1.71	20.9	36	1
Magnesium	101	79	69.8	430	30	35(G)
Manganese	103	79	1.26	17.1	25	0.3(S)
Thallium	103	21	0.21	1	21	0.0005(G)
Selenium	103	20	0.11	0.373	19	0.01(S)
Lead	102	40	0.04	0.22	15	0.025(S)
Arsenic	103	19	0.09	0.362	15	0.025(S)
Nickel	103	50	0.09	0.679	13	0.1(S)
Mercury	98	54	0.00	0.0018	10	0.0007(S)
Chromium	100	36	0.08	0.821	10	0.05(S)
Cyanide	102	72	0.09	0.621	8	0.2(S)
Cadmium	95	14	0.01	0.027	4	0.005(S)
Antimony	103	3	0.09	0.125	3	0.003(G)
Beryllium	103	9	0.00	0.0033	2	0.003(G)
Copper	100	16	0.07	0.202	1	0.2(S)
Zinc	103	25	0.06	0.251	0	2(G)

Table 4.6 Detected Intermediate Groundwater CPOIs Within the Stained and Unstained Material

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Class GA Standards and Guidance
Potassium	103	103	202	1,350	NA	NC
Calcium	102	102	6,287	28,000	NA	NC
Aluminum	100	72	4.51	68.1	NA	NC
Ammonia	34	34	27.16	150	NA	NC

Notes:
1 – Exceeds NYSDEC Class GA groundwater standards (S) and guidance values (G).
2 – Mean concentration values have been rounded.
NA = not applicable as no criterion is available. NC = no criterion.

For the nature and extent discussion, intermediate monitoring well groundwater samples collected during the PSA, FRI, and RI are discussed together. Groundwater screening samples from the intermediate zone are not are not included in the summary statistics or the discussion below.

VOC CPOIs in intermediate groundwater within and outside the stained material include BTEX parameters, acetone, and 2-butanone. Intermediate groundwater within the stained material also included styrene. Benzene and total BTEX concentrations in stained material groundwater are presented on **Figures 88 and 89,** respectively.

Benzene and BTEX in monitoring wells within the stained were detected at the highest concentrations in samples from the southeastern end of the stained materials (MW-07I and MW-22). The highest total BTEX concentration was detected at MW-07I during the November 2004 sampling event. Benzene and BTEX in the monitoring wells outside of the stained materials were detected at the highest concentrations in samples from the southeastern end of the stained materials (MW-10I, MW-09S, and MW-09I) and downgradient of the Wastebeds 1-4 stained materials along the lakeshore (MW-01S). The lowest benzene and BTEX concentrations (detected and non-detected) in intermediate groundwater were typically in the southwestern and northwestern portions of the soils outside of the stained material (MW-08I MW-13I, MW-13S, MW-14I, MW-14S, MW-15I, MW-17I, and MW-18I).

Naphthalene, 2-methylnaphthalene, and assorted phenols represent the majority of detected SVOC CPOIs. The distribution of naphthalene and other PAHs is similar to the distribution of VOCs in groundwater within the stained materials and outside of the stained materials. The highest concentrations detected within the stained materials were in the southeastern portion (MW-07I) and the lowest detected concentrations were from the northwestern portion (MW-16I). The highest naphthalene and total PAH concentrations detected outside of the stained materials were in samples from MW-02S on the lakeshore and MW-10I to the east of the stained material. The majority of the monitoring wells outside of the stained material had no detected concentrations or values less than 20 µg/L for naphthalene and total PAHs. Naphthalene and total PAHs concentrations are presented on **Figures 90 and 91,** respectively.

Assorted phenols above the Class GA standards are more widely distributed across the Site. The highest total phenol concentrations were in MW-03S and MW-03I. Total phenols concentrations are presented on **Figure 92**.

4,4’-DDT, dieldrin, and heptachlor represent the detected pesticide CPOIs that exceed the Class GA standards on-site. These three pesticides were detected once above Class GA standards at MW-10I during different rounds of sampling. Heptachlor also exceeded Class GA standards at MW-07I and MW-22I, as well as all other detected pesticides in intermediate groundwater outside of the stained material, but were observed separately over several groundwater investigations.

Figures 93 through 100 present concentrations of aluminum, arsenic, barium, chromium, mercury, nickel, selenium, and zinc in intermediate groundwater. Inorganics CPOIs associated with Solvay waste or native brines, such as chloride, and sodium, exceeded NYS Class GA groundwater standards. However, the distribution varies across the Site.

Intermediate Groundwater within the Ninemile Creek Deltaic Deposits

Summary statistics are provided on **Table 144** for groundwater chemical parameters detected in the Ninemile Creek sand and gravel zone on-site. These statistics were developed using data from the Deltaic deposit monitoring wells (but not data from the groundwater screening samples). Detected CPOIs are presented below in **Table 4.7**.

Table 4.7 Detected Ninemile Creek Deltaic Deposit Groundwater CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Class GA Standards and Guidance
Volatile Organic Compounds (µg/L)						
Benzene	17	15	776	6,600	15	1(S)
Acetone	17	10	220	440	9	50(S)
Toluene	17	7	438	3,000	6	5(S)
2-Butanone	17	10	57.5	100	5	50(G)
Methylene chloride	17	3	13.6	16.0	3	5(S)
2-Hexanone	17	7	6.61	11.0	0	50(G)
4-Methyl-2-pentanone	17	10	3.93	5.30	NA	NC
Semivolatile Organic Compounds (µg/L)						
2-Methylphenol	17	17	335	670	16	1(S)
4-Methylphenol	17	17	917	1,900	16	1(S)
Phenol	17	17	701	1,800	16	1(S)
2-Chlorophenol	17	7	1.78	3.60	6	1(S)
Naphthalene	17	2	50.2	100	1	10(G)
Benzo(a)anthracene	17	1	0.08	0.08	1	0.002(G)
Chrysene	17	1	0.07	0.07	1	0.002(G)
Indeno(1,2,3-cd)pyrene	17	1	0.28	0.28	1	0.002(G)
2,4-Dimethylphenol	17	8	5.04	11.0	0	50(G)
Inorganics (mg/L)						

Table 4.7 Detected Ninemile Creek Deltaic Deposit Groundwater CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Class GA Standards and Guidance
Barium	17	17	8.23	15.5	17	1(S)
Sodium	17	17	10,064	25,200	17	20(S)
Chloride	17	17	43,306	57,100	17	250
Iron	17	16	23.7	92.0	16	0.3(S)
Manganese	17	17	1.70	4.62	13	0.3(S)
Arsenic	17	6	0.09	0.31	4	0.025(S)
Lead	17	4	0.08	0.14	4	0.025(S)
Thallium	17	4	0.15	0.36	4	0.0005(G)
Cyanide	17	16	0.18	1.37	3	0.2(S)
Magnesium	17	16	35.7	210	3	35(G)
Cadmium	17	3	0.01	0.02	2	0.005(S)
Selenium	17	2	0.20	0.24	2	0.01(S)
Chromium	17	11	0.02	0.13	1	0.05(S)
Nickel	17	10	0.16	0.03	0.02	0.1(S)
Antimony	17	1	0.19	0.19	1	0.003(G)
Zinc	17	8	0.04	0.17	0	2(G)
Sulfate	17	8	62.2	231	0	250
Copper	17	6	0.05	0.11	0	0.2(S)
Mercury	17	5	0.0001	0.0004	0	0.0007(S)
Calcium	17	17	15,038	21,010	NA	NC
Potassium	17	17	305	511	NA	NC
Aluminum	17	6	9.66	55.0	NA	NC
Ammonia	2	2	32.0	32.4	NA	NC

Notes:
1 – Exceeds NYSDEC Class GA groundwater standards (S) and guidance values (G).
2 – Mean concentration values have been rounded.
NA = not applicable as no criterion is available. NC = no criterion.

For the nature and extent discussion, Ninemile Creek deltaic deposit monitoring well groundwater samples collected during the RI and SRI are discussed together.

VOC CPOIs in Ninemile Creek deltaic deposit groundwater include BTEX, acetone, 2-butanone, and methylene chloride. Benzene and Total BTEX concentrations in this groundwater are presented on **Figures 101 and 102**. Benzene and BTEX in these monitoring wells were detected at the highest concentrations in MW-27G, which is near the lakeshore. The benzene and BTEX concentrations were non-detect at locations MW-24G and MW-30G, and the lowest detected benzene and BTEX concentrations were at MW-18G.

Phenols represent the majority of detected SVOC CPOIs, with naphthalene and assorted PAHs making up the remainder. Assorted phenols above the Class GA standards were widely distributed in the deltaic deposits groundwater, with the highest concentrations observed at MW-30G. Similar to VOCs, the highest total PAH concentration was detected at location MW-27G near the lakeshore. The only other naphthalene and total PAH detected in the deltaic deposit groundwater unit were at location MW-25G. Concentrations of naphthalene, total PAHs, and total phenols in the intermediate deltaic deposit groundwater zone are presented on **Figures 103, 104, and 105**, respectively.

Pesticides and PCBs were not detected in groundwater samples collected from the intermediate Ninemile Creek deltaic deposit unit.

Figures 106 through 113 present concentrations of aluminum, arsenic, barium, chromium, mercury, nickel, selenium, and zinc in intermediate groundwater within the Ninemile Creek deltaic deposits. Inorganics CPOIs associated with Solvay waste or native brines, such as chloride, and sodium, exceeded NYS Class GA groundwater standards. However, the distribution varies across the Site.

4.3.3. Deep Groundwater

Summary statistics are provided on **Table 145** for deep groundwater chemical parameters detected on-site. The deep groundwater statistics were developed using data from the deep monitoring wells but not data from the groundwater screening samples. Detected CPOIs are presented below in **Table 4.8**.

Table 4.8 Detected Deep Groundwater CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Class GA Standards and Guidance
Volatile Organic Compounds (μg/L)						
Benzene	70	56	4,878	32,000	50	1(S)
Toluene	70	30	665	3,300	16	5(S)
Xylenes, m & p	52	14	141	690	6	5(S)
Ethylbenzene	70	10	20.5	52.0	5	5(S)
Styrene	70	5	37.6	59.0	4	5(S)
o-Xylene	52	10	78.0	270	3	5(S)
2-Butanone	70	8	31.8	130	3	50(G)
Xylenes, total	18	6	384	1,300	2	5(S)
Chloroform	70	11	1.96	9.20	1	7(S)
Methylene chloride	70	3	31.3	93.0	1	5(S)
Carbon disulfide	70	16	1.78	8.40	0	60(G)

Table 4.8 Detected Deep Groundwater CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Class GA Standards and Guidance
Semivolatile Organic Compounds (µg/L)						
Phenol	69	28	206	1,200	27	1(S)
4-Methylphenol	69	16	346	1,200	16	1(S)
2-Methylphenol	69	16	149	430	11	1(S)
Naphthalene	69	17	149	620	9	10(G)
Bis(2-ethylhexyl)phthalate	69	21	3.89	18.0	4	5(S)
Pesticides (µg/L)						
delta-BHC	69	1	0.09	0.09	1	0.04(S)
Inorganics (mg/L)						
Sodium	69	69	13,005	35,250	69	250
Chloride	69	69	44,225	96,800	69	20(S)
Magnesium	69	69	164	380	68	35(G)
Iron	69	68	75.3	280	68	0.3(S)
Manganese	69	69	5.12	15.5	64	0.3(S)
Sulfate	69	68	711	2,370	49	250
Thallium	69	28	0.20	0.51	28	0.0005(G)
Lead	69	31	0.06	0.13	26	0.025(S)
Arsenic	69	23	0.15	0.42	20	0.025(S)
Selenium	69	18	0.20	0.37	18	0.01(S)
Barium	69	66	7.25	78.4	15	1(S)
Cadmium	61	11	0.02	0.03	11	0.005(S)
Chromium	69	16	0.13	0.48	7	0.05(S)
Beryllium	69	13	0.003	0.005	6	0.003(G)
Cyanide	69	64	0.08	0.60	5	0.2(S)
Nickel	69	16	0.09	0.34	4	0.1(S)
Antimony	69	3	0.06	0.08	3	0.003(G)

Table 4.8 Detected Deep Groundwater CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Class GA Standards and Guidance
Silver	69	22	0.02	0.04	0	0.05(S)
Zinc	69	14	0.12	0.51	0	2(G)
Calcium	69	69	13,168	24,640	NA	NC
Potassium	69	68	187	336	NA	NC
Aluminum	69	41	7.26	110	NA	NC
Nitrogen, ammonia (as N)	23	23	20.5	50.9	NA	NC

Notes:
1 – Exceeds NYSDEC Class GA groundwater standards (S) and guidance values (G).
2 – Mean concentration values have been rounded.
NA = not applicable as no criterion is available. NC = no criterion.

For the nature and extent discussion, deep monitoring well groundwater samples collected during the PSA, FRI, and RI are discussed together.

VOC CPOIs in deep groundwater include BTEX parameters, 2-butanone, and acetone. Deep groundwater benzene and Total BTEX concentrations are presented on **Figures 114 and 115**. Benzene and the other BTEX compounds were detected in deep monitoring wells throughout the Site, with elevated concentrations detected throughout the southeastern portion of the Site. The maximum BTEX concentration was detected at MW-22D2 during the May 2007 sampling event. The lowest benzene and BTEX concentrations were typically from the northwestern portion of the Site.

Naphthalene, assorted PAHs, and assorted phenols represent the majority of detected SVOC CPOIs. Naphthalene and assorted PAHs were detected at varying concentrations in different portions of the Site, with the maximum concentration for naphthalene at MW-06D. Naphthalene was detected at lower concentrations but still exceeded Class GA standards at MW-02D, MW-07D, and MW-10D. Phenols that exceeded Class GA standards in deep groundwater were generally detected in the central portion of the Site. The highest concentration of total phenols was detected at MW-06D. Concentrations of naphthalene, total PAHs, and total phenols are presented on **Figures 116, 117, and 118**, respectively.

Figures 119 through 126 present concentrations of aluminum, arsenic, barium, chromium, mercury, nickel, selenium, and zinc in deep groundwater. Inorganics CPOIs associated with Solvay waste or native brines, such as chloride, and sodium, exceeded NYS Class GA groundwater standards. However, the distribution varies across the Site**.**

4.3.4. Bedrock Groundwater

Summary statistics are provided on **Table 146** for bedrock groundwater chemical parameters detected on-site. The bedrock groundwater statistics were developed using data from the bedrock monitoring wells and not data from the groundwater screening samples. Detected CPOIs are presented below in **Table 4.9**.

Table 4.9 Detected Bedrock Groundwater CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Class GA Standards and Guidance
Volatile Organic Compounds (µg/L)						
Benzene	22	19	6,315	25,000	18	1(S)
Toluene	22	7	6.72	22.0	2	5(S)
Trichloroethene	22	1	190	190	1	5(S)
2-Butanone	22	7	2.21	5.70	0	50(G)
o-Xylene	22	7	0.74	1.90	0	5(S)
Carbon disulfide	22	5	1.00	1.70	0	60(G)
Xylenes, m & p	22	5	1.75	4.70	0	5(S)
Semivolatile Organic Compounds (µg/L)						
Phenol	22	14	13.3	90.0	11	1(S)
2-Methylphenol	22	8	27.4	70.0	8	1(S)
Bis(2-ethylhexyl)phthalate	22	6	3.74	14.0	1	5(S)
Inorganics (mg/L)						
Magnesium	22	22	389	1,720	22	35(G)
Sodium	22	22	27,465	71,530	22	20(S)
Chloride	22	22	65,414	120,000	22	250
Sulfate	22	22	1,500	3,000	22	250
Arsenic	22	9	0.15	0.30	9	0.025(S)
Selenium	22	8	0.21	0.31	8	0.01(S)
Thallium	22	8	0.18	0.39	8	0.0005(G)
Lead	22	4	0.056	0.092	4	0.025(S)
Cyanide	22	17	0.10	0.31	2	0.2(S)
Chromium	22	4	0.063	0.13	2	0.05(S)
Iron	22	22	31.9	88.1	1	0.3(S)
Manganese	22	22	4.19	12.3	1	0.3(S)
Copper	22	5	0.11	0.29	1	0.2(S)

Table 4.9 Detected Bedrock Groundwater CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Class GA Standards and Guidance
Cadmium	22	1	0.008	0.008	1	0.005(S)
Barium	22	22	0.35	0.68	0	1(S)
Silver	22	7	0.019	0.028	0	0.05(S)
Calcium	22	22	11,763	19,100	NA	NC
Potassium	22	22	366	1,360	NA	NC
Aluminum	22	12	2.02	6.70	NA	NC
Nitrogen, ammonia (as N)	22	11	23.9	73.8	NA	NC

Notes:
1 – Exceeds NYSDEC Class GA groundwater standards (S) and guidance values (G).
2 – Mean concentration values have been rounded.
NA = not applicable as no criterion is available. NC = no criterion.

For the nature and extent discussion, bedrock groundwater samples collected during the FRI and RI are discussed together.

VOC CPOIs in bedrock groundwater include BTEX parameters, 2-butanone, and carbon disulfide. Benzene and total BTEX concentrations in bedrock groundwater are presented on **Figures 127 and 128**. Benzene is detected in bedrock monitoring wells throughout the Site, with elevated concentrations detected throughout the southeastern portion of the Site. The maximum BTEX concentration was detected at MW-13BR2 during the May 2007 sampling event. The lowest benzene and BTEX concentrations were typically from the northwestern portion (MW-04BR) of the Site.

Naphthalene, assorted PAHs, phenol, and assorted phenols represent the majority of detected SVOC CPOIs. Naphthalene and assorted PAHs are found in the central and lakeshore portions of the Site, with the maximum total PAH concentration at MW-06BR. Phenols that exceeded Class GA standards were detected in bedrock monitoring wells in the southeastern portion of the Site. The highest concentration of total phenols was detected at MW-09BR in the southeastern portion of the Site. Concentrations of naphthalene, total PAHs, and total phenols are presented in **Figures 129, 130, and 131**, respectively.

Figures 132 through 139 present bedrock groundwater concentrations for aluminum, arsenic, barium, chromium, mercury, nickel, selenium, and zinc, respectively. Arsenic, selenium, and sulfate exceeded Class GA groundwater standards in bedrock groundwater. Also inorganic constituents associated with Solvay waste or native brines, such as magnesium, chloride, and sodium, exceeded Class GA groundwater standards. However, the distribution varies across the Site.

4.3.5. Groundwater Nature and Extent Summary

As part of the integrated IRM discussed in Section 1.5.10 of this report, shallow and intermediate groundwater from the eastern lakeshore, Ninemile Creek bank, and northwest shoreline of Wastebed 5 will be collected using collection trenches and passive collection wells. Groundwater collected will be pumped to the Willis Avenue Groundwater Treatment Plant for treatment.

CPOI concentrations varied between the five rounds of groundwater sample collection. Changes in concentration in intermediate wells along the lakeshore (this includes wells designated with an S and I along the lakeshore) appear to fluctuate seasonally. Organic and inorganic CPOIs were detected at different concentrations between wells within the same groundwater zone, which illustrates the heterogeneity of the fill material at the Site. These CPOIs include BTEX, naphthalene and assorted PAHs, phenolic compounds, and assorted inorganic compounds. Groundwater concentrations are compared to applicable standards and/or guidance values in Section 5 of this report. A conceptual site model for the Site is presented in Section 9.

BTEX parameters and PAHs were detected at their highest concentrations in the intermediate groundwater zone within Wastebeds 1 through 4 stained material and the southeastern portion (MW-09S and MW-09I) adjacent to the lake. In shallow groundwater, concentrations of BTEX and PAHs tended to be lower than those observed in the intermediate zone. Phenols were more widely distributed in the intermediate groundwater zones including the wells screened within the stained material, outside of the stained material, and within Ninemile Creek deltaic deposits across the Site (Wastebeds 1 through 6) compared to other organic CPOIs. Phenol concentrations in shallow groundwater were low (<100 µg/L) throughout the Site.

CPOI concentration patterns in the deep and bedrock groundwater zones differed from the upper two zones. In deep groundwater, BTEX are elevated within Wastebeds 1 through 4 and the lakeshore adjacent to these wastebeds compared to other areas of the Site, while PAHs were only elevated within Wastebed 3 (MW-06D and MW-21D) compared to other areas of the Site. These CPOIs were detected in bedrock groundwater at elevated concentrations along the southeastern lakeshore and southern perimeter of Wastebeds 1, 2, and 7. Phenols were detected primarily in the central portion of Wastebed 3 in the deep groundwater zone and at low concentrations in on the southeastern perimeter of the Site in the bedrock zone.

Benzene exceedances and Total BTEX concentrations are presented on **Figures 75 and 76** for shallow groundwater in the upper system, on figures **Figures 88 and 89** for the intermediate groundwater in the upper system, **Figures 101 and 102** for intermediate groundwater in the Ninemile Creek deltaic deposits, and **Figures 114 and 115** for the deep groundwater in the lower system, and **Figures 127 and 128** for bedrock groundwater in the lower system. Three cross sections (Cross Section 1-1', Cross Section 2-2', and Cross Section 3-3') were generated to present benzene, toluene, and xylene (BTX) data at different depths across site. **Figures 140** presents the cross section locations, and BTX values are presented on **Figures 141, 142, and 143** for Cross Section 1-1', Cross Section 2-2', and Cross Section 3-3', respectively.

The cross section figures present the vertical distribution of BTX parameters and include the nearest available lake pore water locations (OL-VC-30044, OL-VC-30048, and OL-VC-30033 for cross sections 1-1', 2-2', and 3-3', respectively). In general, total BTX concentrations are more evenly composed of benzene, toluene, and xylenes in the shallow and intermediate groundwater of the upper system. In the lower system deep and bedrock groundwater, benzene is the major BTX component observed. The mechanism creating the stratification of BTX components in Site groundwater is not known. It should be noted that a separate Deep Groundwater Investigation (O'Brien & Gere 2007, O'Brien & Gere 2010c) is being conducted to evaluate other potential sources of benzene in deep and bedrock groundwater encountered regionally along the lakeshore and beneath Onondaga Lake.

4.4. SURFACE WATER CHARACTERIZATION

Three rounds of surface water samples were collected at the Site, with two rounds collected during the PSA and one round collected during the RI. Surface water sample locations are presented on **Figure 4F**. The first round of PSA samples were analyzed for VOCs, SVOCs, pesticides, PCBs, inorganics, high resolution mercury, and other parameters (*i.e.*, bicarbonate, carbonate, chloride, hardness, sulfate, and alkalinity). The data are presented in **Tables 147 through 153**. The second round of PSA samples and the RI samples were analyzed for VOCs, SVOCs, pesticides, PCBs, inorganics, high resolution mercury, and hardness. The data are provided in **Tables 147 through 153 and Tables 154 through 160**, respectively.

A summary of the surface water sample locations and analyses performed during the PSA and RI are provided in **Tables 31 and 32**, respectively. Surface water samples were separated between the former Ponded Area (SW-01, 07, and 08) and Ditch A (SW-02 to SW-06) for the nature and extent discussion below.

As part of the Integrated IRM, the Ponded Area has been removed and surface water, seep water, and shallow/intermediate groundwater that provided sources of water to the Ponded Area are being collected by the Ninemile Creek collection system. Additionally, the surface sediment from Middle Ditch A has been removed, and remedial efforts for lower Ditch A described in Section 1.5.10 are ongoing. The section below describes conditions of the former Ponded Area and Ditch A that were used in designing the Integrated IRM, and existed prior to its implementation.

The surface water sampling locations and select CPOIs (*i.e.*, total BTEX, naphthalene, total PAHs, total phenols, and mercury) are presented on **Figure 144**. A brief description of the analytical results for the PSA and the RI is presented below.

4.4.1. Former Ponded Area Surface Water

A total of four samples were collected from the former Ponded Area. Two PSA samples were collected at SW-01, and two RI samples were collected from SW-07 and SW-08. Summary statistics are provided in **Table 161** for Ponded Area surface water constituents detected in the former Ponded Area. Detected CPOIs are presented in **Table 4.10** below.

Table 4.10 Detected Former Ponded Area Surface Water CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Class C Surface Water Values
Volatile Organic Compounds (µg/L)						
Benzene	4	4	3.15	8.5	0	10(S)
Toluene	4	3	3.27	6.6	0	100(G)
Xylenes, total	4	3	1.53	3.2	0	65(G)
Ethylbenzene	4	1	0.15	0.15	0	17(G)
Tetrachloroethene	4	1	0.20	0.20	0	1(G)
2-Butanone	4	4	6.28	9.6	NA	NC
Acetone	4	4	43.3	58	NA	NC
2-Hexanone	4	3	1.25	1.6	NA	NC
1,1-Dichloroethane	4	2	0.25	0.38	NA	NC
4-Methyl-2-pentanone	4	2	0.39	0.43	NA	NC
Xylenes, m & p	1	1	0.53	0.53	NA	NC
Semivolatile Organic Compounds (µg/L)						
Phenol	4	4	53.4	100	4	5(S)
Bis(2-ethylhexyl)phthalate	4	2	1.3	1.50	2	0.6(S)

Table 4.10 Detected Former Ponded Area Surface Water CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Class C Surface Water Values
Naphthalene	4	4	5.4	11.0	0	13(S)
2-Methylnaphthalene	4	3	1.14	2.1	0	4.7(G)
Phenanthrene	4	3	1.24	2.1	0	5(G)
2,4-Dimethylphenol	4	2	2.8	3	0	5(S)
2-Methylphenol	4	4	14.5	29.0	NA	NC
4-Methylphenol	4	4	29.2	54	NA	NC
Di-N-butyl phthalate	4	1	0.90	0.90	NA	NC
Dibenzofuran	4	1	1.9	1.9	NA	NC
Inorganics (mg/L)						
Aluminum	4	3	0.4937	0.670	3	0.1(S)
Iron	4	3	0.597	0.840	2	0.3(S)
Mercury (High Resolution)	4	4	0.00048	0.001	1	0.00077(S)
Cyanide	4	2	0.01	0.01	1	0.0052(S)
Selenium	4	1	0.01	0.01	1	0.0046(S)
Lead	4	2	0.01	0.01	0	58.795
Nickel	4	2	0.03	0.03	0	507.695
Cadmium	4	1	0.0011	0.0011	0	17.3435
Vanadium	4	1	0.0019	0.0019	0	0.014(S)
Zinc	4	1	0.0094	0.0094	0	791.939
Barium	4	4	0.534	0.950	NA	NC
Calcium	4	4	1,326	2,300	NA	NC
Magnesium	4	4	3.03	6.01	NA	NC
Potassium	4	4	63.85	100	NA	NC
Sodium	4	4	492	850	NA	NC
Manganese	4	3	0.02	0.03	NA	NC
Chloride	1	1	5,400	5,400	NA	NC

Table 4.10 Detected Former Ponded Area Surface Water CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Class C Surface Water Values
Sulfate	1	1	28.0	28.0	NA	NC

Notes:
1 – Exceeds NYSDEC Class C surface water standards (S) and guidance values (G).
2 – Mean concentration values have been rounded.
NA = not applicable as no criterion is available. NC = no criterion.

VOC CPOIs included 2-butanone, 2-hexanone, acetone, BTEX parameters, 1,1-dichloroethane, 4-methyl-2-pentanone, and tetrachloroethene. However, there were no exceedances of Class C surface water standards and guidance values. Concentrations of benzene and total BTEX are presented on **Figure 144**. The highest VOC detection was acetone at SW-01, which also had the highest total BTEX concentration.

Naphthalene, assorted PAHs, phenol, and assorted phenols were the major SVOC CPOIs. Concentrations of these CPOIs are presented on **Figure 144.** The highest concentrations of SVOC CPOIs were detected at SW-01.

The VOCs and SVOCs detected within the former Ponded Area surface water are potentially from surface runoff from the Site, shallow groundwater, and Ninemile Creek; however, upgradient surface soil and shallow groundwater concentrations in this area indicate that Wastebeds 1 through 8 is not a likely source for these constituents in the former Ponded Area.

Figure 144 presents inorganic CPOIs including aluminum, arsenic, barium, chromium, mercury, nickel, selenium, and zinc**.** Inorganics were detected at varying concentrations in the five surface water samples collected from the former Ponded Area.

4.4.2. Ditch A Surface Water

A total of ten samples were collected from Ditch A. The ten samples were collected from SW-02 through SW-06 between the two PSA sampling rounds.

Summary statistics are provided in **Table 162** for surface water constituents detected in Ditch A. Detected CPOIs are presented below in **Table 4.11**.

Table 4.11 Detected Ditch A Surface Water CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Class C Surface Water Values
Volatile Organic Compounds (µg/L)						
Benzene	10	3	23	59	2	10(S)
Toluene	10	5	7.22	30	0	100(G)
Ethylbenzene	10	2	1	1	0	17(G)
Xylenes, total	10	2	13.6	24	0	65(G)
Acetone	10	9	4	10	NA	NC
Semivolatile Organic Compounds (µg/L)						

Table 4.11 Detected Ditch A Surface Water CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Class C Surface Water Values
Phenol	10	8	5.58	11	4	5(S)
Bis(2-ethylhexyl)phthalate	10	2	2.2	3.3	2	0.6(S)
Naphthalene	10	4	10.1	35	1	13(S)
4-Methylphenol	10	4	4	10	NA	NC
Inorganics (mg/L)						
Iron	10	10	2.552	15	8	0.3(S)
Aluminum	10	10	0.69	2.0	7	0.1(S)
Cyanide	10	7	0.01	0.01	5	0.0052(S)
Lead	10	10	0.01	0.02	0	58.795
Mercury (High Resolution)	10	10	0.000033	0.000215	0	0.00077(S)
Nickel	10	10	0.0048	0.012	0	507.695
Copper	10	9	0.01	0.03	0	89.4517
Zinc	10	8	0.0206	0.091	0	791.939
Vanadium	10	7	0.00289	0.0064	0	0.014(S)
Arsenic	10	2	0.0033	0.0046	0	0.15(S)
Chromium	10	2	0.0085	0.013	0	672.77
Selenium	10	2	0.0023	0.0024	0	0.0046(S)
Barium	10	10	0.152	0.26	NA	NC
Calcium	10	10	333.9	670	NA	NC
Magnesium	10	10	6.03	16	NA	NC
Manganese	10	10	0.49	3.9	NA	NC
Potassium	10	10	19.1	55	NA	NC
Sodium	10	10	288	710	NA	NC
Chloride	5	5	1,092	1,500	NA	NC
Sulfate	5	4	36.1	90	NA	NC
Antimony	10	3	0.0019	0.0028	NA	NC

Table 4.11 Detected Ditch A Surface Water CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Class C Surface Water Values

Notes:
1 – Exceeds NYSDEC Class C surface water standards (S) and guidance values (G).
2 – Mean concentration values have been rounded.
NA = not applicable as no criterion is available. NC = no criterion.

Detected VOC CPOIs included BTEX and acetone. Benzene was the only CPOI detected above Class C surface water standards and guidance. Concentrations of benzene and total BTEX are presented on **Figure 144**. The highest concentrations of VOCs were detected at SW-02.

Naphthalene, assorted PAHs, phenol, and assorted phenols were the major SVOC CPOIs, and their concentrations are presented on **Figure 144.** The highest concentrations of SVOC CPOIs were also detected at locations SW-02, SW-03, and SW-04. Naphthalene and total PAHs were detected at the highest concentrations at location SW-02. Phenol was detected at the highest concentration at location SW-03, and total phenols at location SW-04.

In addition to the site, a potential source for VOCs and SVOCs in Ditch A surface water is surface runoff from the adjacent parking areas. The lower reach of the ditch also receives surface water runoff from I-690, State Fair Boulevard, the Bridge Street area, and a Crucible parking area that may be impacting Ditch A surface water.

Inorganics were detected at varying concentrations for the twelve surface water samples collected in Ditch A. Selected inorganic CPOIs, including aluminum, arsenic, barium, chromium, mercury, nickel, selenium, and zinc, are presented on **Figure 144.**

4.5. SEDIMENT CHARACTERIZATION

Sediment samples were collected during the PSA and RI. PSA and RI samples were analyzed for VOCs, SVOCs, pesticides, PCBs, inorganics, TOC, and percent solids. The data are provided in **Tables 163 through 168 and Tables 169 through 174** for the PSA and RI, respectively. Sediment sample locations are presented on **Figure 4F**.

A summary of the sediment sample locations and analyses performed during the PSA and RI are provided in **Tables 33 and 34**, respectively. Sediment samples were separated between former Ponded Area (SW-01, 07 and 08) and Ditch A (SW-02 to SW-06) for the nature and extent discussion below.

As part of the Integrated IRM, the Ponded Area has been removed and surface water, seep water, and shallow/intermediate groundwater that provided sources of water to the Ponded Area will be collected by the Ninemile Creek collection system. Additionally, the surface sediment from Middle Ditch A has been removed, and remedial efforts for lower Ditch A described in Section 1.5.10 are ongoing. The section below describes conditions of the former Ponded Area and Ditch A that were used in designing the Integrated IRM, and existed prior to its implementation.

The sampling locations and CPOIs concentrations for total BTEX, naphthalene, total PAHs, total phenols, and mercury are presented on **Figure 145**. A brief description of the analytical results for the PSA and RI is presented below. For the nature and extent discussion, the PSA, and RI data have been combined for each of the two subsections.

4.5.1. Former Ponded Area Sediments

Summary statistics are provided on **Table 175** for sediment constituents detected in the former Ponded Area. Detected CPOIs are presented below in **Table 4.12**.

Table 4.12 Detected Former Ponded Area Sediment CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Technical Guidance for Screening Sediments[3]
Volatile Organic Compounds (µg/kg)						
Benzene	6	6	5.25	9.1	0	11.7
Toluene	6	5	6.72	10	0	955.5
Xylenes, total	6	4	8.48	11	0	1,794
Ethylbenzene	6	2	0.97	0.98	0	468
Isopropylbenzene	4	2	0.6	0.6	0	234
Acetone	6	6	47	66	NA	NC
Carbon disulfide	6	5	1.21	1.6	NA	NC
2-Butanone	6	4	7.90	11	NA	NC
Methylene chloride	6	4	0.7	0.7	NA	NC
Methylcyclohexane	4	3	6.6	11	NA	NC
o-Xylene	4	2	1.40	1.4	NA	NC
Xylenes, m & p	4	2	4.55	4.9	NA	NC
Cyclohexane	4	1	0.76	0.76	NA	NC
Semivolatile Organic Compounds (µg/kg)						
Benzo(A)anthracene	6	3	69	85	3	25.35
Benzo(A)pyrene	6	3	67	84	3	25.35
Benzo(B)fluoranthene	6	3	66.7	78	3	25.35
Benzo(K)fluoranthene	6	3	61.7	71	3	25.35
Chrysene	6	3	82	100	3	25.35
Phenol	6	3	117.3	170	3	9.75
Indeno(1,2,3-CD)pyrene	6	2	48.0	55	2	25.35
Phenanthrene	6	5	140.0	160	0	2,340
Fluoranthene	6	4	123.0	170	0	19,890
Naphthalene	6	4	52.0	82	0	585
Pyrene	6	4	97.3	140	0	18,739.5

Table 4.12 Detected Former Ponded Area Sediment CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Technical Guidance for Screening Sediments[3]
4-Methylphenol	6	4	71.0	140	NA	NC
1-Phenyl-1-(2,4-Dimethylphenyl)ethane	6	2	29.5	32.0	NA	NC
2-Methylphenol	6	2	34.5	37.0	NA	NC
Benzo(G,H,I)perylene	6	2	53	62	NA	NC
Pesticides (µg/kg)						
4,4'-DDE	6	1	7.00	7.00	1	0.195
4,4'-DDT	6	1	1.10	1.10	1	0.195
PCBs (µg/kg)						
Aroclor-1254	6	3	131	380	3	0.0156
Aroclor-1268	6	3	35.3	87.0	NA	NC
Inorganics (mg/kg)						
Mercury	6	6	1.41	3.2	6	1.3(L)
Nickel	6	6	22.7	30.2	5	50(P)
Copper	6	6	10.5	21	1	110(P)
Lead	6	6	18.4	33.9	1	110(P)
Chromium	6	6	16.4	22	0	110(P)
Manganese	6	6	205	400	0	1,100(P)
Zinc	6	6	45.1	60.1	0	270(P/L)
Arsenic	6	5	3.56	4.1	0	33(P)
Antimony	6	2	0.22	0.22	0	25(L)
Cadmium	6	2	0.10	0.14	0	9(L)
Aluminum	6	6	8,523	13,700	NA	NC
Barium	6	6	61.5	70	NA	NC
Calcium	6	6	154,250	294,000	NA	NC
Iron	6	6	13,805	20,400	NA	NC
Magnesium	6	6	6,732	10,800	NA	NC

Table 4.12 Detected Former Ponded Area Sediment CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Technical Guidance for Screening Sediments[3]
Potassium	6	6	1,978	2,910	NA	NC
Sodium	6	6	1,377	1,500	NA	NC
Vanadium	6	6	15.4	20.5	NA	NC
Cobalt	6	4	6.48	9.4	NA	NC
Beryllium	6	3	0.58	0.73	NA	NC
Cyanide	6	2	1.15	1.2	NA	NC

Notes:
1 – Exceeds NYSDEC Technical Guidance for Screening Contaminated Sediments (1999).
2 – Mean concentration values have been rounded.
3 – Lowest applicable criteria value from Benthic Chronic, Human Health and Lowest Effect Metals
NA = not applicable as no criterion is available. NC = No criterion.

VOC CPOIs were not detected above guidance values in *Technical Guidance for Screening Contaminated Sediments* (NYSDEC, 1999). Acetone, BTEX, 2-butanone, carbon disulfide, and methylene chloride were among the VOC parameters detected that did not exceed the guidance values. Benzene and total BTEX concentrations are presented on **Figure 145**. Corresponding with SW-01, SED-01 had the highest detected concentrations of benzene and total BTEX. Sources for VOCs in the former Ponded Area sediments are potentially from surface runoff from the Site, shallow groundwater, and Ninemile Creek; however, upgradient surface soil and shallow groundwater concentrations in this area indicate that Wastebeds 1 through 8 is not a likely source for these constituents in the former Ponded Area.

Seven SVOCs were detected above the guidance values in *Technical Guidance for Screening Contaminated Sediments* (NYSDEC, 1999) and consisted mostly of PAHs and phenols. Concentrations of naphthalene, total PAHs, phenol, and total phenols are presented on **Figure 145.** The maximum concentrations of naphthalene and total PAHs, were also detected at SED-01. Maximum concentrations of phenol and total phenols were observed at SED-08. As with VOCs, sources for these PAHs are potentially surface runoff from the Site, shallow groundwater, and Ninemile Creek; however, shallow groundwater concentrations in this area indicate that Wastebeds 1 through 8 is not a likely source for these constituents in the former Ponded Area. Phenols are potentially related to Site groundwater based on shallow groundwater concentrations in this area.

PCBs and pesticides were detected above guidance values (**Table 4.12**). These constituents included Aroclors 1254 and 1268, 4,4'-DDE, and 4,4'-DDT. As with other CPOIs, potential sources for these constituents include surface runoff from parking areas or Ninemile Creek.

Inorganic constituents (mercury, nickel, copper, and lead) were detected at concentrations above guidance values in *Technical Guidance for Screening Contaminated Sediments* (NYSDEC, 1999). **Figure 145** presents the concentrations for aluminum, arsenic, barium, chromium, mercury, nickel, selenium, and zinc. Inorganics were detected in all seven sediment samples. Potential sources for the inorganics in Ponded area sediment include surface runoff, shallow groundwater, and Ninemile Creek.

4.5.2. Ditch A Sediments

For the nature and extent discussion, sediment data are combined for the PSA, and RI sampling events. Summary statistics are provided on **Table 176** for sediment constituents detected in Ditch A. Detected CPOIs are presented below in **Table 4.13**.

Table 4.13 Detected Ditch A Sediment CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Technical Guidance for Screening Sediments[3]
Volatile Organic Compounds (µg/kg)						
Benzene	7	1	1.10	1.10	0	11.7
Acetone	7	6	43.7	54.0	NA	NC
2-Butanone	7	5	4.56	8.00	NA	NC
Carbon disulfide	7	3	13.0	35.0	NA	NC
2-Hexanone	7	1	1.80	1.80	NA	NC
Semivolatile Organic Compounds (µg/kg)						
Benzo(a)anthracene	7	3	207	330	3	23.35
Benzo(a)pyrene	7	3	240	390	3	23.35
Benzo(b)fluoranthene	7	3	267	420	3	23.35
Benzo(k)fluoranthene	7	3	247	380	3	23.35
Chrysene	7	3	263	420	3	23.35
Indeno(1,2,3-cd)pyrene	7	3	142	210	3	23.35
Bis(2-ethylhexyl)phthalate	7	4	199	360	0	3,890.25
Fluoranthene	7	4	425	700	0	19,890
Phenanthrene	7	4	179	350	0	2,340
Pyrene	7	3	593	730	0	18,739.5
Benzo(g,h,i)perylene	7	3	154	230	NA	NC
Pesticides (µg/kg)						
Dieldrin	7	1	2.70	2.70	1	1.95
PCBs (µg/kg)						
Aroclor-1254	7	2	21.5	27.0	2	0.0156
Aroclor-1268	7	2	20.5	24.0	NA	NC

Table 4.13 Detected Ditch A Sediment CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Technical Guidance for Screening Sediments[3]
Inorganics (mg/kg)						
Nickel	7	7	22.4	40.0	5	16(P)
Copper	7	7	17.1	29.0	4	16(P)
Manganese	7	7	556	920	4	460(P)
Arsenic	7	7	5.91	15.0	2	6(P)
Chromium	7	7	28.0	65.0	2	26(P)
Lead	7	7	24.0	74.0	2	31(P)
Zinc	7	7	60.7	130	1	120(P/L)
Mercury	7	6	0.10	0.30	1	0.15(L)
Silver	7	2	4.44	8.30	1	1(L)
Cadmium	7	6	0.14	0.26	0	0.6(P)
Antimony	7	5	0.37	0.41	0	2(L)
Aluminum	7	7	7,511	14,000	NA	NC
Barium	7	7	179	680	NA	NC
Beryllium	7	7	0.42	0.79	NA	NC
Calcium	7	7	175,714	400,000	NA	NC
Iron	7	7	20,539	48,000	NA	NC
Magnesium	7	7	7,614	15,000	NA	NC
Potassium	7	7	1,199	2,000	NA	NC
Sodium	7	7	1,540	4,400	NA	NC
Vanadium	7	7	19.9	32.0	NA	NC
Cobalt	7	6	7.33	15.0	NA	NC
Selenium	7	6	0.74	1.60	NA	NC
Thallium	7	5	1.09	2.60	NA	NC

Notes:
1 – Exceeds NYSDEC Technical Guidance for Screening Contaminated Sediments (1999).
2 – Mean concentration values have been rounded.

Table 4.13 Detected Ditch A Sediment CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Technical Guidance for Screening Sediments[3]

3 – Lowest applicable criteria value from Benthic Chronic, Human Health and Lowest Effect Metals
NA = not applicable as no criterion is available. NC = No criterion.

VOC CPOIs were not detected above guidance values in *Technical Guidance for Screening Contaminated Sediments* (NYSDEC, 1999). Acetone, 2-butanone, carbon disulfide, 2-hexanone, and benzene were detected, but the detected concentrations did not exceed the guidance values. Benzene and total BTEX concentrations are presented on **Figure 145**. Corresponding with SW-02, SED-02 had the highest detected concentrations of benzene. Benzene was the only BTEX parameter detected. A source for VOCs in Ditch A sediments is potentially surface runoff from the adjacent parking areas. The lower reach of the ditch also receives surface water runoff from I-690, State Fair Boulevard, the Bridge Street area, and a Crucible parking area that may be impacting Ditch A sediments.

Six SVOCs were detected above the guidance values in *Technical Guidance for Screening Contaminated Sediments* (NYSDEC, 1999) and consisted of mostly PAHs. Concentrations of the CPOIs including total PAHs are presented on **Figure 145.** The highest concentrations of total PAHs were detected at SED-05. As with VOCs, a source for these PAHs is potentially surface runoff from the adjacent parking areas and the areas associated with the lower reach discussed above.

PCBs and pesticides were detected above guidance values (**Table 4.13**). These constituents included Aroclors 1254 and dieldrin. As with other CPOIs, sources for these constituents may be related to surface water runoff from State Fair ground parking areas, State Fair Boulevard, I-690, the Bridge Street area, and a Crucible parking area.

Inorganic constituents were detected at concentrations above guidance values in *Technical Guidance for Screening Contaminated Sediments* (NYSDEC, 1999). Inorganic CPOIs included aluminum, arsenic, barium, chromium, mercury, nickel, selenium, and zinc and are presented in **Figure 145**. Potential sources for the inorganics in Ditch A include surface water runoff from State Fair ground parking areas, State Fair Boulevard, I-690, the Bridge Street area, and a Crucible parking area, and shallow groundwater.

4.6. SEEP CHARACTERIZATION

A seep reconnaissance was performed during the PSA and identified 104 seeps designated SP-01 through SP-104. Seep samples were collected as part of the PSA and Chromium Speciation Investigation. Seep samples were also collected by the NYSDEC in May 2003 from locations identified as 101-01 through 101-04. Locations are provided on **Figure 4G**. Surface water and surface soil samples were collected at seep locations. PSA seep surface water data are provided in **Tables 177 through 183** for VOCs, SVOCs, pesticides, PCBs, high resolution mercury, inorganics, and other data (alkalinity, hardness, chloride and sulfate). PSA seep surface soils data are provided in **Tables 184 through 189** for VOCs, SVOCs, pesticides, PCBs, inorganics, and percent solids and TOC. Chromium Speciation Investigation data are provided in **Table 52** for chromium and hexavalent chromium. Samples collected by the NYSDEC were analyzed for VOCs, SVOCs, PCBs, and inorganics, and the data are provided in **Exhibit 5**. For the nature and extent discussion including summary statistics, PSA, Chromium Speciation Investigation, and NYSDEC 2003 data have been combined into one dataset.

As part of the Integrated IRM, seep surface water and shallow/intermediate groundwater that may feed some of the seeps will be collected from three areas on site. These areas include all of the seeps along the eastern lakeshore (SP-21 through SP-87, Pipe-05 and Pipe 06, and 101-02), portions of the northern shorelines of Wastebeds 5 and 6 (SP-88, SP-89, Pipe-07, and Pipe-08), and the bank of Ninemile Creek along the southern portion of Wastebed 5 (SP-93 through SP-104 and Pipe-09). In addition to collection of seep waters, the majority of seep surface soils in these areas will be covered by a combination of seep apron, mitigation wetlands, and vegetative cover. In addition to seeps remediated as part of the IRM, two seeps (SP-91 and SP-92) will be addressed as part of the Onondaga Lake remediation through dredging and cover material placement. Seeps along Ditch A (SP-01 through SP-20, Pipe-01 to Pipe-04, 101-03, and 101-04 will not be remediated as part of the IRM. These seeps will be remediated as part of the final remedy for Ditch A. Conditions used in the design of the Integrated IRM, and existed prior to its implementation are described below.

4.6.1. Seep Surface Water

A total of 22 seep surface water samples were collected on the Site. Summary statistics are provided in **Table 190** for seep surface water constituents detected at the Site. Detected CPOIs are presented below in **Table 4.14**.

Table 4.14 Detected Seep Surface Water CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Class C Surface Water Values
Volatile Organic Compounds (μg/L)						
Xylenes, total	22	13	139.9	1,500	3	65(G)
Benzene	22	5	99.5	480	2	10(S)
Toluene	22	11	151.6	1,600	1	100(G)
Naphthalene	4	2	953	1,900	1	13(S)
Ethylbenzene	22	4	3.05	5.1	0	17(G)
Acetone	22	21	35.7	150	NA	NC
2-Butanone	22	6	9.7	31	NA	NC
2-Hexanone	22	5	2.84	5.0	NA	NC
Xylenes, m & p	4	2	569	1,100	NA	NC
o-Xylene	4	1	330	330	NA	NC
Semivolatile Organic Compounds (μg/L)						
Phenol	22	20	18.3	100	13	5(S)
2-Methylnaphthalene	22	11	35.9	84.0	8	4.7(G)
Naphthalene	22	10	709.5	3,700	7	13(S)
Phenanthrene	22	13	4.62	13.0	3	5(G)
Fluorene	22	2	4.00	5.0	2	0.54(G)
Bis(2-ethylhexyl)phthalate	22	1	3.10	3.1	1	0.6(S)
4-Methylphenol	22	13	22	140	NA	NC
Dibenzofuran	22	11	4.31	7.1	NA	NC

Table 4.14 Detected Seep Surface Water CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Class C Surface Water Values
2-Methylphenol	22	8	10	41	NA	NC
Pesticides (µg/L)						
Heptachlor epoxide	18	1	0.072	0.072	0.072	1
Inorganics (mg/L)						
Cyanide	22	16	0.0122	0.0617	12	0.0052(S)
Aluminum	22	11	3.41	26.4	10	0.1(S)
Iron	22	18	1.88	15.9	6	0.3(S)
Vanadium	22	8	0.0085	0.0359	2	0.014(S)
Cobalt	22	4	0.0086	0.0212	2	0.005(S)
Arsenic	22	5	0.10	0.506	1	0.15(S)
Lead	22	21	0.0091	0.0387	0	93.3
Mercury	22	20	0.0001	0.00055	0	0.00077(S)
Nickel	22	18	0.0128	0.112	0	797
Copper	22	10	0.0131	0.0506	0	141
Zinc	22	10	0.04	0.21	0	1,244
Beryllium	22	9	0.0001	0.00031	0	1.1(S)
Chromium	22	6	0.0158	0.0465	0	672
Barium	22	22	0.34	1.73	NA	NC
Calcium	22	22	1,164	3,700	NA	NC
Potassium	22	22	35.66	110	NA	NC
Sodium	22	22	305	1,090	NA	NC
Chloride	22	18	937	2,600	NA	NC
Sulfate	22	18	46.50	140	NA	NC
Magnesium	22	18	8.84	91	NA	NC
Manganese	22	10	0.36	3.17	NA	NC
Antimony	22	6	0.00	0.0073	NA	NC

Notes:
1 – Exceeds NYSDEC Class C surface water Standards (S) and Guidance values (G).

Table 4.14 Detected Seep Surface Water CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Class C Surface Water Values

2 – Mean concentration values have been rounded.
NA = not applicable as no criterion is available. NC = No criterion.

Benzene, naphthalene, toluene and xylenes were detected at concentrations above NYSDEC Class C surface water standards and guidance values. Other VOCs were detected but did not exceed the guidance values. The highest total BTEX concentration was from location 101-03, with the majority of locations having a total BTEX concentration less than 2 µg/L. Benzene NYSDEC Class C surface water exceedances and total BTEX in seep surface water are presented on **Figures 146 and 147** and were typically highest in seeps along the lakeshore**.** Shallow groundwater is the most likely sources of the VOCs in the seep surface water.

Six SVOCs were detected above the NYSDEC Class C surface water standards and guidance values and consisted mostly of PAHs and phenols. Total PAH and total phenol concentrations were highest at location 101-03. Naphthalene exceedances and total PAH concentrations are presented on **Figure 148 and 149,** and concentrations of total phenols in seep surface water are presented on **Figure 150.** As with VOC CPOIs, the highest concentrations were detected along the lakeshore. Potential sources of the SVOCs in the seep surface water include shallow groundwater and seep location surface soils.

Other detected CPOIs include heptachlor epoxide and inorganics. Heptachlor epoxide was detected at one location above guidance values and is presented in **Table 4.14**. Aluminum, cyanide, and iron are the only inorganic parameters exceeding the NYSDEC Class C surface water standards and guidance values and are presented in **Figures 151, 152, and 153**, respectively. The source of the pesticides is unknown. Potential sources of the inorganics in the seep surface water include shallow groundwater and seep location surface soils.

4.6.2. Seep Surface Soils

A total of 37 seep surface soil samples were collected on the Site, of which 30 were from the PSA, five from the Chromium Speciation Investigation, and two by the NYSDEC in 2003. Summary statistics are provided on **Table 191** for seep surface soil constituents detected at the Site. Detected CPOIs are presented below in **Table 4.15**.

Table 4.15 Detected Seep Surface Soil CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Part 375.6 Unrestricted Use Soil Cleanup Objectives
Volatile Organic Compounds (µg/kg)						
Acetone	32	21	105	240	17	50
Xylenes, total	32	9	6,263	50,000	3	260
Ethylbenzene	32	8	255	1,800	1	1,000
Benzene	32	5	287	1,400	1	60
Chlorobenzene	32	1	1,500	1,500	1	1,100
2-Butanone	32	18	10	19	0	120
Toluene	32	8	23.5	79.0	0	700

Table 4.15 Detected Seep Surface Soil CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Part 375.6 Unrestricted Use Soil Cleanup Objectives
Naphthalene	2	2	280	520	0	12,000
2-Hexanone	32	16	6	13	NA	NC
Styrene	32	7	17	70	NA	NC
Semivolatile Organic Compounds (µg/kg)						
Naphthalene	32	13	35,419	360,000	4	12,000
Chrysene	32	9	398	1,500	1	1,000
Benzo(A)anthracene	32	7	390	1,300	1	1,000
Benzo(A)pyrene	32	7	403	1,300	1	1,000
Benzo(B)fluoranthene	32	7	453	1,500	1	1,000
Benzo(K)fluoranthene	32	7	371	1,100	1	800
Indeno(1,2,3-CD)pyrene	32	6	219	550	1	500
Phenanthrene	32	25	644	5,300	0	100,000
Fluoranthene	32	12	551	2,500	0	100,000
Pyrene	32	11	560	2,600	0	100,000
Dibenzofuran	32	8	839	3,600	0	7,000
Benzo(G,H,I)perylene	32	6	223	520	0	100,000
2-Methylnaphthalene	32	12	5,740	35,000	NA	NC
Bis(2-ethylhexyl)phthalate	32	6	147	230	NA	NC
Pesticides (µg/kg)						
4,4'-DDT	32	11	6.24	19.0	7	3.3
Delta-bhc	32	1	0.5	0.5	2	40
Inorganics (mg/kg)						
Calcium	32	32	317,509	420,000	32	100(a)
Magnesium	32	32	19,158	58,000	32	600(a)
Sodium	32	32	1,353	3,600	19	750(a)
Aluminum	32	32	5,192	13,000	14	4,800(c)

Table 4.15 Detected Seep Surface Soil CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	NYSDEC Part 375.6 Unrestricted Use Soil Cleanup Objectives
Thallium	32	12	0.94	1.4	12	0.1(a)
Mercury	32	32	0.14	0.65	6	0.18
Potassium	32	14	664	1,800	6	400(a)
Lead	32	32	22.6	100	5	63
Chromium	37	37	21.4	320	3	30
Arsenic	32	32	6.84	21	3	13
Antimony	32	12	0.46	0.95	2	0.6(a)
Nickel	32	32	13.2	130	1	30
Barium	32	32	44.7	170	0	350
Beryllium	32	32	0.34	0.69	0	7.2
Copper	32	32	10.8	27	0	50
Manganese	32	32	245	630	0	1,600
Zinc	32	32	27.1	88	0	109
Cyanide	32	26	6.42	25	0	27
Selenium	32	13	0.89	2	0	3.9
Cadmium	32	8	0.14	0.23	0	2.5
Iron	32	32	6,765	22,000	NA	NC
Vanadium	32	32	10.4	27	NA	NC
Cobalt	32	13	5.28	36	NA	NC

Notes:
1 – Exceeds NYSDEC (2006) Part 375.6 Table 6.8(a) Unrestricted Soil Cleanup Objectives.
2 – Mean concentration values have been rounded.
NA = not applicable as no criterion is available. NC = No criterion.

(a) - Background values established by McGovern, 1988.; (c) Typical concentrations in Solvay Waste, Calocerinos & Spina, 1980.

Acetone, benzene, xylenes, ethylbenzene, and chlorobenzene were detected at concentrations above the soil criteria. Other VOCs were detected but did not exceed the criteria. The highest total BTEX concentration was from location SP-30. Benzene exceedances and total BTEX concentrations are presented in **Figures 154 and 155,** respectively**.** Potential sources of VOCs in the seep surface soils include shallow groundwater and material deposited with Solvay waste during operation of the wastebeds.

SVOCs detected above the soil criteria consisted of naphthalene and PAHs (**Table 4.15**). The maximum total PAH concentration was from SP-30 at 0.5 to 1 ft bgs. Naphthalene exceedances and total PAH concentrations are presented in **Figures 156 and 157,** respectively, and concentrations were elevated in sampling locations throughout the Site. The lakeshore and Ditch A samples had the highest concentrations of naphthalene and total PAHs. Phenol was detected in seep sediments at one location (SP-24) and is presented in **Figure 158.** Potential sources of SVOCs in the seep sediment include shallow groundwater and material deposited with Solvay waste during operation of the wastebeds.

4,4'-DDT and dieldrin were detected in concentrations above the soil criteria and are presented in **Table 4.15**. Aroclors 1260 and 1254 were detected but did not exceed the Part 375.6 Table 6.8(a) Unrestricted Use Soil Cleanup Objectives. The source or sources of the pesticides and PCBs are unknown.

Aluminum, arsenic, chromium, lead, mercury and nickel Part 375.6 Table 6.8(a) Unrestricted Use Soil Cleanup Objectives exceedances are presented in **Figures 159 through 164,** respectively. The inorganics in seep surface soils may be related to shallow groundwater and materials co-mingled with Solvay waste during operation of the wastebeds.

4.7. VAPOR INTRUSION

Soil vapor samples were collected from the shallow subsurface soil during the RI. Ambient air samples were also collected as part of this effort at the Site. A sample analytical summary is presented on **Table 30** and the sample locations are presented on **Figure 4H**. The analytical data for the soil vapor and ambient air samples are included in **Table 192**, and summary statistics are presented in **Table 193** for constituents detected at the Site. The detected CPOIs are presented below in **Table 4.16**.

Table 4.16 Detected Soil Vapor and Ambient Air CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	OSWER Target Shallow Soil Gas Guidance Values (10^{-6} RF)
Volatile Organic Compounds (µg/m³)						
Soil Vapor						
Benzene	10	10	6.70	17.0	5	3.1
Trichloroethene	10	2	490	980	2	0.22
m&p-Xylene	10	10	6.7	18	0	7,000
Toluene	10	10	110	930	0	4,000
1,2,4-Trimethylbenzene	10	9	1.92	4.8	0	60
Methylene chloride	10	7	0.65	0.78	0	52
Acetone	10	6	38.0	140	0	3,500
Carbon disulfide	10	6	9.62	14.0	0	7,000
Ethylbenzene	10	6	4.75	8.80	0	22
o-Xylene	10	6	3.97	7.50	0	70,000

Table 4.16 Detected Soil Vapor and Ambient Air CPOIs

Parameter	No. of Samples	No. of Detects	Mean Detected Conc.[2]	Maximum Detected Conc.	No. of Exceedances[1]	OSWER Target Shallow Soil Gas Guidance Values (10^{-6} RF)
1,3,5-Trimethylbenzene	10	5	1.30	3.10	0	60
Chloroform	10	3	0.79	0.94	0	1.1
Naphthalene	10	3	3.43	6.20	0	30
Carbon tetrachloride	10	2	0.67	0.70	0	1.6
Chloromethane	10	2	1.23	1.60	0	24
Ambient Air						
Trichloroethene	6	2	1.34	1.86	2	0.22
Benzene	6	6	0.85	1.04	0	3.1
Methylene chloride	6	6	0.57	0.78	0	52
Toluene	6	6	1.12	1.57	0	4,000
m&p-Xylene	6	4	0.89	1.5	0	70,000
Chloromethane	6	3	0.71	0.82	0	24
1,2,4-Trimethylbenzene	6	2	0.88	1.20	0	60
Acetone	6	2	19.0	19.8	0	3,500
cis-1,2-Dichloroethene	6	2	1.35	2.22	0	350

Notes:
1 – Exceeds OSWER Target Shallow Soil Gas Guidance Values (10^{-6} RF).
2 – Mean concentration values have been rounded.

Several analytes were detected in the shallow soil vapor and the ambient air samples, with soil vapor samples collected between 0 ft and 8 ft bgs and ambient air samples from approximately 4 ft above ground surface. Among the most frequently detected analytes were gasoline type components (toluene, trimethylbenzene, ethylbenzene, xylene, and benzene). Also detected were methylene chloride (solvent), acetone (solvent), carbon disulfide (biodegradation product), naphthalene, trichloroethene (solvent), chloroform (refrigerant), carbon tetrachloride (solvent), 1,1,1-trichloroethane (solvent), and chloromethane (chemical intermediate).

Benzene and trichloroethene in soil vapor samples were detected in exceedance of OSWER Target Shallow Soil Gas Guidance Values (10^{-6} RF). The highest concentrations of benzene and trichloroethene were detected at VI-10 and VI-02. Trichloroethene was the only exceedance in ambient in samples with exceedances at AA-04 and AA-06.

The analytes detected in soil vapor were consistent with those detected in shallow groundwater and Site soils, with the exception of trichloroethene. Because of the constituents present in soil vapor, and their presence in shallow groundwater and subsurface soils suggest that consideration of vapor intrusion mitigative actions will likely be required if future construction takes place on the Site. In particular, the presence of trichloroethene and benzene at concentrations above the guidance values indicate that future building construction may need to address potential vapor intrusion.

4.8. STAINED MATERIALS

Stained materials and Solvay waste were identified in three subsurface locations on-site. The first is a 3 to 17-ft thick layer of stained Solvay waste at the base of Wastebeds 1 through 4. The two other areas are located on the lakeshore near test pit locations TP-03 and TP-10 and possibly TP-05 in the area of TP-03. All three areas contain elevated concentrations of organic CPOIs.

4.8.1. Wastebeds 1 through 4 Stained Material

Soil borings advanced in Wastebeds 1 through 4 encountered a layer of stained Solvay waste directly above the native materials. **Figure 165** presents the approximate extent of this area. Solvay Waste at Wastebeds 1 through 4 is typically white to medium gray with a matrix ranging from paste-like to cemented. Stained materials were observed in the deeper portions of these wastebeds. Stained materials were typically encountered in a defined layer of orange-brown to dark brown colored Solvay waste below the white to medium gray unstained Solvay waste. Odors associated with this staining were variable in description, but typically described in the boring logs and field observations as moderate to heavy odor, chemical odor, or “mothball-like” odor. This layer ranges in thickness from 3 to 17 ft, with PID readings up to 2,658 ppm. This staining was observed between SB-32 to the southeast in Wastebed 1 and SB-49 and MW-23I/SB-51 in the southwestern portion of Wastebed 4 and to SB-31NM to the northwest in Wastebed 4. The stained subsurface layer had elevated VOC and SVOC CPOI concentrations compared to the unstained areas of the Site.

VOC and SVOC CPOIs were detected at elevated concentrations within the extent of this stained layer for subsurface soil samples (**Figures 51 through 60**). Stained layer sample concentrations ranged between 34,720 µg/kg (MW-16D) and 1,100,400 µg/kg (SB-36) for total BTEX. Naphthalene and total PAHs were detected at concentrations ranging from 650 µg/kg (SB-51) to 1,700,000 µg/kg (SB-34) and 1,140 µg/kg (SB-51) to 1,854,000 µg/kg (SB-34) in the stained layer, respectively. Total phenol concentrations in this area were similar to concentrations detected throughout the other areas of the Site.

Groundwater CPOIs from monitoring wells within the estimated area of the stained layer had elevated concentrations with respect to applicable standards and guidance of total BTEX, naphthalene and other PAHs, and phenols. The Site CPOIs had higher concentrations in intermediate and deep groundwater wells screened in the boundaries of the stained materials layer than wells sampled outside the boundaries stained materials layer (**Figures 88 to 92 and Figures 114 to 118**, respectively) with the exception of phenols. Phenols had similar concentrations in intermediate and deep groundwater samples from monitoring wells inside and outside the approximate extent of the stained layer.

The source of this stained layer and elevated VOC and SVOC CPOI concentrations is potentially the co-disposal of materials with the Solvay waste slurry from former Main Plant operations including the former Benzol Plant and the former coke ovens. The presence of phenols is potentially related to co-disposal of material from the former Phenol Plant with the Solvay waste slurry. However, it is uncertain whether co-disposed materials from either plant were co-mingled with Solvay waste during transport and deposition on site, or if they were disposed of by separate means during operation of the Wastebeds. Phenol may also be related to the breakdown of BTEX compounds.

4.8.2. Lakeshore Stained Materials

Stained materials were encountered in soil borings and test pits advanced along the lakeshore during the PSA, FRI, and RI and SRI. There are two distinct areas of stained materials, with one in the vicinity of location TP-03 and TP-05 and the second in the vicinity of TP-10. **Figure 166** presents the approximate extent of these two areas along the lakeshore. The eastern lakeshore has variable deposits including Solvay waste, peat, marl, silt, sand and beach deposits. Stained soils have been observed in the shallow native soils at the Eastern Lakeshore. The stained soils are typically encountered sporadically within the shallow marl deposit and were dark brown to black in coloration. Complicating the delineation of stained soils along the Eastern Lakeshore are the peat deposit and black Solvay waste. Peat typically is a dark brown to black color and readily stains nearby media.

PID measurements and olfactory observations (variable odors typically described in boring logs and field observations as slight to heavy odor) were used in support of the visual observations of stained soil. The presence of stained soil was typically confirmed with analytical results.

Potential source(s) of these stained materials are co-disposal of materials with the Solvay waste slurry and mixed Solvay waste and materials that potentially spilled over the wastebed berms during operation. It is uncertain whether co-disposed materials were co-mingled with Solvay waste during transport and deposition on site, or if they were disposed of by separate means (i.e., direct disposal) during operation of the Wastebeds.

As part of the Integrated IRM, a combination of clean fill, constructed mitigation wetlands, seep aprons will be used to cover stained material identified during the RI. In addition to placement of cover material, shallow and intermediate groundwater impacted by the stained material is being collected and pumped to the Willis Avenue Groundwater Treatment Plant for treatment.

Northwestern Area

The northwestern area stained materials were observed on the eastern side of Lakeview Point. This area was first observed at TP-10 along the lakeshore and is described as black stained Solvay waste extending between approximately 5 ft bgs to the top of marl. SB-11, SB-10, and SB-41 surface and shallow subsurface samples indicate some staining and sheen. Poor recovery from the Solvay waste and marl interface in the soil borings limits the confirmation of staining in these and deeper soils. Staining was also observed in a small pocket to the west of TP-10 as observed in SB-164A. It should be noted that staining was not observed at location SB-163/MW-27G in the near vicinity of SB-164A. PID readings for these borings also confirm the presence of organic constituents in the material, with readings up to 222 ppm. Evidence of staining was not present in SB-42, TP-09, and SB-163/MW-27G which were used to approximate the extent of stained materials. The distribution of stained materials in pockets at the northwestern area indicates heterogeneity of materials in this area.

VOC and SVOC CPOIs in this area include BTEX, naphthalene and total PAHs, and phenols, and were detected at concentrations greater than applicable standards and guidance. **Figures 51, 52, 55, 57, and 59** present benzene exceedances, total BTEX concentrations, naphthalene exceedances, total PAH concentrations, and total phenol concentrations, respectively, for soil samples between 2 to 10 ft bgs. Elevated concentrations with respect to applicable standards and guidance were detected from samples within and immediately adjacent to the stained material. Shallow groundwater (MW-03S) also has elevated concentrations with respect to applicable standards and guidance of these CPOIs (**Figures 88 though 92**).

TCLP analyses were performed on the sample collected from TP-10 (**Tables 79 through 84)**. Benzene and 3&4-methylphenol were the only organics detected, and neither detection exceeded the regulatory limits for characteristic wastes established under 40CFR 261.3. The detections indicate that some leaching is occurring from stained material in this area, but are regulatory acceptable limits. The Integrated IRM collection system addresses groundwater potentially impacted by leaching from the lakeshore area stained materials.

The northwestern area stained materials may be a source of the VOC and SVOC CPOIs detected in the subsurface soils and shallow groundwater in and near this area. The lakeshore area is downgradient of the Wastebeds 1 through 4 stained material layer and typically has elevated concentrations in intermediate and deep groundwater. One TCLP sample was analyzed for VOCs from this stained Solvay waste layer at MW-07D **(tables 79 through 84).** Benzene was detected in the MW-07D sample at levels below the regulatory limits for characteristic wastes established under 40CFR 261.3. A second TCLP sample was collected from this layer at location MW-06D, and was analyzed for metals and reactivity. The Wastebeds 1 through 4 stained material layer may be the source of these CPOIs in the deeper groundwater. This is discussed in greater detail in Section 6.2.3 for BTEX parameters.

Southeastern Area

Stained materials in the southeastern area are located near Ditch A and approximately between SB-03 and SB-02. These materials were first observed at TP-03 and are described as black stained Solvay waste extending between approximately 5 ft bgs to the top of marl. SB-02, GWS-02, and MW-19BR2 contained some staining and sheen in surface and shallow subsurface samples. Stained materials were also observed in a pocket around SB-174 from 6 to 8 ft bgs during the SRI, and may have been observed at 6-6.5 ft bgs in TP-05 during the PSA. Poor recovery from the Solvay waste and marl interface in the soil borings limits the confirmation of staining in deeper material. PID readings for these borings indicate that organics are present in the material, with readings up to 300 ppm. Evidence of staining was not present in SB-03, SB-04, and SB-05, and TP-01, which were used to approximate the extent of stained materials for this area. The distribution of stained materials in several pockets at the southeastern area indicates heterogeneity of materials in this area.

VOC and SVOC CPOIs for this area include BTEX, naphthalene and total PAHs, and phenols and were detected at elevated concentrations with respect to applicable standards and guidance. **Figures 51, 52, 55, 57, and 59** present the exceedances for benzene, total BTEX concentrations, naphthalene exceedances, total PAH concentrations, and total phenol concentrations, respectively, for soil samples between 2 to 10 ft bgs. Elevated concentrations with respect to applicable standards and guidance were detected from samples within and immediately adjacent to the stained materials. MW-01S and MW-09S were situated near the stained materials and also had elevated groundwater concentrations of these CPOIs (**Figures 88 though 92**) compared to other areas of the Site.

TCLP analyses were performed on the samples collected from TP-03 and TP-05(**Tables 79 through 84)**. Benzene was the only organics detected, and was detected in both samples. Neither detection exceeded the regulatory limits for characteristic wastes established under 40CFR 261.3. The detections indicate that some leaching is occurring from stained material in this area, but are within acceptable regulatory limits. The Integrated IRM addresses groundwater potentially impacted by leaching from the lakeshore area stained materials.

The southeastern area stained material may be a source of the VOC and SVOC CPOIs detected in the subsurface materials, and shallow and shallow and intermediate groundwater in and near this area. The lakeshore area is downgradient of the Wastebeds 1 through 4 stained materials layer and typically has elevated concentrations with respect to applicable standards and guidance in intermediate and deep groundwater.

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

This section presents a comparison of analytical results to potentially applicable standards and/or guidance values. The following media were screened.

- Surface soils (sample end depth ≤ 2 ft)
- Subsurface soils (sample end depth > 2 ft)
- Shallow groundwater
- Intermediate groundwater
- Deep groundwater
- Bedrock groundwater
- Surface water
- Sediment
- Seep surface water
- Seep Surface Soil
- Soil vapor and ambient air

5.1. COMPARISON OF SOIL CONCENTRATIONS TO SCREENING CRITERIA

Soil analytical results for the Site were compared to Remedial Program Soil Cleanup Objectives (SCOs) from 6 NYCRR Part 375.6 (Table 375-6.8(a): Unrestricted Use Soil Cleanup Objectives.

NYSDEC criteria are promulgated standards taken directly from the SCOs located in NYCRR Part 375-6 except for inorganic constituents for which the cleanup objective was listed as SB (site background). In absence of Site-specific background data, the lowest of two available background values obtained from *Soil Chemistry of Hazardous Materials* (Dragun, 1988), and *Background of 20 Elements in Soils with Special Regard for NYS* (McGovern, 1988) were used. The lowest available background values were selected to meet the RI's goal of using conservative guidance values to develop a list of preliminary CPOIs. In addition to the two background documents, typical concentrations in Solvay waste derived during Proceedings of the Conference on Geotechnical Practice for Disposal of Solid Waste Materials (Calocerinos and Spina, 1980) were also used to supplement site specific criteria values.. Values from all three sources are listed in **Table 194**.

The guidance values are included in the analytical results tables for surface soils (**Tables 40 through 52, Tables 54 through 60, and Tables 62 through 65**) and subsurface soils (**Tables 67 through 78 and Tables 85 through 101**). Summary statistics for constituents with a detected concentration in at least one surface soil sample are presented on **Tables 53, 61, and 66** for the Parking Lot Area, Upland Area, and Lakeshore Area, respectively. Summary statistics for constituents with a detected concentration in at least one subsurface soil sample are presented on **Table 102**.

Summary statistics for constituents with elevated detection limits exceeding a screening value in at least one sample are presented on **Tables 195, 196, and 197** for surface soils. These tables are for the Parking Lot Area, Upland Area, and Lakeshore Area, respectively. Constituents with non-detect concentrations (reported as the detection limit) and elevated detection limits are presented on **Table 198** for subsurface soils.

Soil samples collected for TCLP analysis during the PSA, FRI, and RI are compared with RCRA guidance values provided in 40 CFR Part 261. The guidance values are included on analytic results **Tables 79 through 84**.

5.2. COMPARISON OF GROUNDWATER CONCENTRATIONS TO STANDARDS AND GUIDANCE VALUES IN 6 NYCRR PART 703 AND NYSDEC TOGS 1.1.1. AMBIENT WATER QUALITY STANDARDS AND GUIDANCE VALUES

Shallow, intermediate, deep, and bedrock groundwater results were compared to Class GA standards and guidance values obtained from *6NYCRR Part 703* and *NYSDEC TOGS 1.1.1 Ambient Water Quality Standards and Guidance Values* (NYSDEC, 1998b). The principal organic contaminant (POC) criteria were used for compounds meeting the POC description found in TOGS 1.1.1 and when a specific standard was not available. Guidance values, if available, were used for constituents for which standards have not been assigned. The standards or guidance values are included in the groundwater analytical results tables (**Tables 109 through 114, Tables 121 through 126, and Tables 131 through 141**). Summary statistics for constituents with a detected concentration in at least one groundwater sample are presented in **Tables 142, 143, 144, 145, and 146** for shallow, intermediate groundwater within and outside stained materials, intermediate groundwater within the Ninemile Creek deltaic deposits, deep, and bedrock groundwater, respectively. Summary statistics for constituents with non-detect concentrations (reported as the detection limit) and elevated detection limits are presented in **Tables 199, 200, 201, 202, and 203** for shallow, intermediate groundwater within and outside stained materials, intermediate groundwater within the Ninemile Creek deltaic deposits, deep, and bedrock groundwater, respectively.

5.3. COMPARISON OF SURFACE WATER CONCENTRATIONS TO STANDARDS AND GUIDANCE VALUES IN 6 NYCRR PART 703 AND NYSDEC TOGS 1.1.1. AMBIENT WATER QUALITY STANDARDS AND GUIDANCE VALUES

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 comparison. Guidance values, if available, were used for constituents for which standards have not been assigned. The standards are included in the surface water analytical results tables (**Tables 147 through 160**). Summary statistics for constituents with a detected concentration in at least one surface water sample are listed in **Tables 161 and 162** for the former Ponded Area and Ditch A, respectively. Summary statistics for constituents with non-detect concentrations (reported as the detection limit) and elevated detection limits are presented on **Tables 204 and 205** for the former Ponded Area and Ditch A, respectively.

5.4. COMPARISON OF SEDIMENT CONCENTRATIONS TO GUIDANCE VALUES FROM TECHNICAL GUIDANCE FOR SCREENING CONTAMINATED SEDIMENTS

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 1.95% was used to calculate criteria for organic compounds and was derived from the mean value observed for all Site sediment samples.

The analytical results were compared to the human health bioaccumulation and benthic chronic screening values to account for a wide range of potential receptors. The guidance values are included in the sediment analytical results tables (**Tables 163 through 174**). Summary statistics for constituents with a detected concentration for at least one sediment sample are listed in **Tables 175 and 176** for the former Ponded Area and Ditch A, respectively. Summary statistics for constituents with non-detect concentrations (reported as the detection limit) and elevated detection limits are presented on **Tables 206 and 207** for the former Ponded Area and Ditch A, respectively.

5.5. COMPARISON OF SEEP WATER AND SEEP SURFACE SOIL CONCENTRATIONS TO STANDARDS AND GUIDANCE VALUES

5.5.1. Seep Water

Analytical 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 comparison. Guidance values, if available, were used for constituents for which standards have not been assigned. The standards or guidance values are included in the seep surface water analytical results tables (**Tables 177 through 183**). Summary statistics for constituents with a detected concentration in at least one sample are listed in **Table 190**. Summary statistics for constituents with non-detect concentrations (reported as the detection limit) and elevated detection limits are presented on **Table 208**.

5.5.2. Seep Surface Soils

Analytical results were compared to screening values obtained from 6 NYCRR Part 375.6 (Table 375-6.8(a): Unrestricted Use Soil Cleanup Objectives. The screening values are included in the seep surface soil analytical results tables (**Tables 184 through 189**). Summary statistics for constituents with a detected concentration in at least one sample are listed in **Table 191.** Summary statistics for constituents with non-detect concentrations (reported as the detection limit) and elevated detection limits are presented on **Table 209**.

5.6. COMPARISON OF SOIL VAPOR AND AMBIENT AIR DATA TO OSWER DRAFT SCREENING GUIDANCE

Soil vapor analytical results for the Site were compared to *OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)* (USEPA, 2002). Soil vapor and ambient air samples were compared to OSWER $1x10^{-6}$ Generic Screening Levels (Target Shallow Soil Gas Concentration to Target Indoor Air Concentration Where the Soil Gas to Air Attenuation Factor = 0.1). The screening values are included with the analytical results for the soil vapor and ambient air samples on **Table 192**. Summary statistics for constituents with a detected concentration in at least one sample are presented on **Table 193**. Summary statistics for constituents with non-detect concentrations (reported as the detection limit) and elevated detection limits are presented on **Table 210**.

6. CONSTITUENTS FATE, PERSISTENCE, AND TRANSPORT

The nature and extent of constituents in various media was described in Section 4.

The most frequently detected constituents in soils, groundwater, and sediment at the Wastebeds 1 through 8 Site are BTEX, naphthalene and assorted PAHs, phenolic compounds, and certain inorganic constituents. Possible migration mechanisms for these compounds are discussed for each of these primary constituents and the relationship of respective potential sources and fate.

The following potential transport mechanisms were evaluated based on data generated during completion of the Site investigations (PSA, FRI, RI, Chromium Speciation Investigation, SRI, and previous investigations) and the physical characteristics of the Site.

- Transport of constituents from soils to surface water bodies via surface water runoff
- Groundwater transport of constituents to adjacent surface water bodies and downward migration into the Lower Groundwater System
- Vapor migration of volatile constituents
- Wind-borne particulate migration of constituents

6.1. TRANSPORT OF CONSTITUENTS FROM SOILS TO SURFACE WATER BODIES VIA SURFACE WATER RUNOFF

Transport of constituents from soils to surface water bodies via surface water runoff may have occurred from areas in close proximity to Onondaga Lake, Ninemile Creek, and the drainage ditches. Surface water drainage is presented on **Figure 11**. Transport potentially occurred in areas where surface water bodies and Site ditches are adjacent to sloped to steeply sloped berms with poor vegetative cover, which allowed for runoff down slope to the adjacent Ninemile Creek, Onondaga Lake, and Ditches A and E. Berms with established vegetation, benched construction, or both potentially reduced this soil erosion and limited the transport of soils to surface water. Ninemile Creek potentially received a limited contribution of soils from high relief and sparsely vegetated areas adjacent to the Ponded Area and Ditch E, which may have also received surface runoff from the adjacent parking lots I-690/695 ramps, and I-690. Onondaga Lake potentially received soil via runoff from the sparsely vegetated portions of the berms along Wastebeds 3, 4, and 6, with some transport also potentially occurred along the northern berms of Wastebeds 1 and 2. This surface runoff has been addressed by the Wastebeds 1 through 8 Integrated IRM, Mitigation Wetlands, and Remediation Area A Hydraulic Control System (Section 1.5.10) and is not considered a current transport pathway.

Minimal surface water runoff is expected from the central areas of the Site and areas of flat relief along the wastebed berms due to vegetation and little topographic relief, which reduces runoff and promotes evapotranspiration. Also, the porous fill material associated with the parking lots limits the scouring of soils and promotes infiltration rather than overland flow.

6.2. GROUNDWATER TRANSPORT OF CONSTITUENTS

The fate, persistence, and transport of constituents by groundwater are largely controlled by the geology and the hydrogeology of the Site and Ninemile Creek Valley discussed in Section 3. The Site hydrogeology is largely the result of the physical characteristics of the geology and the location of the Site within the Ninemile Creek Valley. Also, the properties of the organic chemicals, such as solubility and sorption coefficients, control the retention of constituents in soils.

6.2.1. Transport of Organic Constituents in the Upper Groundwater System

As discussed in Section 3, groundwater migrates from the topographic high of the mounded wastebed in the central portion of the Site. This section discusses possible groundwater transport pathways. The surface water bodies impacted by shallow groundwater are Ninemile Creek, Onondaga Lake, and the Site drainage ditches.

Organic constituents associated with the shallow groundwater are transported to Ninemile Creek, Onondaga Lake, drainage ditches, and the native materials (marl/peat) comprising the Intermediate Hydrogeologic Unit.

The shallow groundwater flows to the Site ditches as groundwater migrates radially outward and downgradient from the upper berm tiers. Limited organic constituents were detected in groundwater from wells adjacent to the drainage ditches. However, surface water runoff from parking lots and roadways may add surface soils in these drainage ditches.

A portion of shallow groundwater in the wastebeds also migrates vertically through the bottom of the wastebeds into native materials. BTEX were likely deposited with the Solvay process slurry, as discussed in Section 1. Organic constituents found in the intermediate groundwater under the central and western portions of the Site potentially originate from BTEX associated with the stained material. These constituents migrate toward Onondaga Lake in certain areas through the higher conductivity lenses of marl and sandy strata in the intermediate hydrogeologic zone.

Groundwater migration towards Onondaga Lake is likely similar to other portions of the wastebeds. The groundwater in the fill materials and upper marl zone along the lakeshore has variable concentrations of organic constituents. The higher concentrations of organic constituents detected in intermediate wells along the lakeshore area of Wastebeds 1 through 4 may be driven by constituents transported from the stained material at the base of the wastebeds. Constituents in wells MW-01S and MW-03S may also be the result of the stained material on the lakeshore. As discussed in Section 4, shallow groundwater from Wastebeds 5 and 6 typically has lower concentrations of organic constituents than shallow groundwater from Wastebeds 1 through 4. This appears to be the result of the absence of stained material in Wastebed 5 and 6.

Site CPOIs in groundwater from the Upper System potentially migrated through the gap in the silt and clay layer to the Lower Groundwater System, and the soluble organic constituents associated with the stained layer at the base of Wastebeds 1 through 4 potentially migrated with groundwater through the silt and clay layer gap, and are currently detected in deep and bedrock wells on-site and in Onondaga Lake.

6.2.2. Transport of Organic Compounds in the Lower Groundwater System

A confining silt and clay unit underlies the Upper Groundwater System under the majority of the Site (**Figure 18**). However, the lack of the confining silt and clay unit under a portion of Wastebeds 1 through 4 provides a potential pathway for groundwater in the Upper System to migrate down to the Lower Groundwater System. Historically, the Lower Groundwater System consisted of Native Halite Brine that would not have allowed leachate impacted groundwater to migrate downwards because of density differences. However, due to 138 years (1788-1926) of salt production around Onondaga Lake (Thompson, 2002) the subsurface hydrogeologic and geochemical conditions may have been changed. The long-term production of salt may have reduced the size of the brine pool allowing less dense water to migrate vertically downward explaining how leachate impacted groundwater and site related CPOIs have been observed in the Lower Groundwater System on the Site.

The organic constituents from the base of Wastebeds 1 through 4 were potentially transported into the Lower Groundwater System at the time of wastebed operation as discussed above. The extent of the leachate influence in the Lower Groundwater System is unclear. Leachate signatures and benzene concentrations are reported at depth in OL-STA-30033 offshore of the Site. To the east, lakeshore monitoring wells north of the Semet Ponds Site (OW-11D) and the Willis Avenue Site (WA-1D and WA-2D) also contain groundwater with a leachate signature and detectable benzene concentrations.

Some bedrock wells located on-site also contain groundwater with a leachate or leachate/halite brine mix signature and organic constituents, as discussed in Section 3.4. Organic constituents migrated in the bedrock to the northeast, north, and south. The mechanism for this migration is unknown.

6.2.3. BTEX Partitioning, Sorption, and Degradation

The chemical properties of BTEX can play an integral part in determining the component proportions detected in groundwater as they are transported from the site of origin. These properties that may influence BTEX migration and partitioning include solubility, soil-water partition coefficients, and anaerobic biodegradation.

The solubility of BTEX differs significantly, with values of 1,780 mg/L, 535 mg/L, 167 mg/L, and 152 mg/L for benzene, toluene, xylene isomers, and ethylbenzene, respectively. As a result, groundwater initially migrating through soil with the BTEX present at equal concentrations will leach higher concentrations of benzene than the other BTEX compounds. Additionally, because of these solubility differences, the source area would be expected to become depleted of benzene more rapidly than the other compounds, and the relative concentration of benzene to the other components in the groundwater will decline with time.

The soil-water partition coefficient (K_{ow}) determines the magnitude of adsorption of BTEX to particulate organic matter attached to soil particles. Higher K_{ow} values indicate a higher rate of adsorption to soil particles and a slower effective rate of migration of the parameter solubilized in groundwater. K_{ow} is defined as the product of the organic carbon partition coefficient (K_{oc}) and the fraction of organic matter in the subsurface. The K_{oc} values are 92 L/Kg, 242 L/kg, 292 L/kg and 622 Kg/L, for benzene, toluene, xylenes, and ethylbenzene, respectively. Benzene has the lowest K_{oc} value, and the relative rate of migration in groundwater is faster than the other BTEX components. As a result, benzene is the BTEX component that is typically found at the leading edge of a leachate plume.

The anaerobic biodegradation of benzene is a microbially mediated process in the presence of sulfide and has been established as a viable pathway in both laboratory and field studies (Coates *et al*., 2001). The biodegradation process may play a role in the transport and fate of BTEX at the Site; however, the previous Site microcosm study conducted by Bioremediation Consulting, Inc. established that biodegradation was not effective for conditions on the Wastebeds 1 through 8 Site (O'Brien & Gere, 2010a).

Figures 167, 168, 169, 170, and 171 present plan views of BTEX distribution in the shallow, intermediate, Ninemile Creek deltaic deposits, deep, and bedrock hydrogeologic unit wells, respectively. The pie charts show representative proportions of BTEX detected in groundwater. The size of each pie presents the normalized *(i.e.,* natural log of total) concentrations of BTEX. The concentrations were normalized for visual presentation and space preservation of the figures. Benzene and total benzene concentrations are presented on the figures under the location IDs. The color of the location IDs also presents the inorganic water type as described in Section 3.4, in order to visually present the distribution of BTEX compounds in conjunction with the inorganic water type distribution.

Figure 167 presents the pie chart representations for BTEX in the shallow hydrogeologic unit. MW-04S, MW-05S, MW-06S, MW-07S, MW-08S, MW-10S, MW-15S, MW-16S, MW-17S, MW-18S, MW-21 Sand MW-22S are on the upper portion of the Site. MW-07S and MW-22S have relatively high concentrations of BTEX. The remaining monitoring wells have either low or non-detectable concentrations of BTEX. Detectable BTEX compounds are found associated with chloride depleted leachate type water in the shallow groundwater unit.

Figure 168 presents the intermediate hydrogeologic unit pie chart representations for BTEX. Monitoring wells located within the intermediate zone have a variable distribution of BTEX components. Intermediate monitoring wells located within Wastebeds 5 and 6 tend to have lower concentrations of BTEX than intermediate wells located in Wastebed 1 though 4 and the Lakeshore Area. Detectable BTEX compounds are generally found associated with dilute leachate, leachate, or the native halite brine and leachate mix groundwater. Three monitoring wells, MW-01I, MW-02I and MW-03I have VOCs associated with native halite brine groundwater. Benzene is found associated with native halite brine type groundwater in MW-01I and MW-02I, and benzene and toluene is found with native halite brine type groundwater in MW-03I. These three wells are the only three wells screening the fine grained marl at the base of the Intermediate Hydrogeologic Unit.

Figure 169 presents the Ninemile Creek Deltaic Deposits pie chart of BTEX. Monitoring wells located with the deltaic deposits tend to have higher proportions of benzene than toluene, ethylbenzene, and xylene isomers. Detectable BTEX compounds are found associated with leachate or the native halite brine and leachate mix type groundwaters in the Ninemile Creek Deltaic Deposits Hydrogeologic Unit.

Figures 170 and 171 present the deep and bedrock groundwater pie chart representations of BTEX. Both figures present locations that have been primarily impacted by benzene. Monitoring wells located with Lower Groundwater System tend to have higher proportions of benzene than toluene, ethylbenzene, and xylene isomers with the exception of WB18-MW-03D, WB18-MW-06D, and WB18-MW-03BR. Detectable BTEX compounds are generally found associated with leachate, or the native halite brine and leachate mix groundwaters in both the Deep and Bedrock Hydrogeologic Units. Two bedrock monitoring wells, MW-03BR and MW-20BR have VOCs associated with native halite brine groundwater. Toluene, benzene and xylenes are found associated with native halite brine type groundwater in MW-03BR, and benzene is found with native halite brine type groundwater in MW-20BR.

As discussed earlier, benzene was potentially transported into the Lower Groundwater System through a gap in the silt and clay layer under Wastebeds 1 through 4. However, the wastebeds may not be the sole source for the benzene in the Lower Groundwater System based on the distribution of BTEX between the Upper Groundwater System and the Lower Groundwater System. A separate Deep Groundwater Investigation (O'Brien & Gere 2007, O'Brien & Gere 2010c) is being performed in order to evaluate potential sources of benzene to the deep and bedrock groundwater encountered regionally along the Lakeshore Area and beneath Onondaga Lake.

6.3. WIND-BORNE PARTICULATE MIGRATION OF CONSTITUENTS

Surface soils may be eroded via wind, and particulate-bound constituents could potentially be carried off-site. Wind-borne particulate migration is most prevalent for constituents that sorb strongly to particulate matter, such as metals. This transport mechanism is feasible for sparsely vegetated areas.

6.4. VAPOR MIGRATION OF VOLATILE CONSTITUENTS

Volatile constituents in Site soils and groundwater can vaporize, migrate through soil as soil vapor, and enter the atmosphere or the equipment buildings on-site. There are currently no occupied buildings on-site. Future use of the Site may include construction of buildings on the Site.

6.5. CONSTITUENT FATE AND PERSISTENCE

Analytical results obtained during the PSA, FRI, and RI suggest that certain constituents are being leached from the soil. Compounds detected in soils and groundwater at the greatest frequency included:

- BTEX (benzene, ethylbenzene, toluene, and xylenes)
- Phenolic compounds
- PAHs
- Dieldrin and DDT
- Inorganic constituents (arsenic, barium, chloride, lead, manganese, mercury, selenium, sodium, and sulfate)

Table 211 presents the relevant environmental fate data for the potentially Site-related compounds detected during the investigation. This table gives the water solubility, K_{oc}, K_{ow}, and aquatic degradation rates for these compounds, where K = coefficient, OC = organic carbon, and OW = octanol-water partition. The K_{oc} values for these compounds are rough estimates of their mobility in soil. **Table 6.1** presents the relationship between K_{oc} and mobility:

Table 6.1 Detected Soil Vapor and Ambient Air CPOIs

K_{oc}	Mobility Class (examples)
0 – 50	Very High (acetone, phenol)
50 – 150	High (benzene, TCE)

Table 6.1 Detected Soil Vapor and Ambient Air CPOIs

K_{OC}	Mobility Class (examples)
150 – 500	Medium (toluene, total xylenes, 2,4-dichlorophenol, 4,6-dinitrophenol)
500 - 2,000	Low (ethylbenzene, dieldrin, naphthalene)
2,000 - 5,000	Slight (Acenaphthene)
greater than 5,000	Immobile [benzo(a)anthracene, benzo(a)pyrene, DDT]

Note:
Source: (Swann, RL, *et al.*, 1985)

6.5.1. BTEX Fate and Persistence

Benzene, toluene, ethylbenzene, and xylenes were produced at the former benzol facility and coke plant, and benzene was used at the Willis Avenue Plant in the production of chlorinated benzenes. These compounds are also used in many other industrial processes including the manufacturing of other chemicals, some rubbers, paints, paint thinners, lubricants, pesticides, fuel oil, and cleaning solvents. A probable source of BTEX is historical deposition in conjunction with the Solvay waste slurry pumped to the wastebeds.

BTEX tend to partition to vapor and are lost through volatilization. Benzene has the highest affinity for the vapor phase of these four compounds. The other compounds tend to go the vapor phase but with less affinity. The BTEX in soils will also readily leach into groundwater, with benzene being the most mobile (ATSDR, 2006a).

Anaerobic microbial fermentation is known to biodegrade BTEX in certain instances. However, the previous Site microcosm study conducted by Bioremediation Consulting, Inc. established that biodegradation was not effective for conditions on the Wastebeds 1 through 8 Site (O'Brien & Gere, 2010a).

6.5.2. Phenols Fate and Persistence

Phenol is used in the production of bisphenol-A and the production of phenolic resins, as well as xylenols (ATSDR, 2006b). The probable source of phenols is deposition in conjunction with the Solvay waste slurry pumped to the wastebeds. Phenols may also be present as a breakdown product of benzene. Phenol was also produced for a brief period, 1942-1946, at the Main Plant Site.

Phenol has a high water solubility value and is relatively mobile in groundwater. The high solubility and low soil sorption coefficient indicates poor adsorption onto soil particles, and hence it would be expected to leach into groundwater (ATSDR, 2006b). However, increasing soil organic content leads to a higher sorption coefficient for phenol (ATSDR, 2006b).

Phenol in water and soil is degraded by abiotic reactions and microbial activity. Phenol degrades to a number of compounds, including carbon dioxide and methane. Phenol will degrade in both anaerobic and aerobic conditions, but is slower under anaerobic conditions (ATSDR, 2006b).

6.5.3. PAHs Fate and Persistence

PAHs (including naphthalene) are often associated with combustion processes, such as wood burning and exhaust from automobiles. The likely source of naphthalene is the co-disposal with the Solvay waste slurry. PAHs are ubiquitous in the environment and some of the other PAHs detected on site (in the vicinity of the parking lots and related roads) are potentially related the general use of the area as a NYS Fairgrounds parking area.

Generally, PAHs have low water solubilities and high affinity for organic carbon (ATSDR, 1995). This leads to a preference to sorb to soil and sediment particles in the environment and increases with organic carbon content.

Even though PAHs have low water solubilities, some percentage will dissolve in groundwater and can be transported via groundwater.

PAHs can be broken down aerobically and this can be significant in the degradation process of these constituents. These compounds tend to be persistent in the environment especially in anaerobic conditions. They do not readily evaporate in soil and groundwater.

Among PAHs, the heavier 4-, 5-, and 6-ring PAHs are more persistent in the environment, while the lighter 2- and 3-ring PAHs (*e.g.*, naphthalene) exhibit more mobility within soil and groundwater environments. Naphthalene easily volatilizes from aerated soils and can be moderately adsorbed with the extent dependent on the organic carbon content. This adsorption will only somewhat retard naphthalene's groundwater transport (ATSDR, 2005). Biodegradation of naphthalene in soil occurs primarily under aerobic conditions, while abiotic degradation seldom occurs in soils (ATSDR, 2005).

6.5.4. Dieldrin Fate and Persistence

Dieldrin is a pesticide and the source of the dieldrin at the Site is unknown; however, it was possibly used on adjacent sites or may have been deposited on-site within the Biosolids Area. Dieldrin has been identified as ubiquitous in the environment (ATSDR, 2002a).

Dieldrin has a low vapor pressure and strongly adsorbs to soil. This leads to minimal transport in groundwater and surface water. If present, it typically is bound to suspended solids. Additionally, this compound is persistent in the environment due to its resistance to biodegradation and abiotic degradation (ATSDR, 2002a).

Dieldrin is resistant to degradation in soils and sediments, while aldrin is readily converted into dieldrin. This indicates a possibility that detected dieldrin concentrations are related to transformed aldrin instead of dieldrin deposition. However, there are no known sources of aldrin at the Site.

6.5.5. DDT Fate and Persistence

DDT is a pesticide that was possibly used on adjacent sites and may have been deposited on-site with the Biosolids Area. DDE and DDD are its primary metabolites. This compound has a long residual persistence and low acute mammalian toxicity, which made it popular along with its low cost and effectiveness (ATSDR, 2002b).

DDT sorbs strongly to surface soils and is less likely to leach into subsurface soils or groundwater. It may volatilize (or revolatilize) into the atmosphere. Loss of surficial DDT typically involves surface runoff and volatilization. DDT is only slightly soluble in water and will also adsorb to sediment (settled and suspended) in the water column. Sediments act as a sink for DDT and its metabolites.

Transformation mechanisms of DDT in the environment are biodegradation and photolysis. DDT will biodegrade to DDE under aerobic (unflooded) conditions and DDD in anaerobic (flooded) conditions (ATSDR, 2002b). Adsorption and sequestering of DDT in soil pores limits the effectiveness of biodegradation

6.5.6. Inorganics Fate and Persistence

Inorganic constituents include metals (*i.e.*, arsenic, barium, lead, manganese, mercury, selenium, and sodium) and other Solvay waste-related constituents (chloride and sulfate).

Mercury

Mercury is present in the environment in inorganic and organic forms. Inorganic mercury exists in three valence states: mercuric (Hg^{2+}), mercurous (Hg^{+1}), and elemental (Hg^0) mercury (Nriagu, 1979). Inorganic mercuric compounds are strongly retained in soils containing an organic component, whereas soils (particularly subsurface soils) 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 migration into the atmosphere.

The abiotic and biotic transformation of inorganic mercury within the soil can form the organic mercuric compounds (methyl mercury (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 migrating 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). Organic mercuric compounds generally make up less than 1% of the total mercury present in the soil.

Chromium

Chromium is present in the environment primarily in particulate form. Key soluble forms are chromium(VI) and chromium(III), with chromium(VI) the more soluble, mobile and toxic to living organisms (ATSDR, 2000). Chromium(III) has low solubility and reactivity, which result in low mobility and low toxicity.

In the atmosphere, gaseous forms of chromium are rare, and the adsorbed chromium is deposited via wet and dry deposition on the ground and surface waters (ATSDR, 2000). Additionally, chromium compounds do not volatilize from water to the atmosphere, and its fate is typically deposition in sediments.

In aquatic environments, soluble chromium accounts for a very small percentage of the total chromium. The majority of soluble chromium is present as chromium(VI) and chromium (III) complexes (ATSDR, 2000). Soluble and suspended forms can undergo intramedia transport; chromium(VI) will likely reduce to chromium(III) by organic matter in water, but this reduction can be influenced by environmental conditions.

Chromium is primarily present in soil as an insoluble oxide and is not very mobile (ATSDR, 2000). Results from leachability investigations (ATSDR, 2000) indicated that chromium has an initial period of mobility (vertical migration) before forming insoluble complexes that do not migrate easily. Similar to aquatic environments, soluble chromium(VI) and chromium(III) account for a very small percentage of the total chromium. Chromium(VI) and chromium(III) are more mobile in soil, which is dependent on the sorption characteristics of the soil. Transport of chromium occurs mainly through surface runoff and leaching into groundwater. Soluble and unabsorbed chromium(VI) leachability increases with increasing soil pH. However, organic matter is expected to convert the soluble forms (predominantly chromium[VI]) to insoluble forms (*e.g.*, chromium[III] complexes).

Chemical transformations of chromium in aquatic and soil/sediment environments are similar. Chromium(VI) may be present under oxidizing conditions. Under anaerobic conditions, chromium(VI) is reduced to chromium(III) by S^{-2} and Fe^{+2}, which occurs at a faster rate in water than soils and sediments (ATSDR, 2000). This reduction can also occur under aerobic conditions but is dependent upon pH and the amount of organic matter present.

Other Metals

Other key Site metals include arsenic, barium, lead, manganese, selenium, and sodium. Like mercury, the behavior of these metals is typically dependent on its form. Some compounds become more soluble when formed, while others form precipitates and settle out of water columns or pore water. An example is barium; it is more likely to become more mobile and leach from soils in the presence of chloride (ATSDR, 2007a). Lead is typically in particulate form and is strongly retained in by soil organic matter. This metal does not generally get transported from soils due to leaching (ATSDR, 2007b).

The majority of metals will be transported in two ways: surface runoff and leaching into groundwater. Surface runoff can contain dissolved and particulate-bound species, while groundwater generally transports dissolved species.

Chloride and Sulfate

These anions were detected with higher frequency and elevated concentrations due to the waste materials deposited in the Site wastebeds, especially Solvay waste. Chloride can be present as a precipitate and particulate-bound speciation. It can also move through groundwater as a dissolved compound. Comparatively, the majority of sulfates are soluble in water (excluding barium sulfate and lead sulfate; RAIS, 1991). This indicates that sulfate can be transported via groundwater.

6.5.7. Fate and Persistence of Site Compounds Observed in Soil Vapor

For purposes of this discussion, the chemical compounds found in soil vapor at the Wastebeds 1 through 8 Site have been classified into the three categories. They are petroleum compounds, solvents, and degradation products.

Petroleum compounds are expected to biodegrade with time. These compounds include BTEX. The vapor intrusion pathway for these compounds may not be complete, because these compounds often biodegrade within the vadose zone. However, these compounds are highly volatile and do not strongly adsorb to soils.

In contrast to the petroleum compounds, the detected chlorinated solvents would not be expected to degrade as rapidly and would remain in the subsurface for a longer time period. TCE, for example, would be expected to adhere to soils and remain there. TCE is a common chlorinated aliphatic industrial organic solvents used in degreasing operations. Transformation by-products are also found in association with TCE without any known source other than from reductive dechlorination. Dechlorinated byproducts include 1,1-dichloroethane and *cis*-1,2- dichloroethene indicating that some degradation has occurred at the Site.

Based on the above discussion, given the high vapor pressure of many of the compounds detected, preventative measures may need to be taken to prevent the intrusion of vapors into future buildings that may be constructed on-site. Such measures may include the use of a vapor barrier and installation of a venting system.

7. WETLAND DELINEATION AND FLOODPLAIN ASSESSMENT

A May 2006 *Wetland Delineation and Floodplain Assessment Report* (O'Brien & Gere, 2006c) indicated that wetlands were not present on-site. Based on NYSDEC comments (NYSDEC, 2007), a supplemental wetland delineation was performed by representatives of Honeywell, the NYSDEC, and the USEPA in the spring and summer of 2008. As part of the supplemental field efforts, a revised delineation method was developed to address difficulties in applying the three parameter method of the *Wetlands Delineation Manual* (ACOE, 1987) at the Site. Utilization of the atypical method resulted in the delineation of two wetlands totaling 0.721 acres in the lakeshore area of the Site. These wetlands (Wetlands A and B) were 0.317 and 0.404 acres in size, respectively. Both had dense monoculture stands of common reed (*Phragmites Australis*) and were of low habitat quality, function, and value. A map showing the delineated wetlands is presented as **Figure 9**. The *Wetland Delineation and Floodplain Assessment Final Report* (O'Brien & Gere, 2009b) was submitted in May of 2009 and subsequently approved by NYSDEC in June 2009.

The delineated wetlands identified during the May 2009 *Wetland Delineation and Floodplain Assessment Final Report* (O'Brien & Gere, 2009b) are not hydrologically connected to the lake via surface water. As part of the ongoing Integrated IRM the wetlands will be covered and shallow and intermediate groundwater from the area will be collected. The acreage of the covered wetlands is included in the mitigation wetlands being constructed on the lakeshore. The mitigation wetlands will minimize exposure to site constituents, and will provide higher habitat quality function, and value than the current delineated wetlands. Design of the integrated IRM took into account appropriate regulatory requirements, including Section 404 of the Clean Water Act, and Executive Order 11990 (O’Brien & Gere, 2013).

The 100- and 500-year flood boundaries for the Site area, as demarcated by the Federal Emergency Management Agency’s (FEMA) *Flood Insurance Study* (1981), are shown on **Figure 10**. FEMA maps were accessed electronically via FEMA Q3 flood data from Global Information System (GIS) Data Depot (http://data.geocomm.com). FEMA has adopted the 100-year flood boundary as a base flood for purposes of floodplain management measures. The 500-year flood boundary is used to indicate additional areas of flood risk in a community.

Within the Site boundaries, the 100-year and 500-year flood zone elevations are nearly equivalent at topographic elevations of 372 and 373.4 feet above mean sea level (amsl), respectively. Relatively small portions of the Site are within the flood zone. Specifically, the northwestern tip of the Site adjacent to the mouth of Ninemile Creek and the Lakeshore Area immediately adjacent to Onondaga Lake are within FEMA’s 100-yr flood zone.

8. BASELINE RISK ASSESSMENTS

8.1. HUMAN HEALTH RISK ASSESSMENT

The Wastebeds 1 through 8 revised Human Health Risk Assessment (HHRA) was submitted under separate cover to the NYSDEC on April 29, 2011 and approved by the NYSDEC on June 13, 2011. The HHRA evaluated potential receptors for each of the Site Exposure Areas (Biosolids Area, New York State Fair Parking Areas, Lakeshore Area, Upland Old Field Successional Area, former Ponded Area, Site Ditches, and Ditch A – South. A hypothetical potable water source area (Site-wide) was also evaluated.

The screening values used to evaluate concentration data from these Exposure Areas used the lowest of the USEPA Region 9 Preliminary Remediation Goals (PRGs; USEPA, 2004b) or the USEPA Region 3 Risk-Based Concentrations (RBCs; USEPA, 2007b). RBCs and PRGs for tap water were applied to screen surface water and groundwater detected concentrations. RBCs and PRGs for residential soils were applied to screen the soil and sediment detected concentrations. RBCs and PRGs utilized in the screening process corresponded to a cancer risk of 10^{-6} or a hazard quotient of 0.1. Other screening levels were included in the RAGS Table 2 Series for surface and subsurface soils (6NYCRR 375-6.8 Soil Cleanup Objectives) and for surface water and groundwater [USEPA (2008a) *National Primary and Secondary Drinking Water Regulations*]. These were included for informational purposes and were not used to screen constituents in or out of the HHRA.

Based on current conditions at the main portion of the Site and the nature of the surrounding area, the following current receptor populations were identified:

- Older child transient trespasser (Exposure Unit 1 – NY State Fair Parking Area, Upland Old Field Successional Area, Biosolids Area, former Ponded Area, and Ditch A - South)
- Adult lunchtime trespasser (Exposure Unit 2 – NY State Fair Parking Area, Upland Old Field Successional Area, and Biosolids Area)
- Utility/sewer worker (Exposure Unit 2 – NY State Fair Parking Area, Upland Old Field Successional Area, and Biosolids Area)
- Older child and young adult trespasser/ATV recreator (Exposure Unit 3 – NY State Fair Parking Area, Upland Old Field Successional Area, Biosolids Area, and Lakeshore Area)
- Adult, Older child, and younger child state fairgrounds attendee (Exposure Unit 4 – NY State Fair Parking Area)
- State fairgrounds maintenance worker (Exposure Unit 4 – NY State Fair Parking Area)
- Ditch maintenance worker (Exposure Unit 5 – Site Ditches)
- Trespasser/fisherperson (Exposure Unit 6 – Lakeshore Area and Ditch A – South)
- Utility/sewer worker (Exposure Unit 7 – Site Wide Shallow Groundwater)

Future users at this Site will potentially include all of the current users listed above and may include additional users related to industrial or commercial activities. The Onondaga County Department of Transportation is extending the Lake Canalways Trail Section 1 roughly 1.5 miles along the lakeshore over the wastebeds. It is also possible, though extremely unlikely, that future residents and commercial/industrial workers could use Site groundwater as potable water. Based on these considerations, the following receptors, in addition to those listed above, were identified under reasonably foreseeable future conditions:

- Construction worker (Exposure Unit 3 – NY State Fair Parking Area, Upland Old Field Successional Area, Biosolids Area, and Lakeshore Area, and Exposure Unit 7 - Site Wide Shallow Groundwater)
- Commercial/industrial worker (Exposure Unit 2 – NY State Fair Parking Area, Upland Old Field Successional Area, and Biosolids Area)

- Adult and child residents (Exposure Unit 7 – Site Wide Groundwater)

For Site-wide cancer risk, the only receptors that exceed the regulatory threshold (10^{-4} to 10-6) were potential future adult and child residents under the RME and CT scenarios. These risks are driven by exposure to benzene and, to a lesser extent, PAHs and arsenic in Site-wide groundwater. If this extremely unlikely exposure scenario was prevented in the future, this HHRA indicates that all other cancer risks would be within acceptable regulatory ranges.

For Site-wide non-cancer risk, the only receptors exceeding the regulatory threshold (Hazard Index of 1) were current/future older child trespasser/ATV recreator, future construction worker, and potential future adult and child residents under the RME and CT scenarios, while the current/future utility worker, future commercial/industrial worker, and current/future young adult trespasser/ATV recreator exceeded under the RME scenario. The risk drivers by receptor are:

- Current/future utility worker – benzene
- Future commercial/industrial worker – highly chlorinated PCBs
- Current/future older child trespasser/ATV recreator – manganese and nickel
- Current/future young adult trespasser/ATV recreator – manganese and nickel
- Future construction worker – manganese, nickel, and benzene
- Future adult and child residents - benzene

A full discussion of the HHRA evaluation and conclusions is presented in the approved report (O'Brien & Gere. 2011a).

8.2. BASELINE ECOLOGICAL RISK ASSESSMENT

The Wastebeds 1 through 8 revised Baseline Ecological Risk Assessment (BERA) was submitted under separate cover to the NYSDEC on March 9, 2011 and approved by the NYSDEC on March 31, 2011. Potential ecological risk to Site community-level receptors (terrestrial plants, soil invertebrates, benthic invertebrates, and fish) was evaluated by comparing the average and exposure point constituents of concern concentrations in various media to standards, criteria and guidance values that are considered protective of these receptors. Risk to upper trophic level receptors was estimated based on direct exposure and exposure through the food chain.

Several literature references were used to identify ecological screening levels, including criteria documents as well as guidance documents. The screening values were chosen based on NYSDEC and USEPA direction and guidance and included:

- Part 375 Environmental Remediation Program. 6NYCRR Part 375 Subpart 375-6.6 (NYCRR, 2006)
- National Recommended Ambient Water Quality Criteria (USEPA, 2009a)
- Ecological Soil Screening Levels (Eco-SSLs; USEPA, 2003a)
- Technical and Operational Guidance Series Number 1.1.1. New York State Ambient Water Quality Standards and Guidance Values (NYSDEC, 1998b)
- ECO Update: Ecotox Thresholds (USEPA, 1996d)
- NYSDEC's Technical Guidance for Screening Contaminated Sediments (NYSDEC, 1999)
- Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision (Efroymson et al., 1997a)
- Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision (Efroymson et al., 1997b)
- Biological Technical Assistance Group (BTAG) Screening Value (Draft): Region 3 (USEPA, 2006)

The majority of estimated ecological risk at this Site is associated with exposure to Site surface soils (terrestrial exposure). Food chain exposure for receptors that are exclusively aquatic (belted kingfisher and great blue heron) yielded just three no observed adverse effects level (NOAEL)-based hazard quotients (HQs) that were equal to or greater than one. No lowest observed adverse effect level (LOAEL)-based HQs were greater than one for these receptors. In contrast, food chain calculations for exclusively terrestrial receptors (American robin, short-tailed shrew, red fox and red-tailed hawk) yielded 56 NOAEL-based HQs and 32 LOAEL-based HQs that were greater than or equal to one.

The majority of HQs that exceed one in this BERA Report for both terrestrial and aquatic upper trophic level receptors are for metals, BTEX, naphthalene, and phenols. Seventy-three percent of all NOAEL-based HQs that were equal to or greater than one in this BERA Report were for metals. The following metals had the highest number of NOAEL-based HQs greater than one: chromium (6), cadmium (4), vanadium (3), and thallium (3). The same trend was observed when LOAEL based HQs were examined for inorganics for both terrestrial and aquatic receptors. Seventy-two percent (23) of the 32 LOAEL-based HQs that were equal to or greater than one in the BERA Report were for metals. The highest number of LOAEL-based HQs greater than one were for chromium (4), cadmium (3), and zinc (3). Thirty-four of the NOAEL-based HQs that are greater than one were for organic constituents. These included primarily hexachlorobenzene, bis(2-ethylhexyl)phthalate, dieldrin, dibenz(a,h)anthracene, total PCBs, and xylenes.

There is uncertainty associated with metal concentrations in surface and seep soil at the Wastebeds 1-8 Site as they relate to the results of this BERA Report. The primary areas of uncertainty are:

- The EPCs for eight Site metals do not exceed maximum background concentrations for New York
- Eight metals have average detected concentrations that are significantly influenced by a single outlier. For example, removing a single ProUCL-identified outlier from the total chromium dataset reduces the Site-wide average concentration by 28% and the EPC by 50%.
- Surface soil data from the Biosolids Area has a disproportionate impact on the average concentrations of several metals. For example, when zinc data from the Biosolids Area is removed from the Site-wide surface soil dataset, the weighted average concentration for zinc at the Site decreases by 90%. The Biosolids Area should thus be considered during the risk management stage of the evaluation of the Site. It should be noted that excising the hot spots identified in the BERA does not eliminate all potential risk posed by the Site.

Thirty-four of the NOAEL-based HQs that are greater than one were for organic constituents. These included primarily hexachlorobenzene, bis(2-ethylhexyl)phthalate, dieldrin, dibenz(a,h)anthracene, total polychlorinated biphenyls (PCBs), and xylenes. As with metals, there is significant uncertainty associated with some of these results. The primary areas of uncertainty are:

- One organic constituent (hexachlorobenzene) was detected at very low frequencies (<5%); however, it was retained for further evaluation because it is a bioaccumulative compound.
- Two organic constituents that were detected at relatively low frequencies (~25%) contributed to HQs greater than 1 (bis(2-ethylhexyl)phthalate and dieldrin).
- The concentrations of methyl mercury in various environmental media were derived based on an assumed presence at a level equal to 1% of the measured mercury concentrations. Uncertainty is introduced by this process because methyl mercury concentrations may actually comprise a higher or lower percentage of the total mercury found on the Site and the true value is unknown. Based on this methodology, methyl mercury in surface soils contributed to a maximum HQ of 38 (mink).

A full discussion of the BERA evaluation and conclusions is presented in the approved report (O'Brien & Gere. 2011b). It should be noted, that, as a result of Integrated IRM activities in the Ponded Area and lower Ditch A, potential risks to aquatic receptors are fully addressed. In addition, potential risks to terrestrial receptors along the eastern shoreline of the Site have also been addressed by the Integrated IRM shoreline cover system.

9. CONCEPTUAL SITE MODEL

The conceptual site model (CSM) was developed according to the guidelines presented in *Data Quality Objectives for Remedial Response Activities* (USEPA, 1987). The information presented herein is based on data obtained during the PSA, FRI, RI, Chromium Speciation Investigation, SRI, and other previous investigations. The CSM is presented on **Figures 172 and 173**.

In general, the Site consists of variable terrain with topographic highs and lows that range from 363 ft above MSL at the shore of Onondaga Lake to 430 ft above MSL on top of the wastebeds. Transportation features bisect the Site and include I-690, access roads for the New York State Fairgrounds parking lots, and footbridges. Surface water features are present around most of the Site, with Onondaga Lake along the northern boundary, Ninemile Creek along the north and west, and drainage ditches along the southwestern and eastern boundaries of the Site.

Surface drainage from Wastebeds 1 through 8 generally flows radially outward from the central portion of the Site. Where transportation features are present, surface water runoff is collected in several drainage ditches and eventually channeled from the central portion of the Site towards Ninemile Creek and Onondaga Lake.

9.1. HYDROGEOLOGY

The Site geology is similar to other Onondaga Lake sub-sites, where up to 250 ft of both anthropogenic and natural unconsolidated deposits overlie the Silurian Age Vernon Shale. The overburden deposits above the bedrock consist of till, basal sand and gravel, fine sand and silt, glaciolacustrine silt and clay confining layer, marl, and anthropogenic fill.

Hydrogeologic investigations have identified two groundwater systems comprising seven hydrogeologic units at the Site. These two systems and each of the six units are presented below:

- Upper Groundwater System
  - A shallow zone composed of Solvay waste and anthropogenic fill within the upland portions of the beds
  - An intermediate zone composed largely of marl, with some peat and Solvay waste
  - The Ninemile Creek deltaic deposits
- Lower Groundwater System
  - A confining layer composed of silt and clay
  - A deep zone consisting of the silt and fine grained sand unit and the basal sand and gravel unit
  - A confining till unit
  - A shallow bedrock zone

The groundwater at the Site is divided into two flow zones, the upper flow system and the lower flow system. These two zones are separated by a silt and clay confining layer, where it exists. The upper flow system comprises the anthropogenic fill/wastebed hydrogeologic unit and the native marl hydrogeologic unit, and includes the Ninemile Creek deltaic deposits on the western side of the site. The lower flow system is comprises the fine sand, a basal sand and gravel, and bedrock.

The Lower Groundwater System at the Wastebed 1 through 8 Site likely is recharged at least in part from the overlying Upper Groundwater System through the gap in the silt and clay. This system is also likely a part of a more substantial, regional groundwater system which includes the Ninemile Creek Valley and areas adjacent to the Site. The distribution of the leachate type groundwater and proximity of the Wastebed 1 through 8 Site to the Lower Groundwater System suggest that the Wastebed 1through 8 Site may be a source for leachate.

However, there are other wastebeds in the area with leachate impacted groundwater. These Sites may also contribute to the impact to groundwater conditions in the Lower Groundwater System.

9.2. SOURCE AREAS

Compounds generated at the Main Plant during the operation of Wastebeds 1 through 8 included chlorinated benzene, hydrochloric acid, ammonia, coke, phenol, caustic soda, caustic potash, chlorine gas, BTEX, and naphthalene. These compounds and compounds associated with these operations may have been disposed with the Solvay waste slurry in the wastebeds or by alternative means. Stained materials are present at the base of Wastebeds 1 through 4 and along the lakeshore. The stained materials may be a current source of organic constituents detected in Site groundwater; however, the exact source or sources of the organics is unknown. Certain inorganics, in particular chromium and nickel, are detected at higher concentrations in the vicinity of the Crucible Landfill suggesting these compounds may be related to the former operation of this landfill. Also, higher concentrations of CPOIs were detected in the Biosolids Area indicating this may be a source area.

9.3. PRELIMINARY CHEMICAL PARAMETERS OF INTEREST (CPOIS)

The preliminary CPOIs are based on the screening documented in Section 5 of this report. For each environmental medium the Site constituents were considered to be preliminary CPOIs if one of the following criteria was exceeded:

- 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 is known to bioaccumulate
- The constituent has no screening criterion

The preliminary CPOIs were modified and updated based on the results of the risk. The preliminary CPOIs for the Site include the constituents listed in **Table 212**.

9.4. IMPACTED MEDIA AND POTENTIAL TRANSPORT OF CPOIS

Based on comparison of data to conservative screening values, impacted media includes soils (surface and subsurface), groundwater, sediment, surface water, and soil vapor. The following pathways are considered to be potential, viable migration pathways at the Site:

- Shallow and intermediate groundwater migration to adjacent water bodies and downward migration into the deep and bedrock groundwater zones. As part of the Integrated IRM, shallow and intermediate groundwater is being collected along the eastern shoreline, along Ninemile Creek, and along Remediation Area A.
- Surface water runoff or leaching
- Transport of sediments from the on-site ditches, and seeps along Ditch A not addressed by the Integrated IRM
- Wind-borne particulate migration
- Vapor migration
- Surface soil to human and ecological receptors outside of areas addressed along the eastern shoreline of the Site as part of the Integrated IRM
- Surface water and sediment to human and ecological receptors outside of the former Ponded Area and lower Ditch A addressed as part of the Integrated IRM

Impacted media and transport pathways are described in detail within Sections 4 and 6, respectively.

9.5. POTENTIAL RECEPTORS

Potential receptors of CPOIs include humans and wildlife exposed to impacted media, including Site surface soil, subsurface soil, groundwater, sediments, and surface water. The human and ecological receptors are described in detail within Section 8 of this report.

10. CONCLUSIONS AND PRELIMINARY REMEDIAL ACTION OBJECTIVES (RAOS)

10.1. CONCLUSIONS

Data collected during the Remedial Investigation (RI) and other investigations Site indicates that the environmental conditions observed at the Site are related to historical industrial activities, as well as former and current land uses, including:

- Solvay waste - The historic use of the site as a settling basin for Solvay waste, an inert material consisting largely of calcium carbonate, calcium silicate, and magnesium hydroxide, and the periodic co-disposal of former Allied Chemical Main Plant byproducts including BTEX; naphthalene and other PAHs; and phenol during settling basin operations from approximately 1916 to 1943. These activities resulted in impacts to lakeshore surface soils/fill, subsurface soils/fill, groundwater, and surface water. The impacts to Onondaga Lake and Ninemile Creek are being addressed by the Integrated IRM that has been implemented at the Site.
- Crucible Landfill - The disposal of waste materials containing chromium, nickel and other metals from Crucible Specialty Metals in an on-site Landfill from 1973 until its regulated closure in 1988. This activity resulted in impacts to surface soils/fill, subsurface soils/fill, and groundwater.
- Municipal sewage sludge - The placement of municipal sewage sludge from Onondaga County generally containing metals, PAHs, pesticides, and PCBs in the Biosolids Area from 1925 to 1978. This activity resulted in impacts to surface soils/fill and subsurface soils/fill.
- Other - Portions of the Site are used as parking lots for the New York State Fair and the Site is transected by Interstate-690 and the New York State (NYS) Route 695 interchange. Storm water run-off from the parking areas, Interstate 690 and NYS Route 695, and upstream areas (*i.e.*, Bridge Street and Crucible Parking lots) have resulted in impacts to site surface water and sediment in Ditch A. These impacts include constituents ubiquitous to the environment and general urban run-off such as BTEX, PAHs, pesticides, PCBs, and metals.

Based on the investigations conducted, the following detailed conclusions have been developed.

- The Site geology consists of seven distinct layers including fill/Solvay waste, marl/peat, silt and clay, silt and fine-grained sand, basal sand and gravel, basal till, and bedrock.
- The marl layer pinches out to the south, away from the lake, and transitions to alternating layers of marl and peat.
- The Site Hydrogeology consists of two groundwater zones, an Upper Groundwater System and a Lower Groundwater System separated by a confining silt and clay layer.
  - The Upper Groundwater System consists of the anthropogenic fill/waste and the native marl/peat. Localized deltaic deposits were also observed along the former Ninemile Creek channel to Onondaga Lake under Wastebeds 5 and 6.
  - The discontinuous confining or low flow zones are a silt and clay layer between the marl/peat and deep zone, and the basal till lying between the deep and bedrock zones.
  - The Lower Groundwater System consists of the silt and fine grained sand deposits and the basal sand and gravel deposits, and a bedrock zone that consists of the Vernon Shale.
- The silt and clay confining layer was not observed under the central sections of Wastebeds 2, 3, 4, and 5 and portions of Wastebeds 7 and 8.

  - The lack of this confining layer may have allowed for downward migration of CPOIs from the Upper Groundwater System into the Lower Groundwater Zone.
- Shallow groundwater generally flows radially from the wastebeds into Onondaga Lake, Ninemile Creek, and drainage ditches
  - Shallow groundwater also surfaces in areas along the lakeshore and Ninemile Creek as seeps.
- Groundwater flows along the former Ninemile Creek channel deltaic deposits into Onondaga Lake and Ninemile Creek.
- CPOIs at the Site include BTEX, naphthalene and assorted PAHs, phenolic compounds, pesticides, and inorganics. The preliminary CPOIs presented in Section 4 of this report are based on based on conservative screening values and may not be representative of current or future uses of the Site, or calculated risks.
- Two areas of stained Solvay waste are present along the lakeshore, which are located on the eastern side of Lakeview Point and southeastern lakeshore of the Site and extend roughly 5 ft bgs and these areas are currently being mitigated through cover systems and the collection of shallow and intermediate groundwater by the on-going IRM.
- A layer of stained fill (*i.e.*, Solvay waste) is present at the base of Wastebeds 1 through 4 approximately 60 ft below the surface. This deep layer may be a source of BTEX, naphthalene and other PAHs, and phenol concentrations along the lakeshore and southeastern portion of the Site. including deep and bedrock groundwater beneath both the Site and the adjacent Onondaga Lake. It should be noted that a separate Deep Groundwater Investigation is being conducted to evaluate other potential sources of benzene in deep and bedrock groundwater encountered regionally along the lakeshore and beneath Onondaga Lake.

The nature and extent of CPOIs are defined sufficiently to conduct a FS for the Site, and no further Site characterization is warranted at this time.

10.2. RISK ASSESSMENT SUMMARY

10.2.1. Human Health Risk Assessment

Potential risks related to human exposures to soil/fill material were limited to non-cancer risks driven by inhalation of metals in dust or the accidental ingestion PCBs in surface soil. The estimated risks to human health are similar to those risk levels estimated for typical background concentrations, or were associated with concentrations only detected in a relatively small area proximal to the Crucible Landfill.

Potential risks and hazards can be minimized using measures such as visitors abiding by posted rules and signage, and recreational users staying on the bike trail or other areas designated for recreational use. It should be noted that the HHRA (O'Brien & Gere, 2011d) found no unacceptable risks for most site visitors and exposure scenarios (*e.g.*, transient trespasser, lunchtime trespasser, State Fair attendee, or fisherperson/trespasser). The only receptors and exposure scenarios for which risks or hazards were potentially unacceptable were for receptors that do not abide by posted rules and signage (*e.g.*, ATV recreators), or receptors that would be involved in intrusive work such as a construction worker. Also, the EPA's Wastebeds 1-8 Bike Trail Risk Assessment (USEPA, 2009a) indicated that risks and hazards to receptors using the bike trail as intended were within acceptable regulatory limits, and the Wastebeds 1-8 Lakeview Amphitheater Supplemental Human Health Risk Evaluation (USEPA, 2014) found that risks and hazards associated with the amphitheater attendee were within acceptable risk ranges and targets.

Organics and to a lesser extent arsenic in groundwater also drove cancer and non-cancer risk when Site groundwater is considered a source of potable water. The use of Site groundwater as potable water is already highly unlikely due to its saline nature. This extremely unlikely exposure scenario can be avoided by preventing the use of Site groundwater as a source of potable water through zoning and other preventative measures (*e.g.*, deed restrictions).

10.2.2. Baseline Ecological Risk Assessment

Potential risks related to terrestrial ecological receptor exposures to soil/fill[1] material were primarily driven by metals for which detected concentrations do not exceed background concentrations in New York State, are associated with a single outlier, or are associated with the Biosolids Area at the Site. To a lesser extent than metals, organic constituents including BTEX compounds, naphthalene, phenols, and several other compounds detected at low frequencies but retained for their biaccumulative properties presented potential risk to terrestrial ecological receptors exposed to soil/fill. Potential risks to aquatic ecological receptors were related to exposure to soil/fill material substrate in one location at the Site (lower Ditch A).

10.3. PRELIMINARY REMEDIAL ACTION OBJECTIVES

Based on the results of the PSA, FRI, RI, Chromium Speciation Investigation, SRI, HHRA, BERA, and previous investigations, the following list of preliminary remedial action objectives (RAOs) has been developed.

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

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

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

- Prevent, or reduce to the extent practicable, the migration of contaminants to groundwater, sediment or surface water 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 material or sediment causing toxicity or impacts from bioaccumulation through the terrestrial food chain.

Groundwater Preliminary 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

- In the event that buildings are constructed at the Site, mitigate impacts to public health resulting from existing, or the potential for, soil vapor intrusion into buildings at a Site.

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[1] As noted in the Executive Summary, the Site was used historically as a settling basin for Solvay waste, an inert material consisting largely of calcium carbonate, calcium silicate, and magnesium hydroxide. Additional wastes that were periodically co disposed (from approximately 1916 to 1943) during settling basin operations include former allied chemical Main Plant byproducts including benzene, toluene, ethylbenzene, and xylenes (BTEX); naphthalene and other polycyclic hydrocarbons (PAHs); and phenol. The term "soil/fill material" throughout this document refers to Solvay waste, other Allied wastes as described above, fill materials (*e.g.*, gravel) that have been placed at the site, and soil that has formed above the Solvay waste.

10.4. FUTURE ACTIVITIES

Two Feasibility Studies will be conducted for the site, one for the Site soil/fill and a second for Site groundwater.

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Appendix A

Site Photograph Log

Photo 1 – Debris piles along a vegetated area in the north central/northeastern portion of the Site; photo looking northeast. Date photo taken: 6/30/03

Photo 2 – Close-up photo of the debris piles; debris includes soils, asphalt, broken pipes, and vegetation. Date photo taken: 6/30/03

Photo 3 – Photo looking west across a grassy area north of the upper parking area and west of the debris piles. Date photo taken: 6/30/03

Photo 4 – Looking east along the Onondaga Lake shoreline with areas of exposed Solvay waste. Date photo taken: 6/30/03

Photo 5 – Looking east along the perimeter of the Site, with the shoreline vegetation and exposed areas of Solvay waste visible. Date photo taken: 6/30/03

Photo 6 – Ninemile Creek adjacent to the western extent of the Site near the creek outlet to Onondaga Lake. Date photo taken: 6/30/03

Photo 7 – Connecting path between the upper and lower perimeter paths, with evidence of all terrain vehicle use in the past. Date photo taken: 6/30/03

Photo 8 – Debris piles (miscellaneous materials) and berm face (exposed Solvay waste) north of the paved roadway located near the eastern gate entrance if the upper parking area. Date photo taken: 6/30/03

Photo 9 – Lengthwise view of TP-06 located within the Onondaga County Biosolids Area.
Date photo taken: 6/2/04

Photo 10 – Looking southeast from TP-26 in the upper parking area at the temporary background air monitoring station.
Date photo taken: 6/4/04

Photo 11 – Lengthwise view of TP-04 located in the Onondaga County Biosolids Area.
Date photo taken: 6/7/04

Photo 12 – Lengthwise view of TP-08.
Date photo taken: 6/16/04

Photo 13 – View of VI-03 installation
Date photo taken: 1/16/07

Photo 14 – Standing on Wastebeds 7 and 8 looking towards the eastern margin of the Wastebeds.
Date photo taken: 1/18/07

Photo 15 – Standing on Wastebeds 6 looking towards the MW-03 S/I/D/BR cluster while drilling MW-03BR.
Photo taken in February 2007 by Parratt Wolff during site visit. Exact Date not known.